Mitutoyo

Line Laser Sensor
SurfaceMeasure

SurfaceMeasure1008S

User's Manual
- Instructions for use -

Read this document thoroughly before operating the product. After reading, retain it close at hand for future reference.
This English language version of the document contains the original instructions.

No. 99MCA912A2
Date of publication: October 1, 2022 (1)

Product names and model numbers covered in this document

Product name	Model number
Line Laser Sensor SurfaceMeasure	SurfaceMeasure 1008S

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- Upon loan or transfer of this product, be sure to attach this document to the product.
- In the event of loss or damage to this document, immediately contact the agent where you purchased the product or a Mitutoyo sales office.
- Read this document thoroughly before operating the product. In particular, be sure to fully understand "Safety Precautions" on page 8 and "Precautions for Use" on page 12.
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Contents

MEMO

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About This Document

■ Positioning of this document, document map

This describes the positioning of this document and its relationship with other installments.

● For hardware, software

Line Laser Sensor SurfaceMeasure SurfaceMeasure1008S User's Manual (This document)	Provides precautions for use, operations and functions of SurfaceMeasure1008S.
Line Laser Sensor SurfaceMeasure SurfaceMeasure1008S Instruction Manual	A quick guide for using the SurfaceMeasrue1008S.
Line Laser Sensor SurfaceMeasure SurfaceMeasure1008S Measurement tool Technical Manual	Provides technical descriptions and algorithms of SurfaceMeasure1008S.

● Others

Line Laser Sensor SurfaceMeasure SurfaceMeasure1008S Grounding Guide	Provides guides for reducing the effects of potential differences and noise.

■ Intended readers and purpose of this document

● Intended readers

This is intended for those who use this product, and those who build inspection and evaluation systems, and perform various kinds of non-contact form measuring.

● Purpose

The purpose of this document is to help you to understand the functional outline of the product, functions of each part, how to use it and maintenance details.

Conventions Used in This Document

■ Safety reminder conventions warning against potential hazards

⚠ DANGER	Indicates a hazard with a high level of risk which, if not avoided, **will result in death or serious injury.**
⚠ WARNING	Indicates a hazard with a medium level of risk which, if not avoided, **could result in death or serious injury.**
⚠ CAUTION	Indicates a hazard with a low level of risk which, if not avoided, **could result in minor or moderate injury.**
NOTICE	Indicates a situation which, if not avoided, **may result in property damage.**
	**Electricity** Alerts the user to a specific hazardous situation that means "Caution, risk of electric shock".

■ Conventions indicating prohibited and mandatory actions

	Indicates concrete information about prohibited actions.
	Indicates concrete information about mandatory actions.
	Indicates that grounding needs to be implemented.

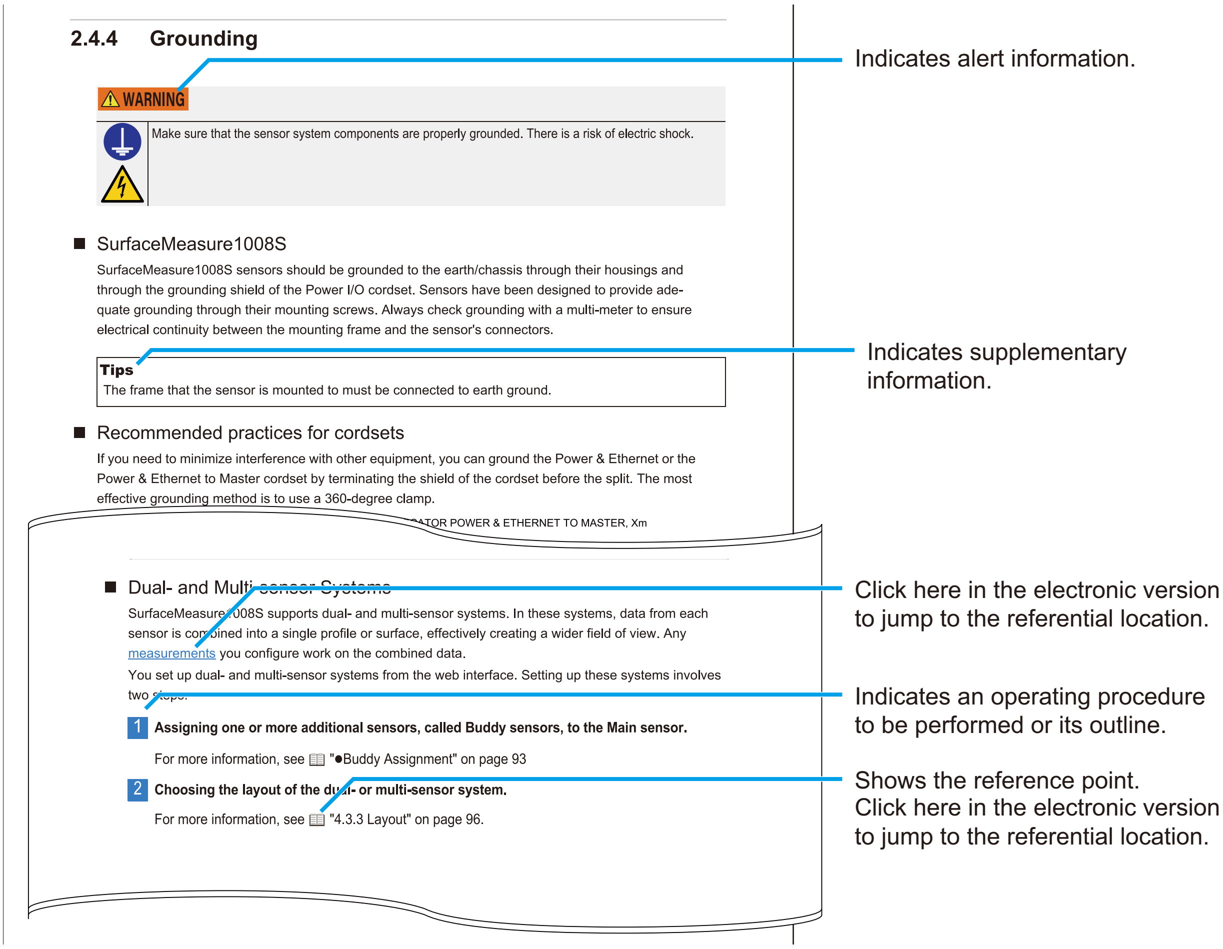
■ Conventions indicating referential information or reference location

IMPORTANT	Indicates information that must be known when using the product.
Tips	Indicates further information and details relevant for the operating methods and procedures that are explained in that section.
	Indicates reference location if there is information that should be referred to in this document or an extraneous User's Manual. Example: For details about XX, see  "1 Overview" on page 15.

■ Other conventions

( ): Round brackets	Represent a paraphrase of an immediately preceding phrase or a supplementary explanation.
" ": Double quotation marks	Represent a highlighted phrase. They also indicate an index where information to be referenced is described.
[ ]: Square brackets	Represent the menu names on screen, the name of screens, buttons, display items, tab names, and keyboard keys. They also indicate an item to be purposely entered or selected by the customer.
1, 2, 3 ... 1, 2, 3, ...	Indicates the order and the contents of tasks. (1: indicates main tasks, 1: indicates detailed tasks)
»	Indicates the action resulted from some operation(s).

■ Example of conventions use



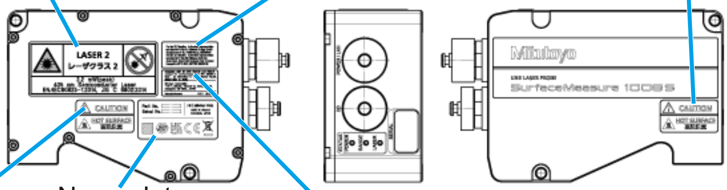
Labels on Product

Product safety labels

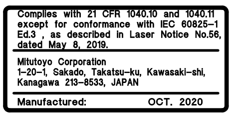
This product has been designed and manufactured with human safety as a priority. In order to use it more safely, product safety labels have been applied to the main body and all peripheral devices. This section explains the meaning and the contents of each safety label on the product.

Before operating this product, be sure to carefully read this section to use this product safely and for a long time.

■ Locations of labels



■ Label details and precautions

Product safety labels	Notes
①High temperatures caution label 	Caution that the sensor surface becomes high temperatures
②Laser Caution label 	**Laser Precaution 1: Caution against high-intensity light (laser beam)** This product is equipped with laser-related devices corresponding to Class 2. Read 📖 "Safety Precautions" on page 8 thoroughly, and then handle this product carefully and pay enough attention.
③Certification plate  Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed.3 , as described in Laser Notice No.56, dated May 8, 2019. Mitutoyo Corporation 1-20-1, Sakado, Takatsu-ku, Kawasaki-shi, Kanagawa 213-8533, JAPAN Manufactured: OCT. 2020	**Laser Precaution 2**

Safety Precautions

Read these "Safety Precautions" thoroughly before operating the product to use it properly.
These safety precautions include such information as to prevent injury to the operator and other persons, damage to property and product defects. Be sure to observe these precautions carefully.

■ Precautions for this product

⚠ WARNING

Removing the covers or disassembling this product will cause electric shock or burns, and in a worse case it may result in serious injury or death.

- If the SurfaceMeasure Interface Unit housing cover is removed and disassembled, this might cause accidents due to electric shocks or burn, or the infiltration of metallic powders, etc. Since there is a risk of danger, absolutely do not disassemble this product.
- Absolutely do not remove the housing cover of Line Laser Probe SurfaceMeasure. When the product is being powered, there is a risk of electric shock.
- Do not touch the connection terminals with your hands or objects in order to prevent electric shocks due to connection faults.

⚠ WARNING

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

⚠ CAUTION

If the product is going to be used in the following places, adequately implement shielding countermeasures. In conjunction with the causes of injuries, if the product is used beyond the conditions that are indicated in the specifications, its functions and performance can no longer be guaranteed.

- Where noise is generated due to static electricity, etc.
- Where there is strong electrical field intensity
- Where power cables and power transmission lines are running through nearby
- Where there are risks of radiation being irradiated
- Where there are risks of being exposed to corrosive gases, etc.

⚠CAUTION

This product uses a visible light laser beam. Any procedures other than the procedures described herein may result in hazardous radiation exposure.

As for the laser product safety standards, this product conforms to the following standards.

Applicable standards	Laser class
EN/IEC 60825-1:2014	Class 2 laser product
JIS C 6802:2014	Class 2 laser product

Class 2 laser product:

This product is a laser product which emits visible light in the 400 nm to 700 nm wavelength spectrum, and it is dangerous if you intentionally look into the laser beam. Even if the beam hits your skin, it will not particularly be a problem.

Protective equipment such as protective eyewear, etc., is not necessary, but if protective eyewear is purchased for use, refer to the wavelengths contained in 📖"Specifications" on page 1001.

Laser Safety:

SurfaceMeasure1008S is referred to as components, indicating that they are sold only to qualified customers for incorporation into their own equipment. These sensors do not incorporate safety items that the customer may be required to provide in their own equipment (e.g., refer to the references below for detailed information).

- Absolutely do not peel off the following laser class label which is applied to the main unit of the Line Laser Probe SurfaceMeasure for precautions.

  📖 "■Locations of labels" on page 7

- Do not look into the laser emitter. Absolutely do not look into it even if the beam is not emitted.
- Do not look directly at the laser beam with optical equipment (things which converge light such as magnifying glasses, etc.). In addition, do not allow the light reflected from the flat surfaces to enter into your eyes, when measuring flat surfaces such as mirror surface. Even if the beam hits your skin, it will not particularly be a problem.

■ Electrical Safety

⚠WARNING

Failure to follow the guidelines described in this section may result in electrical shock or equipment damage.

	Sensors should be connected to earth ground. All sensors should be connected to earth ground through their housing. All sensors should be mounted on an earth grounded frame using electrically conductive hardware to ensure the housing of the sensor is connected to earth ground. Use a multi-meter to check the continuity between the sensor connector and earth ground to ensure a proper connection.
	Minimize voltage potential between system ground and sensor ground. Care should be taken to minimize the voltage potential between system ground (ground reference for I/O signals) and sensor ground. This voltage potential can be determined by measuring the voltage between Analog_out- and system ground. The maximum permissible voltage potential is 12 V but should be kept below 10 V to avoid damage to the serial and encoder connections. For a description of the connector pins, see "14.2.2 SurfaceMeasure1008S I/O Connector" on page 1008.
	Use a suitable power supply. The power supply used with sensors should be an isolated supply with inrush current protection or be able to handle a high capacitive load. Verify the voltage input requirements for your sensor in the sensor's specifications; for specifications, see "14.2 Sensor Connectors" on page 1006.
	Use care when handling powered devices. Wires connecting to the sensor should not be handled while the sensor is powered. Doing so may cause electrical shock to the user or damage to the equipment.

■ Heat Warning

⚠CAUTION

If a sensor is not adequately heat-sunk, the housing may get hot enough to cause injury.

	Sensors should be properly heat-sunk. To avoid injury and to ensure that a sensor functions properly, mount the sensor to a thermally conductive material for good heat-sinking. See also, "■Environment and Lighting" on page 11.

■ Handling, Cleaning, and Maintenance

IMPORTANT

Dirty or damaged sensor windows (emitter or camera) can affect accuracy. Use caution when handling the sensor or cleaning the sensor's windows.

- Keep sensor windows clean
  Use dry, clean air to remove dust or other dirt particles. If dirt remains, clean the windows carefully with a soft, lint-free cloth and non-streaking glass cleaner or volatility alcohol. Ensure that no residue is left on the windows after cleaning.
- Turn off lasers when not in use
  Mitutoyo uses semiconductor lasers in SurfaceMeasure1008S. To maximize the lifespan of the sensor, turn off the laser when not in use.
- Avoid excessive modifications to files stored on the sensor
  Sensor settings are stored in flash memory inside the sensor. Flash memory has an expected lifetime of 100,000 writes. To maximize lifetime, avoid frequent or unnecessary file save operations.

■ Environment and Lighting

IMPORTANT

Avoid strong ambient light sources.

The imager used in this product is highly sensitive to ambient light. Do not operate this device near windows or lighting fixtures that could influence measurement or data acquisition.If the unit must be installed in an environment with high ambient light levels, a lighting shield or similar device may need to be installed to prevent light from affecting measurement.

IMPORTANT

Ensure that ambient conditions are within specifications.

Sensors are suitable for operation between 0–40° C and 25–85% relative humidity (non-condensing). Measurement error due to temperature is limited to 0.015% of full scale per degree C. The storage temperature is -30–70° C.

The Master network controllers are similarly rated for operation between 0–50° C.

IMPORTANT

The sensor must be heat-sunk through the frame it is mounted to. When a sensor is properly heat sunk, the difference between ambient temperature and the temperature reported in the sensor's health channel is less than 15° C.

IMPORTANT

Sensors are high-accuracy devices, and the temperature of all of its components must therefore be in equilibrium. When the sensor is powered up, a warm-up time of at least ninety minutes is required to reach a consistent spread of temperature in the sensor.

NOTICE

To ensure reliable operation and to prevent damage to sensors, avoid installing the sensor in locations

- that are humid, dusty, or poorly ventilated;
- with a high temperature, such as places exposed to direct sunlight;
- where there are flammable or corrosive gases;
- where the unit may be directly subjected to harsh vibration or impact;
- where water, oil, or chemicals may splash onto the unit;
- where static electricity is easily generated.

Precautions for Use

■ Use and handling of the product

● Use this product only by connecting to instruments which support this product.

Do not use this product for instruments which does not support this product.
For measuring instruments supported by this product, contact the agent where you purchased the product or a Mitutoyo sales office.

● This product is for industrial usage.

Do not use this product for purposes other than for industrial usage.

● The product is a precision instrument.

- Do not subject the product to drastic shocks such as dropping it, or exert excessive force upon it.
- Do not disassemble or modify the product.

If the product is used beyond the conditions indicated in the specifications (📖 "14 Specifications" on page 1001), be aware that the functions and performance cannot be guaranteed.

■ Environment for placement

For usage environment explanations, see 📖 "■Environment and Lighting" on page 11.

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This product complies with the EMC Directive and the UK Electromagnetic Compatibility Regulations; however, if this receives electromagnetic interference that exceeds these requirements, it will be out of warranty and require appropriate measures.

This product is an industrial product, and is not intended to be used in residential environment. If this product is used in residential environment, this product may cause electromagnetic interference with other instruments. In such a case, it is required to take appropriate measures for preventing such electromagnetic interference.

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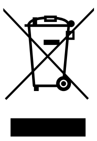
Please follow the official instruction in each community and country.

Disposal of Old Electrical & Electronic Equipment (Applicable in the European Countries with Separate Collection Systems)



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This product has been manufactured under strict quality management, but should it develop problems within one year of the date of purchase in normal use, repair shall be performed free of charge. Please contact the agent where you purchased the product or Mitutoyo sales representative (📖 "SERVICE NETWORK" on page App-1). This warranty, however, shall not affect any provisions of the Mitutoyo Software End User License Agreement.

If this product fails or is damaged for any of the following reasons, it will be subject to a repair charge, even if it is still under warranty.

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- Failure or damage owing to inappropriate handling, maintenance or repair, or to unauthorized modification
- Failure or damage owing to transport, dropping, or relocation of the product after purchase
- Failure or damage owing to fire, salt, gas, abnormal voltage, lightning surge, or natural disaster
- Failure or damage owing to use in combination with hardware or software other than those designated or permitted by Mitutoyo
- Failure or damage owing to use in ultra-hazardous activities

This warranty is effective only where the product is properly installed and operated in conformance with the instructions in this document within the original country of the installation.

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1 Overview

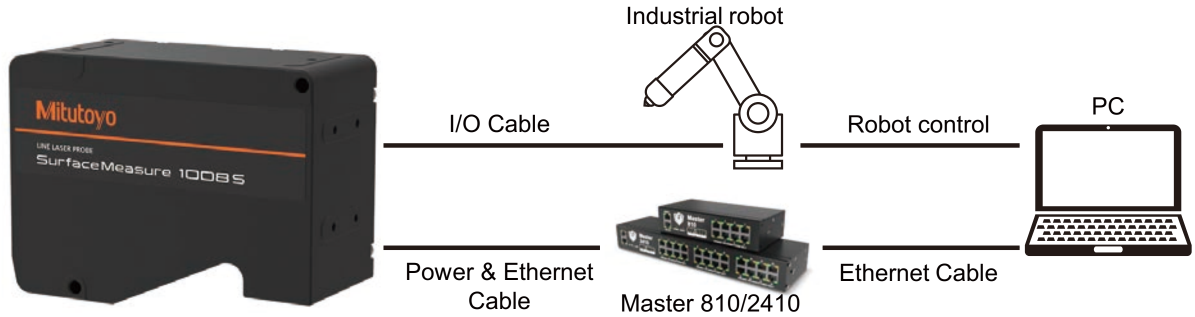
The Line Laser Sensor SurfaceMeasure1008S is a laser sensor system that uses a line laser to enable non-contact form measurement. The Line Laser Sensor SurfaceMeasure1008S (hereinafter referred to as the sensor, or SM1008S) is mounted onto various transport devices and industrial robots for use.
The mounted sensor irradiates the target to be measured with a laser beam, detects the reflected light, and measures the form of the targets in a non-contact manner.

The product has the following features.

- Enables high-precision non-contact form measuring.
- Enables data acquisition in various applications, and can be used as a simple measuring tool. Application examples: total inspections, 3D data acquisition applications
- Enables measuring via high environmental resistance (IP67) even in poor environmental conditions.
- Enables various kinds of measuring, and GO/NG judgment via the advanced processing functions built into the sensor.
- Enables setups of the sensor using Internet browsers.
- Enables data check and analysis off line using the supplied emulator.
- Enables supporting various input and output devices using the supplied software development kit (SDK).

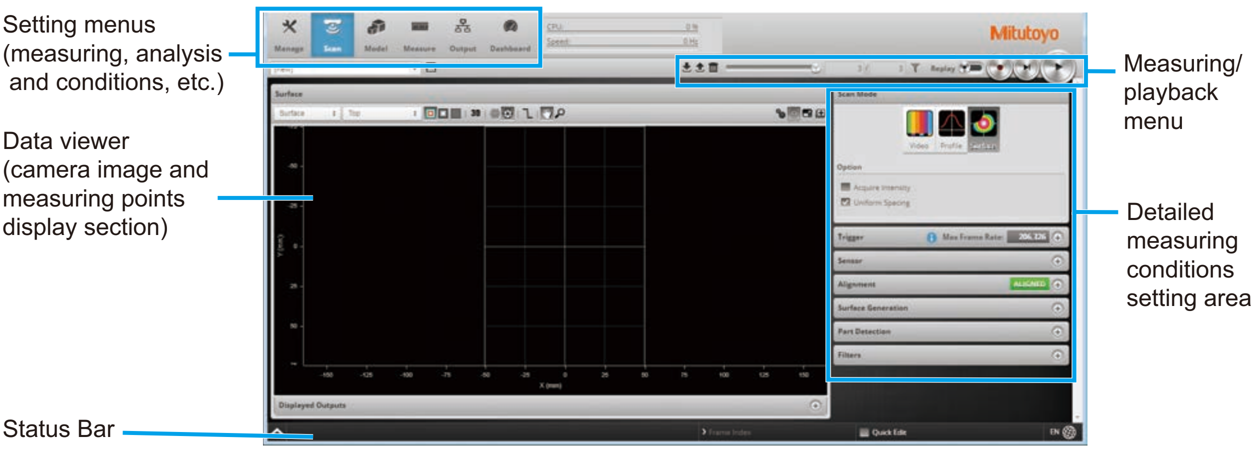
In addition, multiple sensors can be connected to configure a measuring system by using the Master810/2410 network controller.

Example of a system configuration whereby the sensor or body and Master network controller are used.



■ Web interface basic screen

This shows the web interface basic screen used on the PC and the name of each section.



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2 Getting Started

The following sections provide system and hardware overviews, in addition to installation and setup procedures.

2.1 Sensor Part Numbers

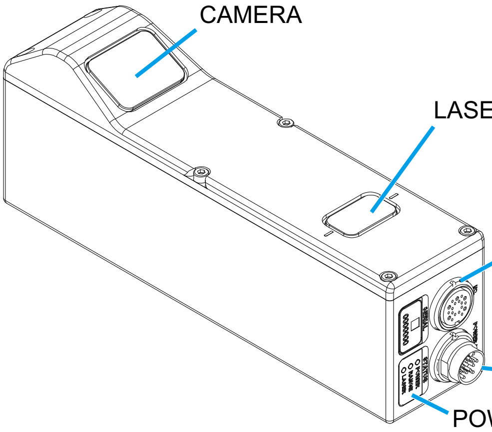
The sensor's code number is as per the following.

SurfaceMeasure1008S: Code number 553-100

2.2 Hardware Overview

The following sections describe SurfaceMeasure1008S and its associated hardware.

2.2.1 SurfaceMeasure1008S



SurfaceMeasure1008S

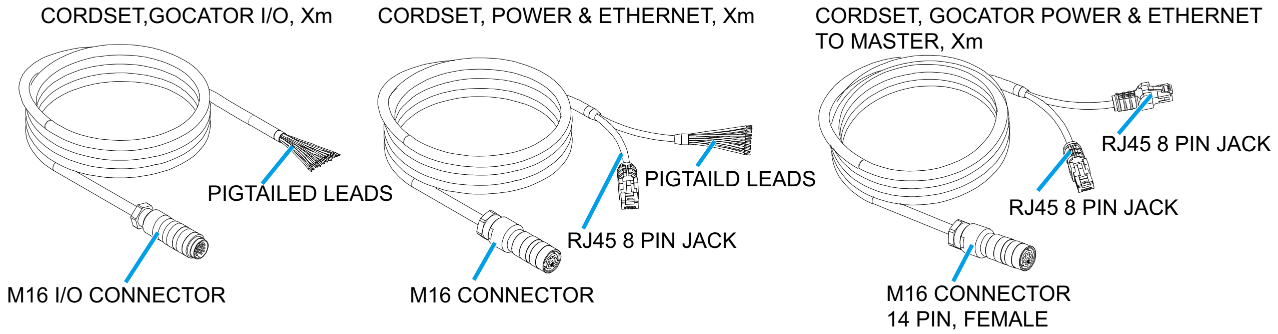
Item	Description
Camera	Observes laser light reflected from target surfaces.
Laser Emitter	Emits structured light for laser profiling.
I/O Connector	Accepts input and output signals.
Power / LAN Connector	Accepts power and laser safety signals and connects to 1000 Mbit/s Ethernet network.
Power Indicator	Illuminates when power is applied (blue).
Range Indicator	Illuminates when camera detects laser light and is within the sensor's measurement range (green).
Laser Indicator	Illuminates when laser safety input is active (amber).

2.2.2 Cordsets

The cordset is used to drive sensors and transfer acquisition data. SurfaceMeasure1008S uses two types of cordsets: the Power & Ethernet cordset and the I/O cordset.

The Power & Ethernet cordset provides power, laser safety interlock to the sensor. It is also used for sensor communication via 1000 Mbit/s Ethernet with a standard RJ45 connector. The Master version of the Power & Ethernet cordset provides direct connection between the sensor and a Master network controller (for more information, see "14.3 Master Network Controllers" on page 1012).

The I/O cordset provides digital I/O connections, an encoder interface, RS-485 serial connection, and an analog output.



The maximum length of the I/O cordset is 60 m.

For details on pinout details, see "14.2.2 SurfaceMeasure1008S I/O Connector" on page 1008, and "14.2.1 SurfaceMeasure1008S Power/LAN Connector" on page 1006.

For details on the cordset lengths and part numbers, see "15 Accessories" on page 1023.

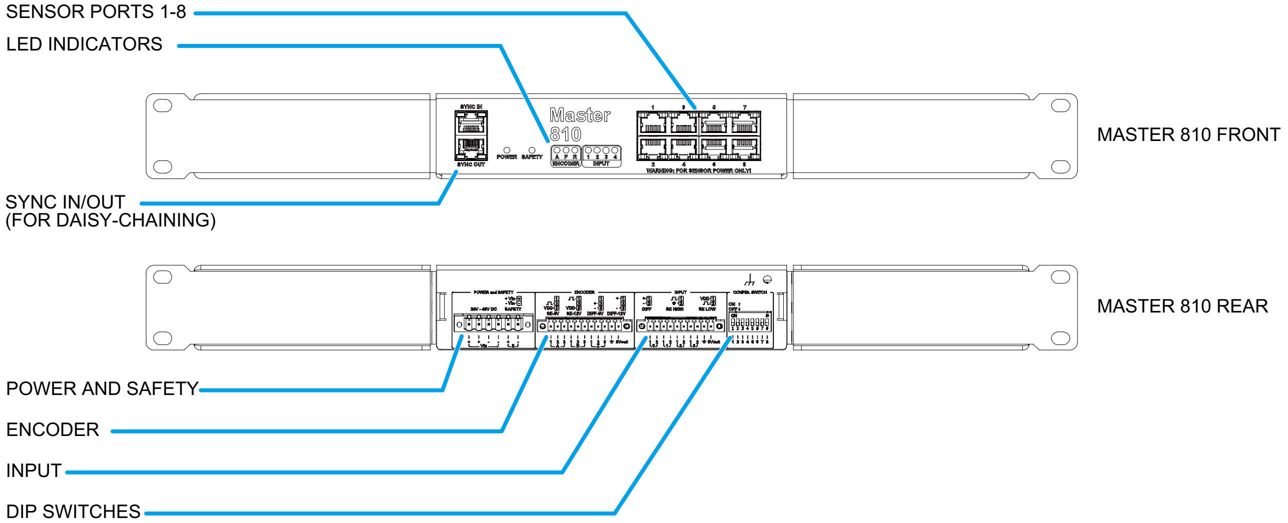
In the event of loss or damage to this document, immediately contact the agent where you purchased the product or a Mitutoyo sales office.

2.2.3 Master 810 / 2410

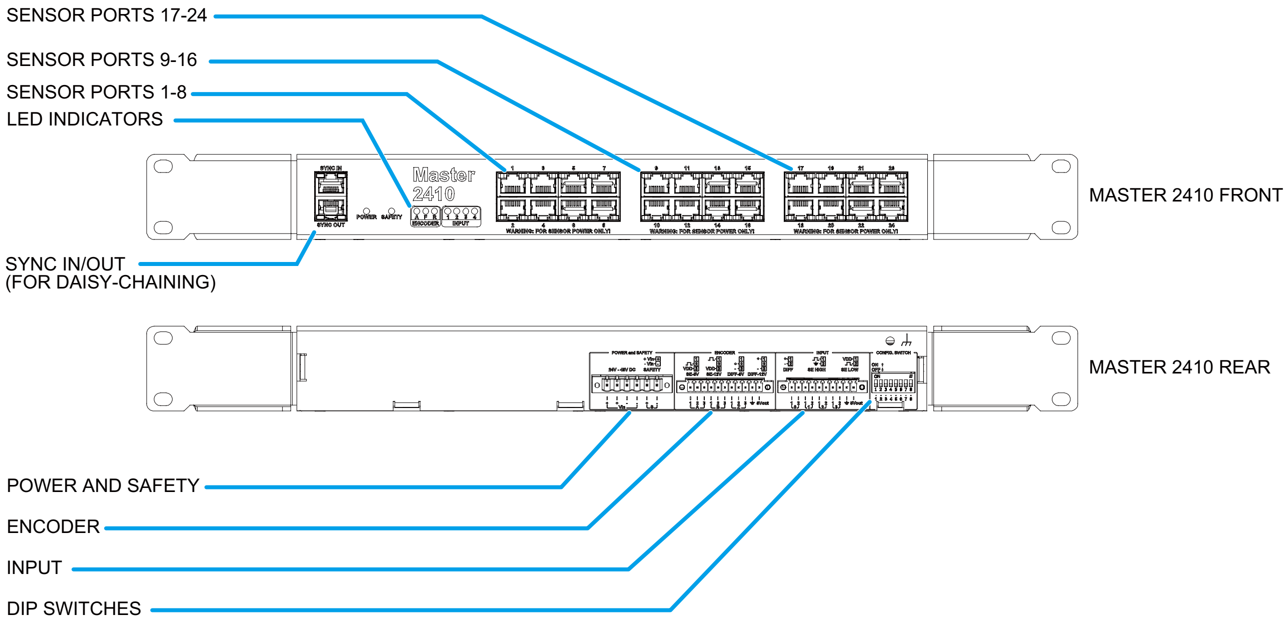
If using a Master 810/2410 network controller, you can connect multiple sensors to configure a multi-sensor system.

- Master 810 accepts up to eight sensors.
- Master 2410 accepts up to twenty-four sensors.

Both models allow you to split the orthogonal frequency of the connected encoder and set the frequency to be compatible with the master. You can also set the debounce time to accommodate faster encoders. For more information, see 📖 "2.4.6 Configuring Master 810" on page 40.



Master 810



Master 2410

Item	Description
Sensor Ports	Master connection for sensors (no specific order required).
Power and Safety	Power and safety connections. Safety input must be high in order to scan with laser-based sensors.
Encoder	Accepts encoder signal.
Input	Accepts digital input.
DIP Switches	Configures the Master (for example, allowing the device to work with faster encoders). For information on configuring Master 810 and 2410 using the DIP switches, see "2.4.6 Configuring Master 810" on page 40.
LED Indicators	For more information, see "14.3.1 Master 810/2410" on page 1012.

For pinout details, see "14.3.1 Master 810/2410" on page 1012.

2.2.4 Alignment Target

The alignment target is used to align the mounting errors during sensor installation and to calibrate the transport system.

An alignment target can be a disk, an alignment bar, or a polygon.

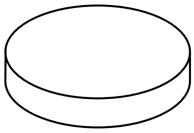
Tips

This section describes the types of alignment targets used when setting up the sensor system. For more information, see the appropriate references below.

- Disc alignment targets

Disks are typically used in systems with a single sensor. Note that the disk alignment targets that come with the standard are typically used on demonstration systems because their alignment accuracy is not sufficient. When selecting a disk for your system, select the largest disk that completely fits the required measurement width. See "15 Accessories" on page 1023 for the disk part number to use.

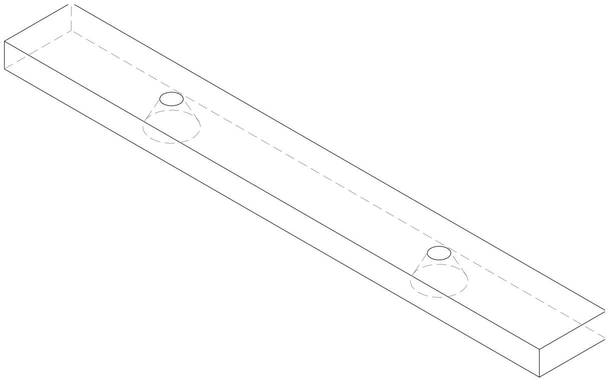
Calibration Disk



- Alignment bar

Use alignment bars to align dual-sensor or multi-sensor systems with side-by-side sensors, or single-sensor systems that require high accuracy (with Z-rotation).

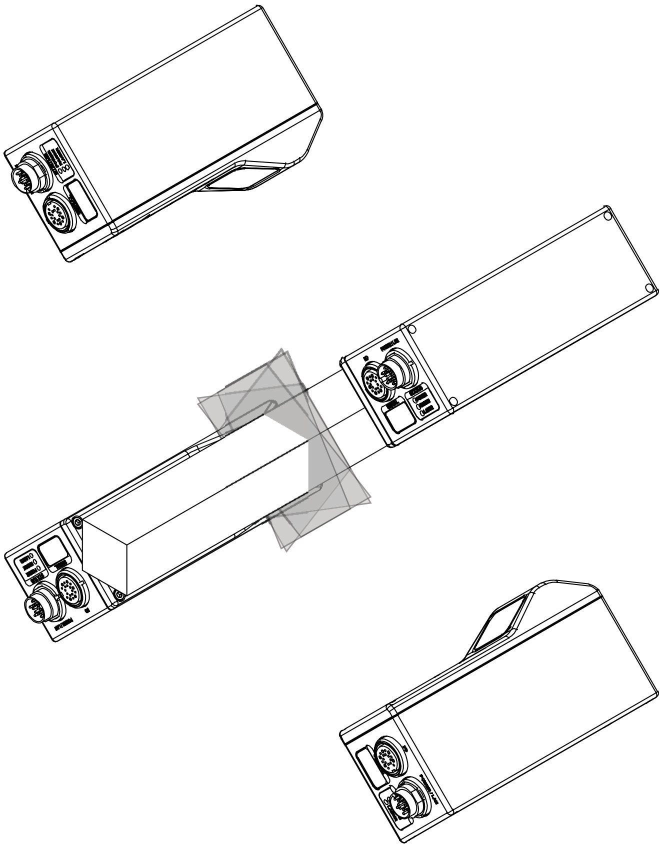
Provide an appropriate alignment bar for your environment. For the bar structure requirements, see "4.5.3 Aligning Sensors with up to 5 Degrees of Freedom" on page 175.



- Polygonal shaped alignment targets

  For multi-sensor systems in a ring layout, where a lower degree of accuracy is acceptable, or X angle correction is not required, use a polygonal shaped alignment target.

  The number of corners in the target should correspond with the number of sensors in the system. Sensors should be positioned so that each sensor can scan a corner and surrounding surface. For the polygonal shaped alignment target structure requirements, see 📖 "4.5.3 Aligning Sensors with up to 5 Degrees of Freedom" on page 175.



- Miscellaneous alignment targets

  Finally, you can perform a high-accuracy alignment of ring (360-degree or partial) and wide layouts using special alignment targets and built-in measurement tools. For more information on this type of alignment, see 📖 "4.5.4 Aligning Sensors to 6 Degrees of Freedom" on page 195.

  For more general information on the alignment process, including how to choose the alignment type for your sensor system, see 📖 "4.5 Aligning Sensors" on page 171.

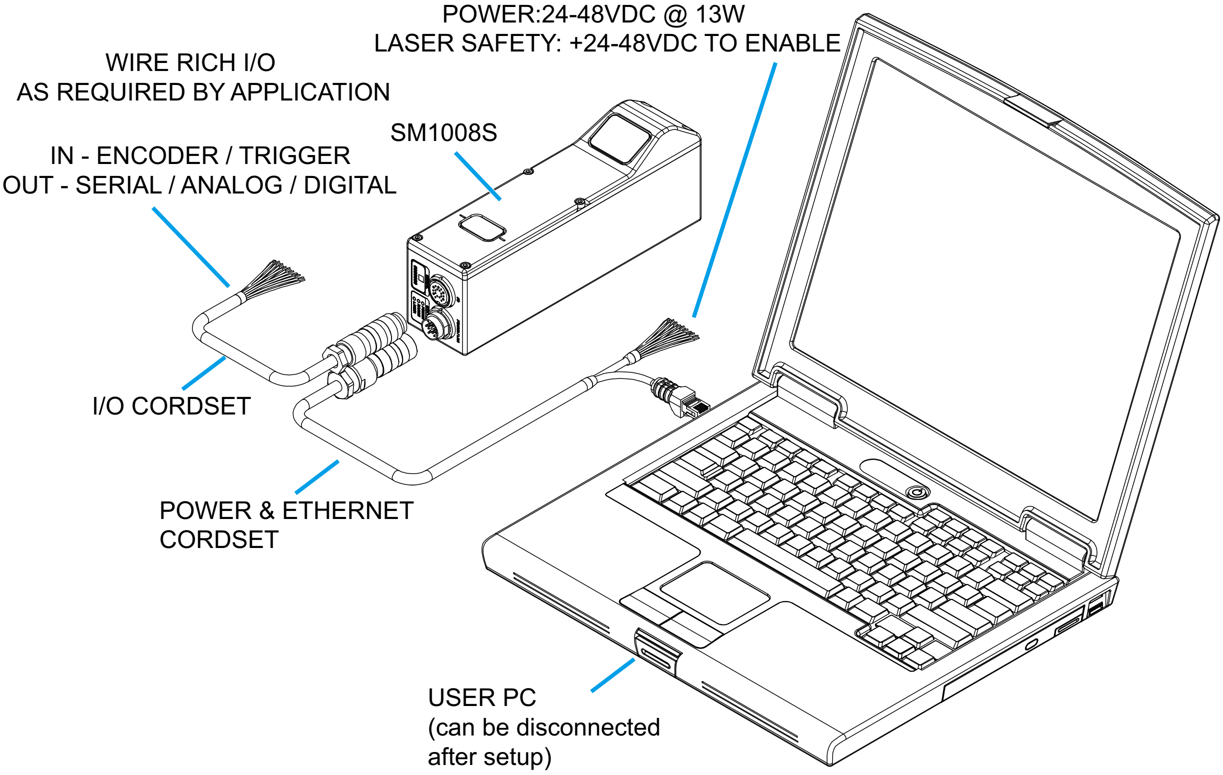
2.3 System Overview

The SurfaceMeasure1008S can be configured into systems according to the various measuring environments (situations). Sensors can be connected in the forms of standalone devices, dual-sensor systems, or multi-sensor systems.

2.3.1 Standalone System

Standalone systems are typically used when only a single sensor is required.

The device can be connected to a computer's Ethernet port for setup and can also be connected to devices such as encoders, photocells, or PLCs.

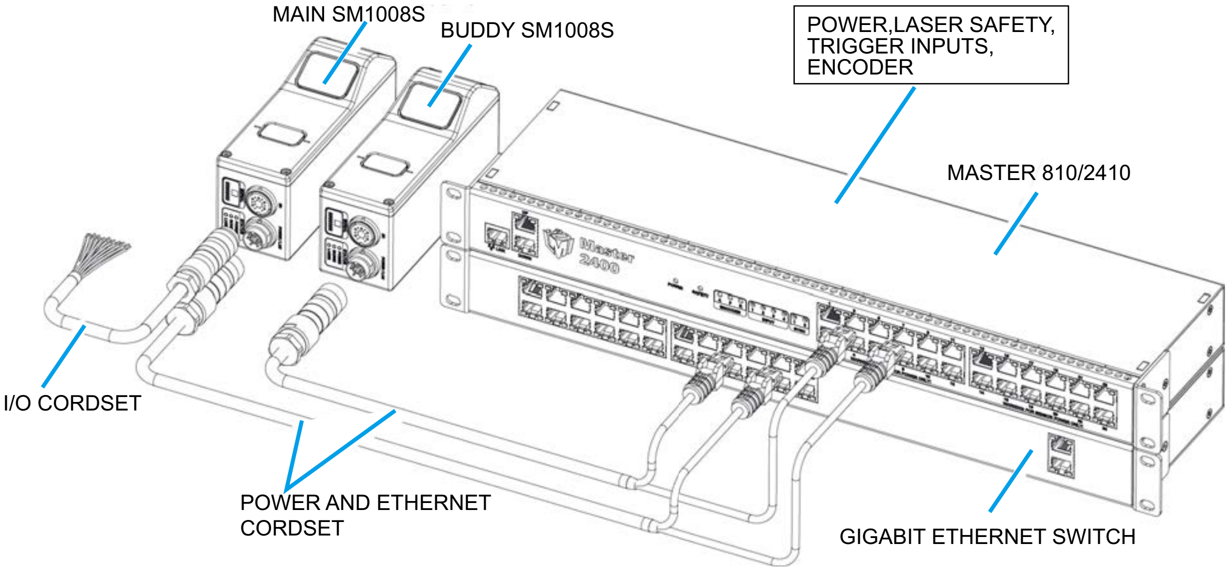


2.3.2 Dual-Sensor System

In a dual-sensor system, the two sensors work in tandem to acquire measuring data, and the combined results are output.

The main sensor is called the Control sensor, and the other sensor is called the Buddy sensor. The sensors' software recognizes three installation orientations: Opposite, Wide, and Reverse.

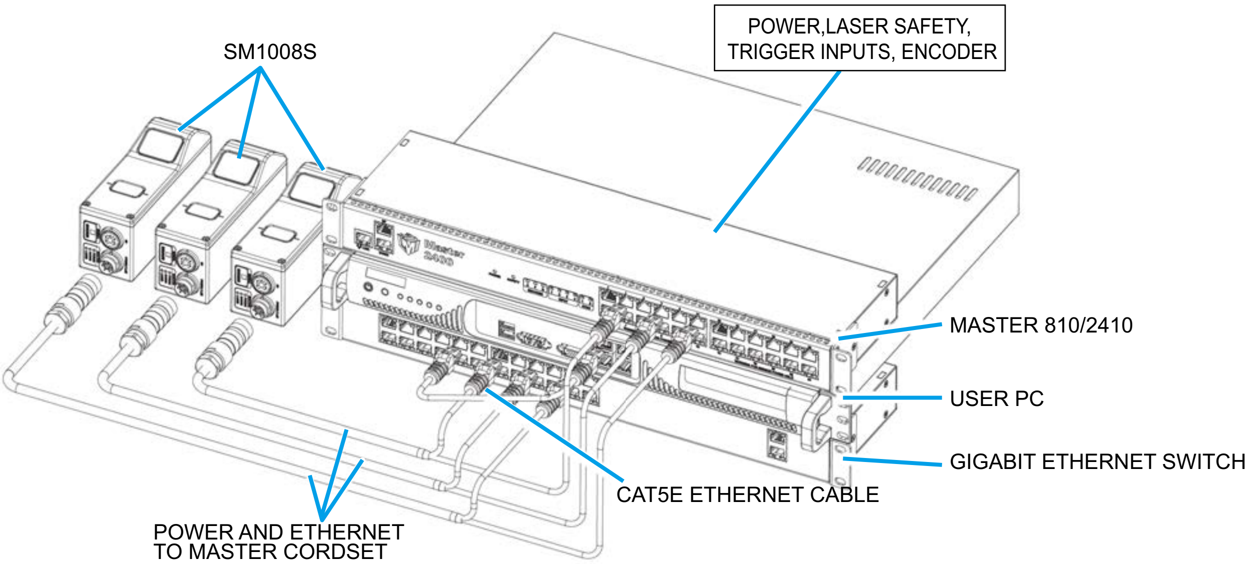
A Master network controller (excluding Master 100) must be used to connect two sensors in a dual-sensor system. Power and Ethernet to Master cordsets are used to connect sensors to the Master.



2.3.3 Multi-Sensor System

When connecting two or more sensors to a multi-sensor system, use the Master network controller as shown below. The Master code set is used to connect the sensor to the Master. The Master provides a single point of connection for power, safety, encoder, and digital inputs. With the Master810/2410 network controller that is used when connecting multiple units, the scan timing can be precisely synchronized across sensors. Sensors and client computers communicate via an Ethernet switch (1 Gigabit/s recommended).

Master networking hardware does not support digital, serial, or analog output.



2.4 Installation

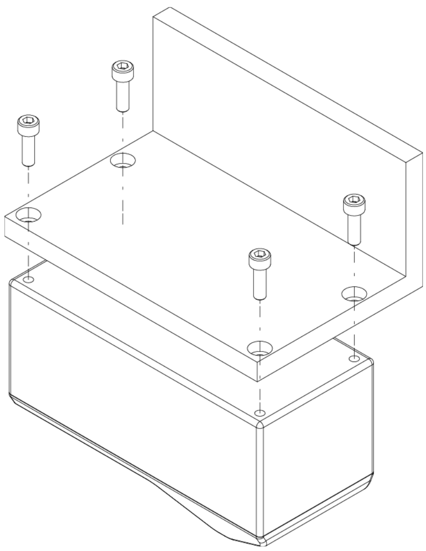
The following sections provide grounding, mounting, and orientation information.

2.4.1 Mounting

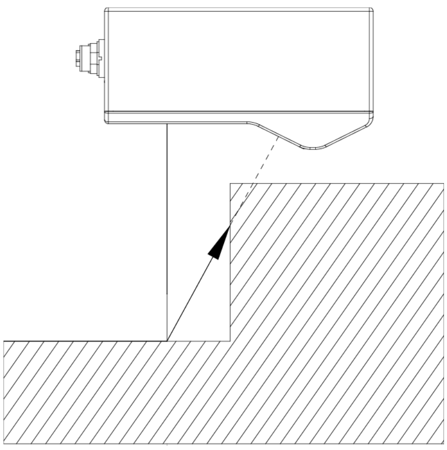
Sensors should be mounted using a model-dependent number of screws. Some models also provide the option to mount using bolts in through-body holes. Refer to the dimension drawings of the sensors in 📖 "14 Specifications" on page 1001 for the appropriate screw diameter, pitch, and length, and bolt hole diameter.

NOTICE

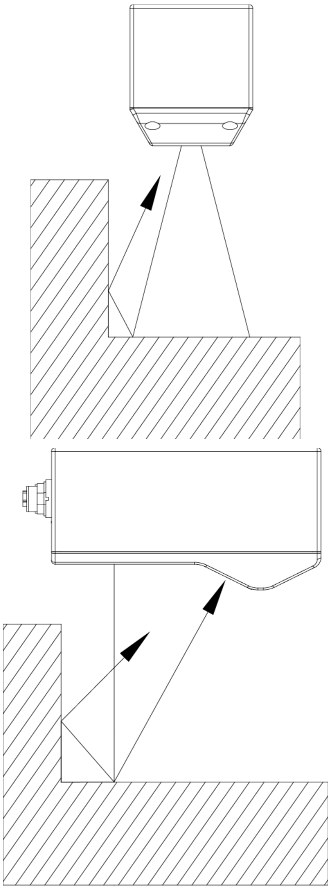
Proper care should be taken in order to ensure that the internal threads are not damaged from cross-threading or improper insertion of screws.



Sensors should not be installed near objects that might occlude a camera's view of the projected light.



Do not place the sensor near objects that can cause unexpected laser reflections.



IMPORTANT

The sensor must dissipate heat through the frame. If the heat dissipation is obstructed, that might cause malfunctions. If the sensor is properly dissipated, the difference between the ambient temperature and the temperature reported by the sensor health diagnostic channel will be less than 15 °C.

IMPORTANT

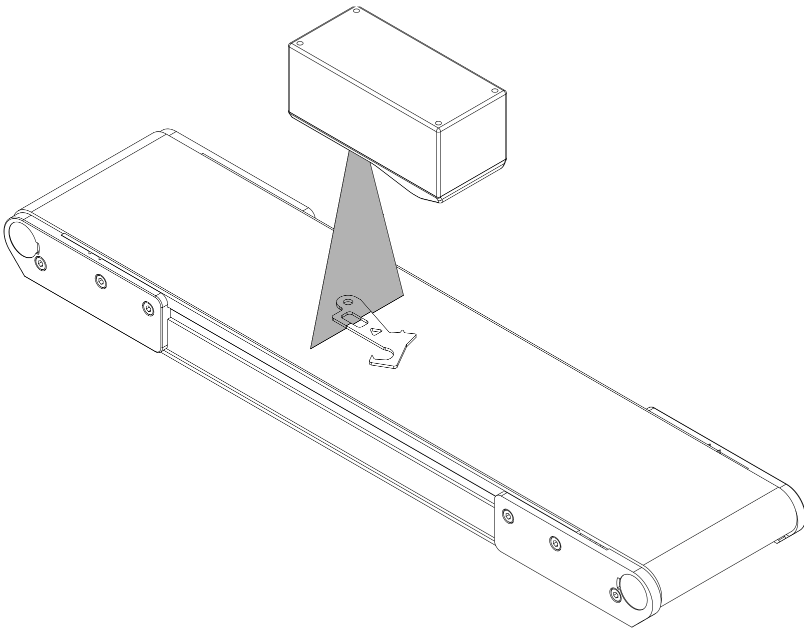
The SurfaceMeasure 1008 S sensor is a precision device. The temperature of all of its components must be in equilibrium. After powering on the sensor, it should take at least an hour to warm up before the temperature inside the sensor stabilizes.

2.4.2 Orientations and Layouts

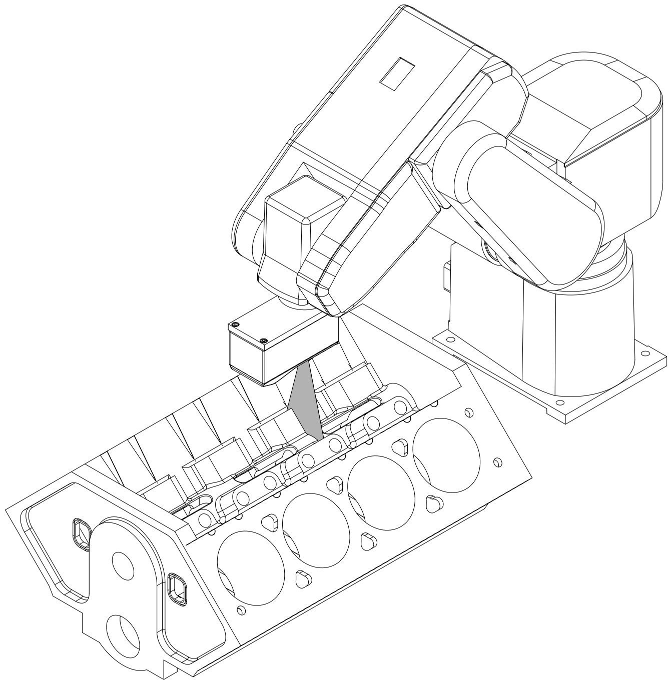
The examples below illustrate some of the possible mounting orientations and layouts for single-sensor, dual-sensor, and multi-sensor systems. The choice of orientation will depend on your application. For more information on orientations and setting them up using the SurfaceMeasure1008S interface, see 📖 "4.3.3 Layout" on page 96.

Typically, you will perform an alignment procedure with sensors using either the flat surface of the conveyor or an alignment target (for an introduction to alignment targets, see 📖 "2.2.4 Alignment Target" on page 22). The choice of alignment target and whether it moves when you perform the alignment depends on the kinds of inaccuracies in sensor mountings. For more information on aligning, see 📖 "4.5 Aligning Sensors" on page 171.

Standalone Orientations

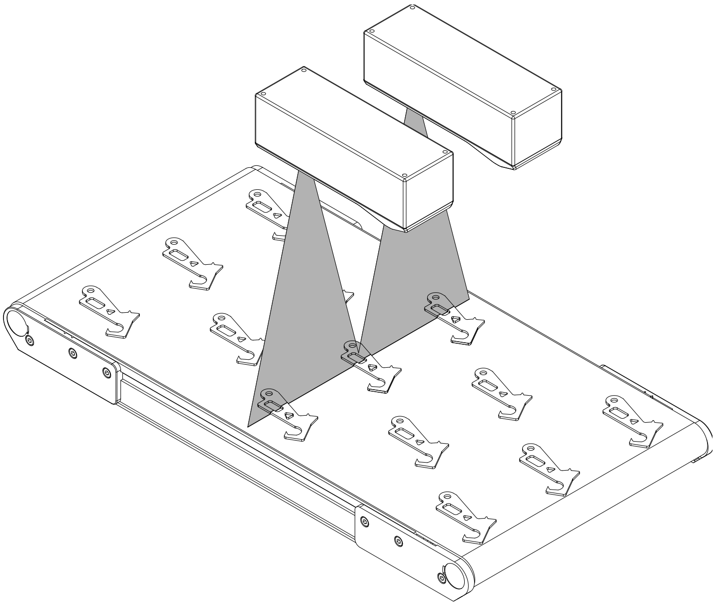


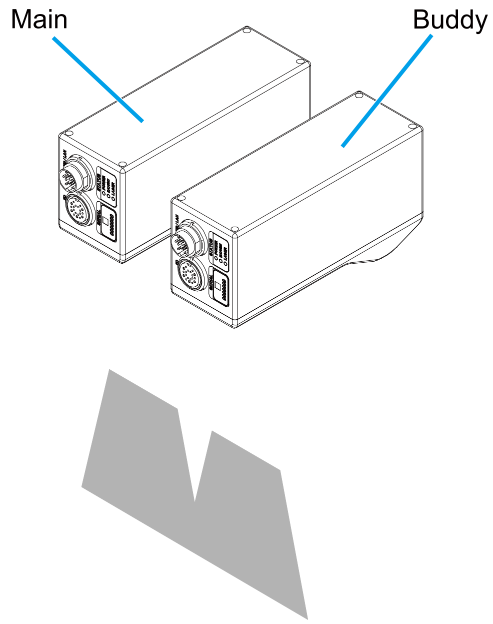
Single sensor above conveyor

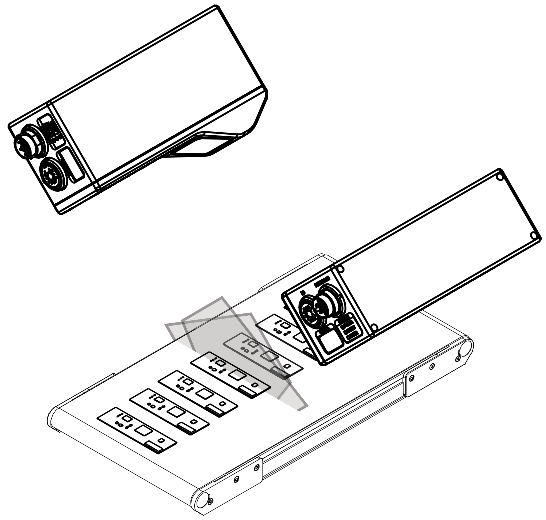


Single sensor on robot arm

Dual-Sensor System Orientations:



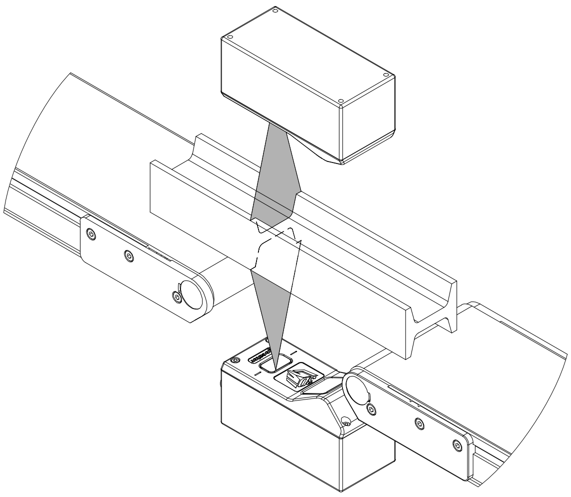


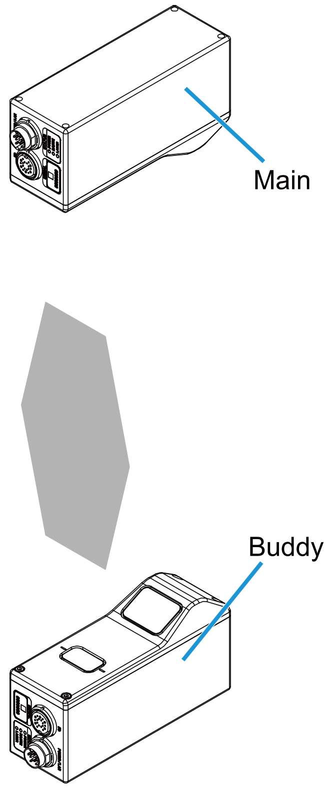


Side-by-side for wide-area measurement (Wide). Sensors can also be angled toward each other, around the Y axis.

Sensors can also be mounted with space between their laser lines to scan the width of a large web of material such as metal or rubber.

The left sensor (when looking into the positive Y direction) must be defined as Main; for more information, see 📖 "●Buddy Assignment" on page 93 For information on the positive Y of your sensor, see the sensor's coordinate system orientation in 📖 "14.1 Sensors" on page 1001. (A rule of thumb is that Y increases from the camera to the laser emitter.)



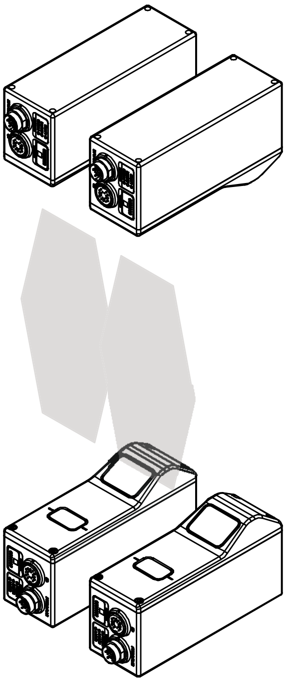


Above/below for two-sided measurement (Opposite)

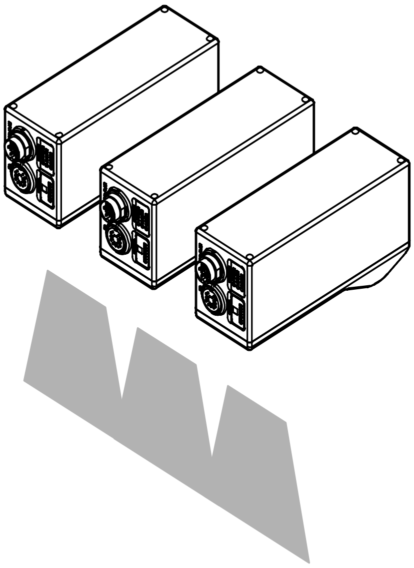
The top sensor must be defined as Main; for more information, see 📖 "●Buddy Assignment" on page 93.

A multi-sensor system is defined as containing three or more sensors.

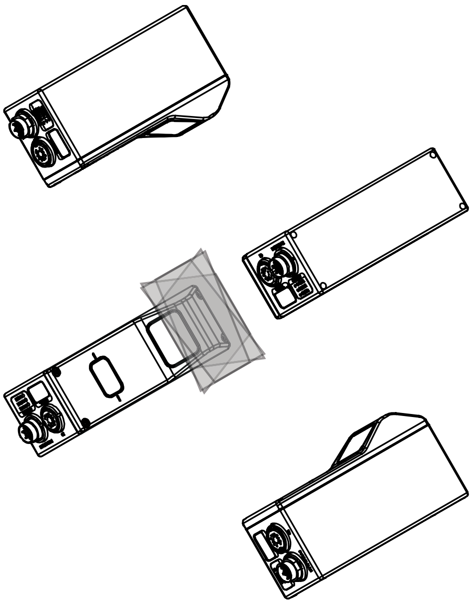
Multi-Sensor System Orientations:



Side-by-side top-bottom (and wide) measurement



Side-by-side for wide-area measurement

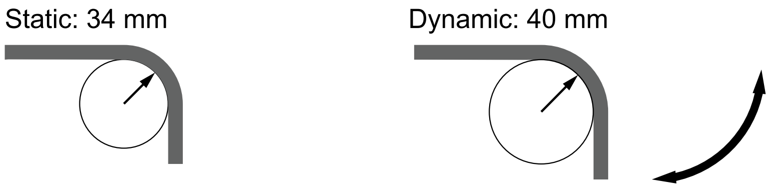


Ring layout for 360-degree scans

2.4.3 Cordset Bend Radius Limits

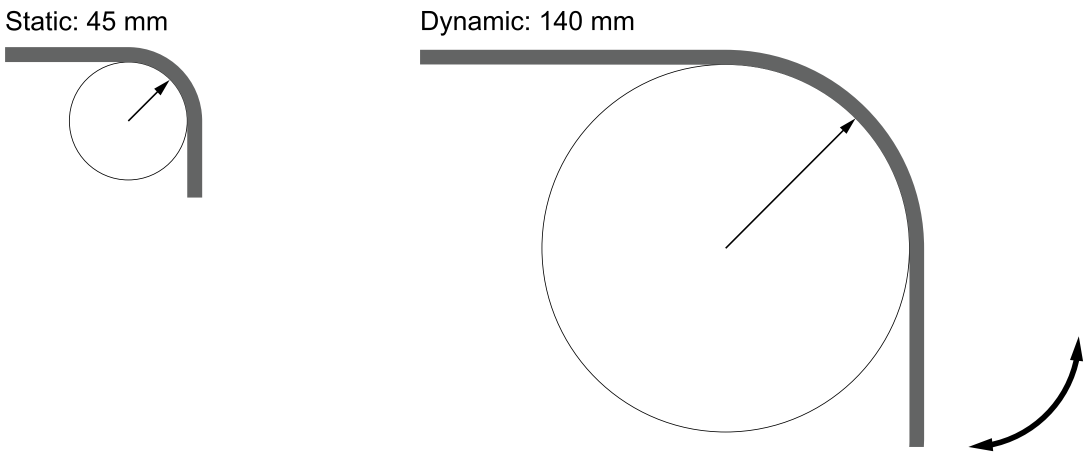
With high flex cordsets of lengths 25 meters and lower, limit bends as follows:

- In installations where a cordset does not bend continuously, limit bending to the static bend radius of 34 mm.
- In installations where a cordset bends continuously, limit bending to the dynamic bend radius of 40 mm.



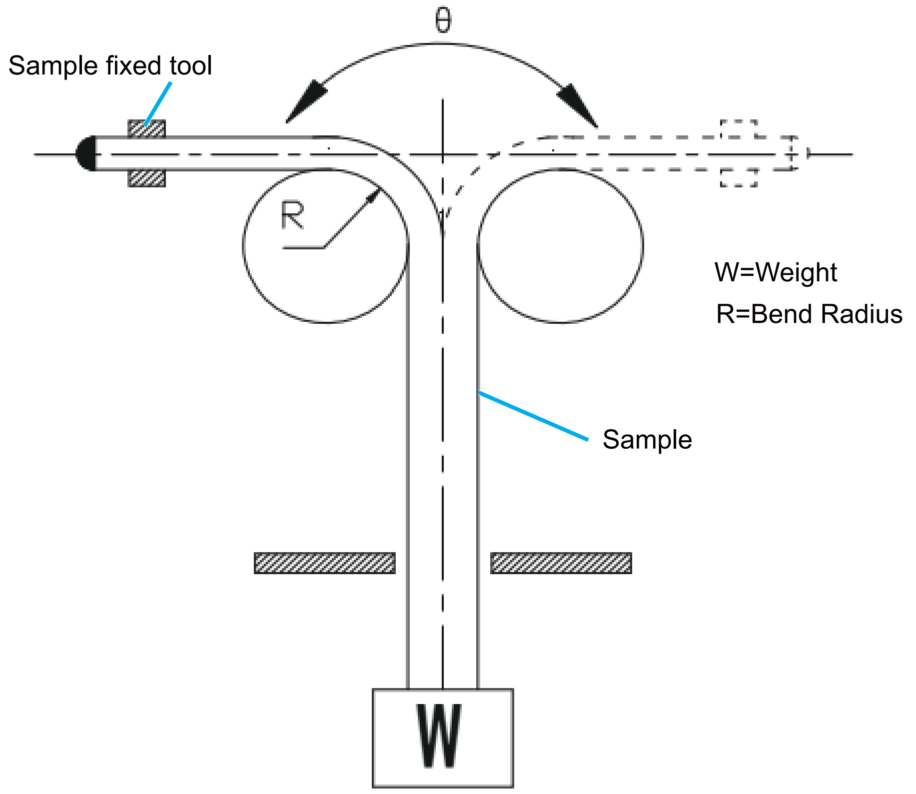
High flex cordset bend radius limits

Custom cordsets between 25 and 60 meters (the maximum length available) have a static bend radius limit of 45 mm and a dynamic limit of 140 mm.

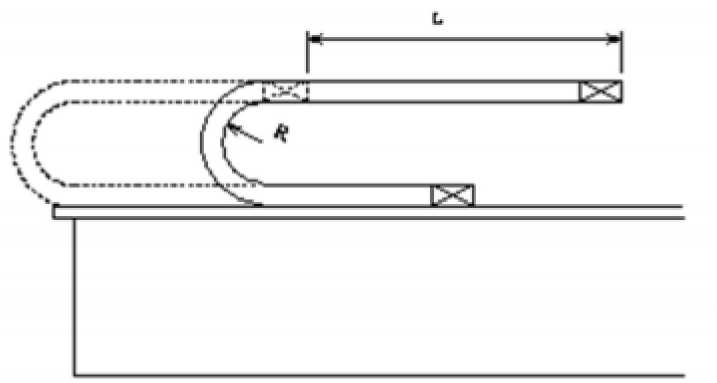


Standard cordset bend radius limits

High flex cordsets are rated for a minimum of 2 million 90° Tick Tock bends and 7 million U-shaped bends, both at the dynamic bend radius limit of 40 mm. The following illustrations show the test setups used to determine the number of bends in high flex cordsets.



Tick-tock test setup (θ = 180°)



U-shape test setup (L = 500 mm).

For cordset part numbers, see 📖 "15 Accessories" on page 1023.

For more information on cordsets, see 📖 "2.2.2 Cordsets" on page 19 on page 42.

2.4.4 Grounding

⚠ WARNING

	Make sure that the sensor system components are properly grounded. There is a risk of electric shock.

■ SurfaceMeasure1008S

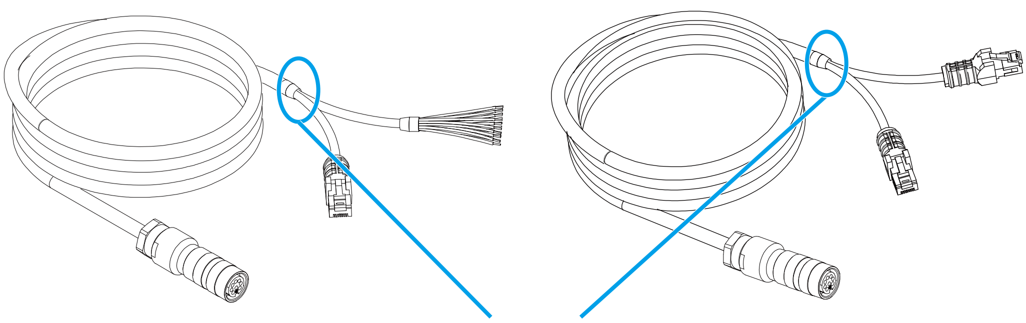
SurfaceMeasure1008S sensors should be grounded to the earth/chassis through their housings and through the grounding shield of the Power I/O cordset. Sensors have been designed to provide adequate grounding through their mounting screws. Always check grounding with a multi-meter to ensure electrical continuity between the mounting frame and the sensor's connectors.

Tips
The frame that the sensor is mounted to must be connected to earth ground.

■ Recommended practices for cordsets

If you need to minimize interference with other equipment, you can ground the Power & Ethernet or the Power & Ethernet to Master cordset by terminating the shield of the cordset before the split. The most effective grounding method is to use a 360-degree clamp.

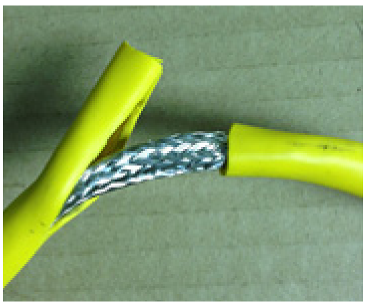
CORDSET, POWER & ETHERNET, Xm   CORDSET, GOCATOR POWER & ETHERNET TO MASTER, Xm



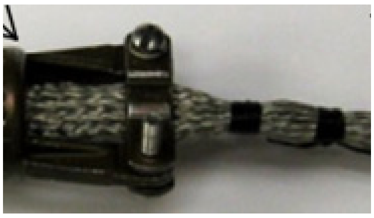
Attach the 360-degree clamp before the split

To terminate the cordset's shield:

1. **Expose the cordset's braided shield by cutting the plastic jacket before the point where the cordset splits.**



2 Install a 360-degree ground clamp.



■ Master network controller

The rack mount brackets provided with all Masters are designed to provide adequate grounding through the use of star washers. Always check grounding with a multi-meter by ensuring electrical continuity between the mounting frame and RJ45 connectors on the front.

⚠ WARNING

Confirm the grounding. There is a risk of electrical shocks.

When using the rack mount brackets, you must connect the frame or electrical cabinet to which the Master is mounted to earth ground.

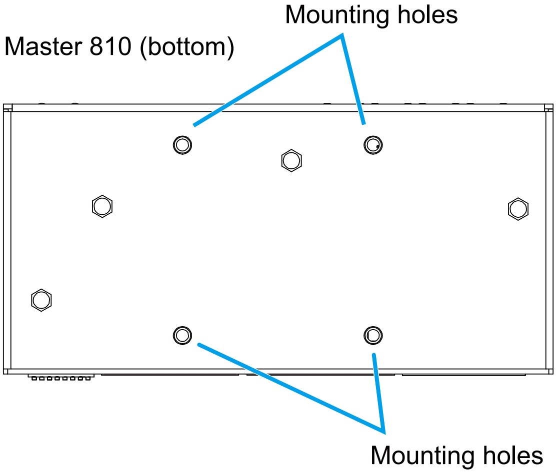
You must check electrical continuity between the mounting frame and RJ45 connectors on the front using a multi-meter.

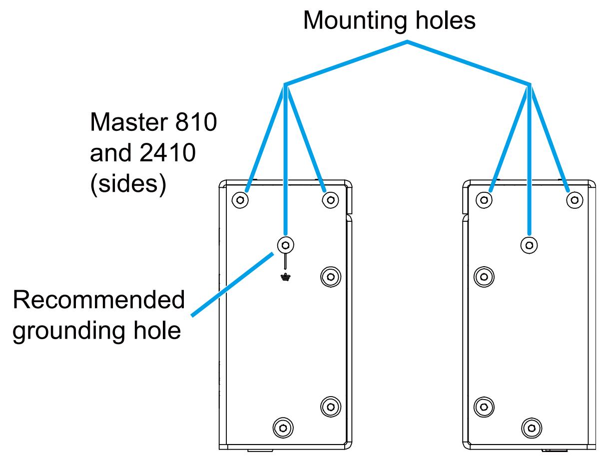
If you are mounting Master 810 or 2410 using the provided DIN rail mount adapters, you must ground the Master directly; for more information, see "●Grounding When Using a DIN Rail (Master 810/2410)" on page 37.

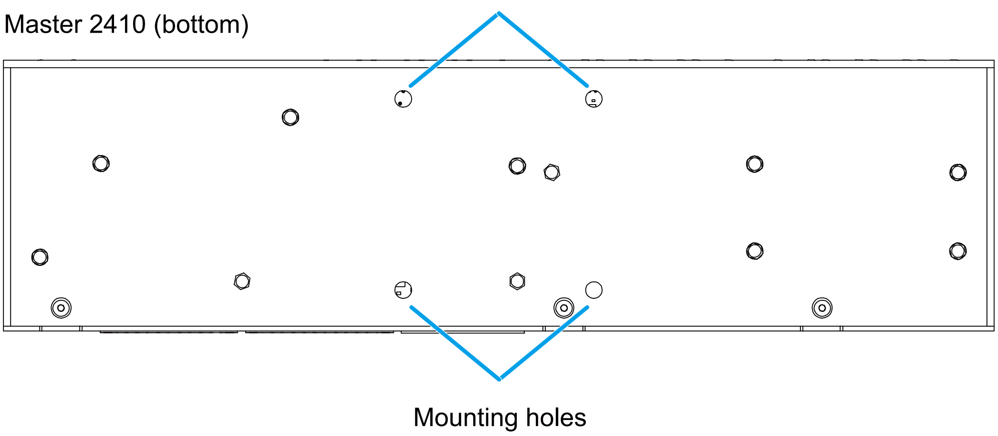
- Grounding When Using a DIN Rail (Master 810/2410)

If you are using DIN rail adapters instead of the rack mount brackets, you must ensure that the Master is properly grounded by connecting a ground cable to one of the holes indicated below. The holes on the bottom of the unit accept M4 screws. The holes on the sides of the unit accept M3 screws.

> **Tips**
> You can use any of the holes shown below. However, Mitutoyo recommends using the holes indicated on the housing by a ground symbol.







An additional ground hole is provided on the rear of Master 810 and 2410 network controllers, indicated by a ground symbol.

Additional Grounding Schemes

Potential differences and noise in a system caused by grounding issues can sometimes cause sensors to reset or otherwise behave erratically. If you experience such issues, see the Grounding Guide (https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/) in the Download center for additional grounding schemes.

2.4.5 Installing DIN Rail Clips: Master 810 or 2410

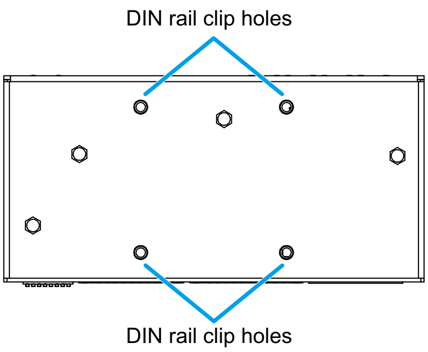
You can mount the Master 810 and 2410 using the included DIN rail mounting clips with M4x8 flat socket cap screws. The following DIN rail clips (DINM12-RC) are included:

To install the DIN rail clips:

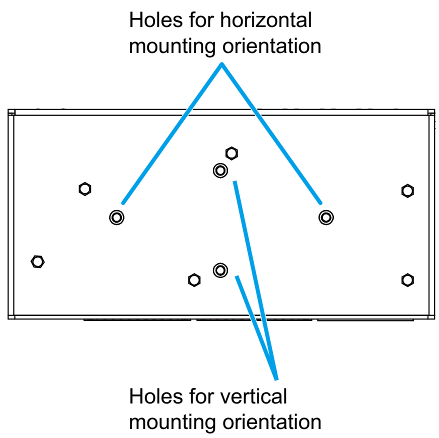
1 **Remove the 1U rack mount brackets.**

2 **Locate the DIN rail mounting holes on the back of the Master (see below).**

Master 810:

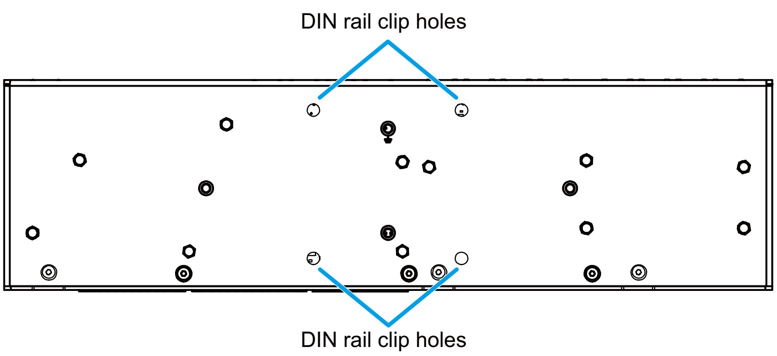


Current revision



Older revision

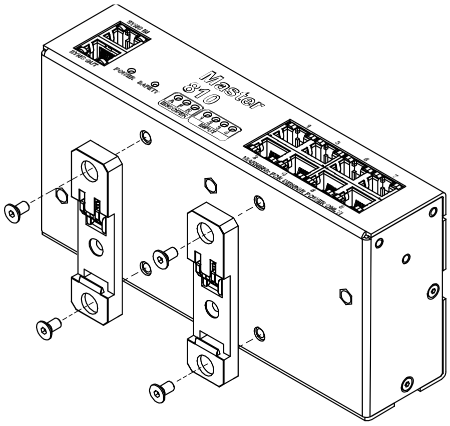
Master 2410:



Current revision

3 **Attach the two DIN rail mount clips to the back of the Master using two M4x8 flat socket cap screws for each one.**

The following illustration shows the installation of clips on a Master 810 for horizontal mounting:



Tips

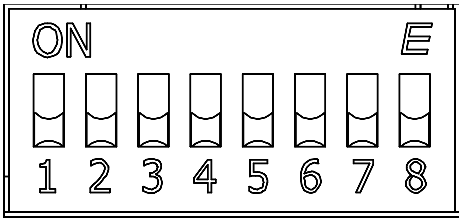
Ensure that there is enough clearance around the Master for cabling.

2.4.6 Configuring Master 810

If you are using Master 810 with an encoder that runs at a quadrature frequency higher than 300 kHz, you must use the device's divider DIP switches to limit the incoming frequency to 300 kHz.

Tips
Master 810 supports up to a maximum incoming encoder quadrature frequency of 6.5 MHz.

The DIP switches are located on the rear of the device.



Tips
Switches 5 to 8 are reserved for future use.

This section describes how to set the DIP switches on Master 810 to do the following:

- Set the divider so that the quadrature frequency of the connected encoder is compatible with the Master.
- Set the debounce period to accommodate faster encoders.

■ Setting the Divider

To set the divider, you use switches 1 to 3. To determine which divider to use, use the following formula:

Output Quadrature Frequency = Input Quadrature Frequency / Divider

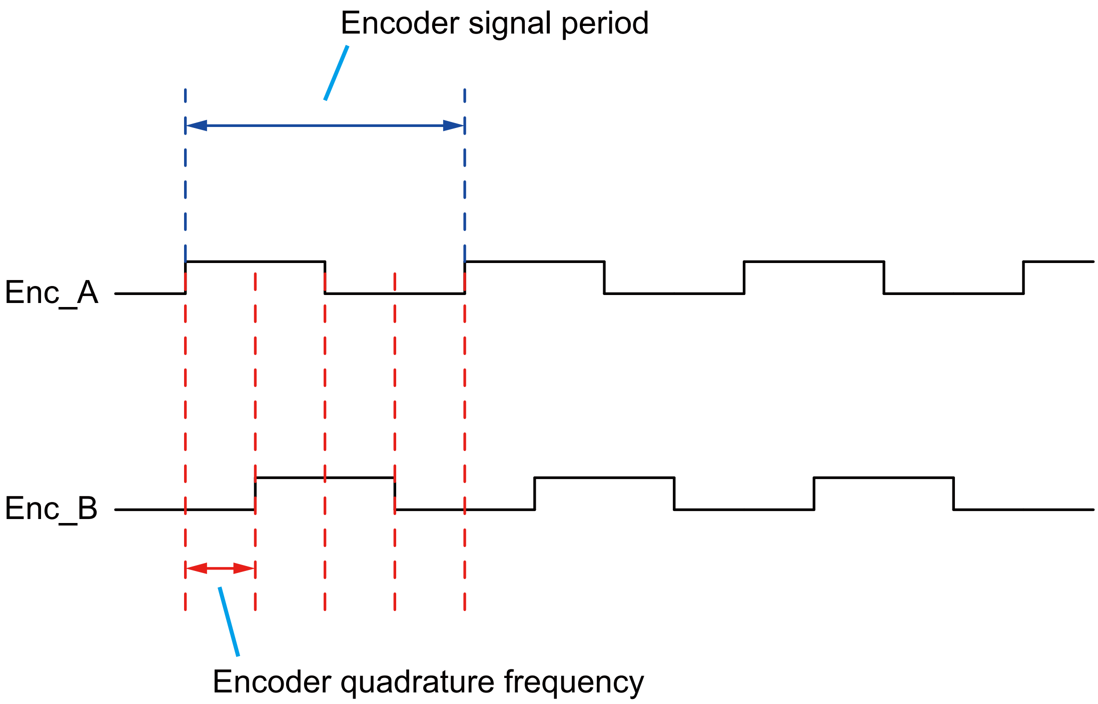
In the formula, use the quadrature frequency of the encoder (for more information, see 📖 "●Encoder Quadrature Frequency" on page 41) and a divider from the following table so that the Output Quadrature Frequency is no more than 300 kHz.

Divider	Switch 1	Switch 2	Switch 3
1	OFF	OFF	OFF
2	ON	OFF	OFF
4	OFF	ON	OFF
8	ON	ON	OFF
16	OFF	OFF	ON
32	ON	OFF	ON
64	OFF	ON	ON
128	ON	ON	ON

Tips
The divider works on debounced encoder signals. For more information, see 📖 "■Setting the Debounce Period" on page 41.

- Encoder Quadrature Frequency

Encoder quadrature frequency is defined as illustrated in the following diagram. It is the frequency of encoder ticks. This may also be referred as the native encoder rate.



You must use a quadrature frequency when determining which divider to use (see 📖 "■Setting the Divider" on page 40). Consult the datasheet of the encoder you are using to determine its quadrature frequency.

Tips
Some encoders may be specified in terms of encoder signal frequency (or period). In this case, convert the signal frequency to quadrature frequency by multiplying the signal frequency by 4.

■ Setting the Debounce Period

If the quadrature frequency of the encoder you are using is greater than 3 MHz, you must set the debounce period to “short.” Otherwise, set the debounce period to “long.”

You use switch 4 to set the debounce period.

Debounce period	Switch 4
short debounce	ON
long debounce	OFF

2.5 Network Setup

The following sections provide procedures for client PC and sensor network setup.

Tips
DHCP is not recommended for sensors. If you choose to use DHCP, the DHCP server should try to preserve IP addresses. Ideally, you should use static IP address assignment (by MAC address) to do this.

Tips
The following sections refer to using the sensor's web interface. For important information on browser compatibility, see 📖 "4.1 Browser Compatibility and Performance" on page 75.

2.5.1 Client Setup

To connect to a sensor from a client PC, you must ensure the client's network card is properly configured.

Sensors are shipped with the following default network configuration:

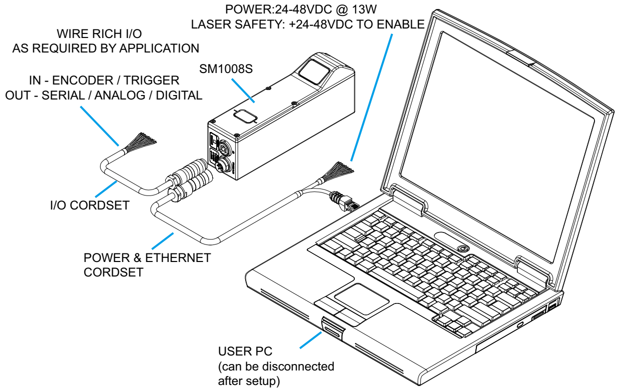
Setting	Default
DHCP	Disabled
IP Address	192.168.1.10
Subnet Mask	255.255.255.0
Gateway	0.0.0.0

Tips
All sensors are configured to 192.168.1.10 as the default IP address. For a dual-sensor system, the Main and Buddy sensors must be assigned unique addresses before they can be used on the same network. Before proceeding, connect the Main and Buddy sensors one at a time (to avoid an address conflict) and use the steps in 📖 "■Running a Dual-Sensor System" on page 46 to assign each sensor a unique address.

To connect to a sensor for the first time:

1 Connect cables and apply power.

Sensor cabling is illustrated in 📖 "2.3 System Overview" on page 24.



2 Change the client PC's network settings.

Windows 7

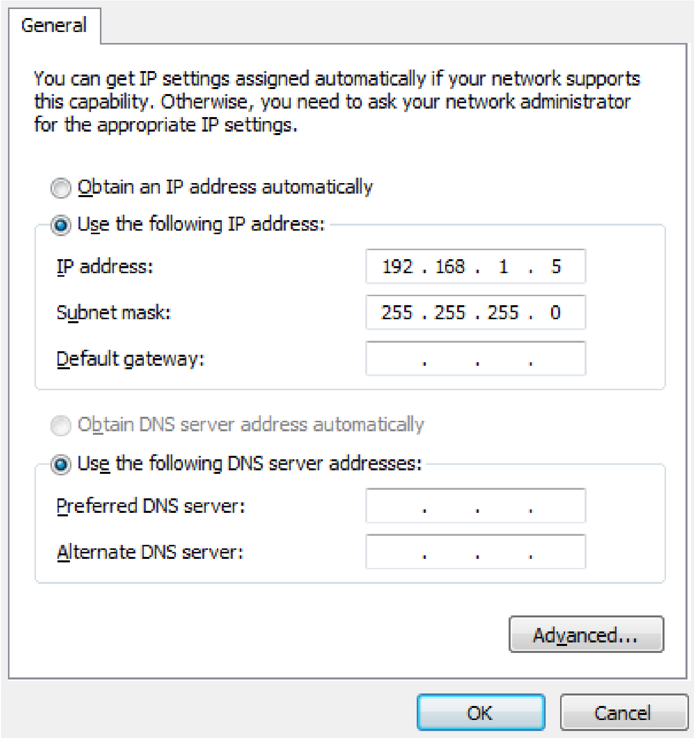
1 Open the Control Panel, select [Network and Sharing Center], and then click [Change Adapter Settings].

2 Right-click the network connection you want to modify, and then click [Properties].

3 On the [Networking] tab, click [Internet Protocol Version 4 (TCP/IPv4)], and then click [Properties].

4 Select the [Use the following IP address] option.

5 Enter IP Address "192.168.1.5" and Subnet Mask "255.255.255.0", then click [OK].

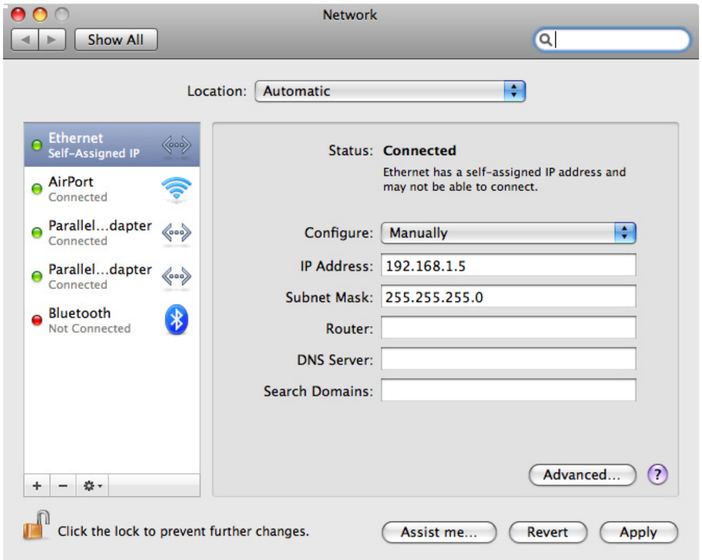


Mac OS X v10.6

1 Open the Network pane in [System Preferences] and select [Ethernet].

2 Set [Configure] to [Manually].

3 Enter IP Address "192.168.1.5" and Subnet Mask "255.255.255.0", then click [Apply].



Tips

See "13 Troubleshooting" on page 999 if you experience any problems while attempting to establish a connection to the sensor.

2.5.2 SurfaceMeasure1008S Setup

The SurfaceMeasure1008S is shipped with a default configuration that will produce 3D data for most targets.

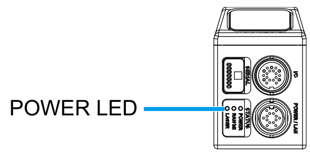
The following describes how to set up a sensor system for operations. After you have completed the setup, you can perform a scan to verify basic sensor operation.

■ Running a Standalone Sensor System

To configure a standalone sensor system:

1 **Power up the sensor.**

» The power indicator (blue) should turn on immediately.

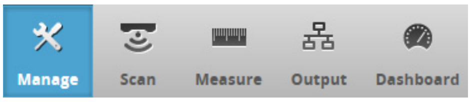


2 **Enter the sensor's IP address (192.168.1.10) in a web browser.**

» The sensor interface loads.

If a password has been set, you will be prompted to provide it and then log in.

3 **Go to the [Manage] page.**

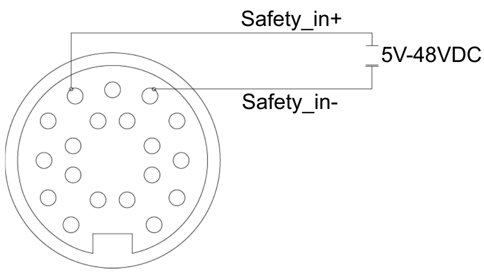


4 **Ensure that Replay mode is off (the slider is set to the left).**

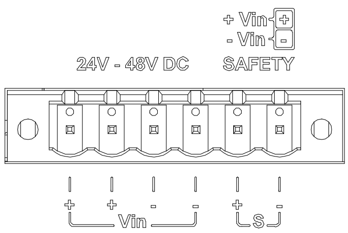
Tips

Replay mode disables measurements.

5 **Ensure that the Laser Safety Switch is enabled or the Laser Safety input is high.**



Standalone



Master 810/2410

6 **Go to the [Scan] page.**

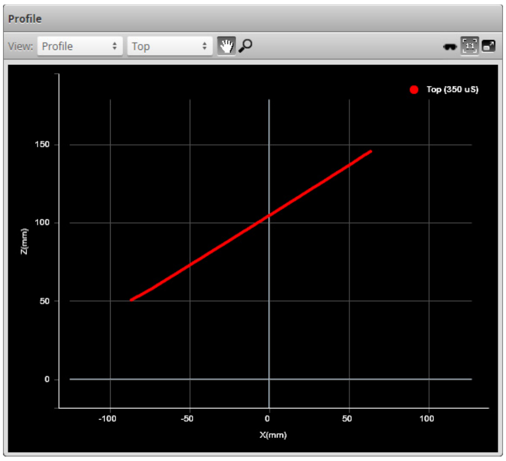
7 **Observe the profile in the data viewer**

8 **Press the [Start] button or the [Snapshot] on the [Toolbar] to start the sensor.**

» The [Start] button is used to run sensors continuously. The [Snapshot] button is used to trigger the capture of a single frame.

9 **Move a target into the sensor's projected light.**

- » If a target object is within the sensor's measurement range, the data viewer will display scan data, and the sensor's range indicator will illuminate.
- » If no scan data is displayed in the data viewer,
  📖 "13 Troubleshooting" on page 999.



10 **Press the [Stop] button.**

» The projected light should turn off.

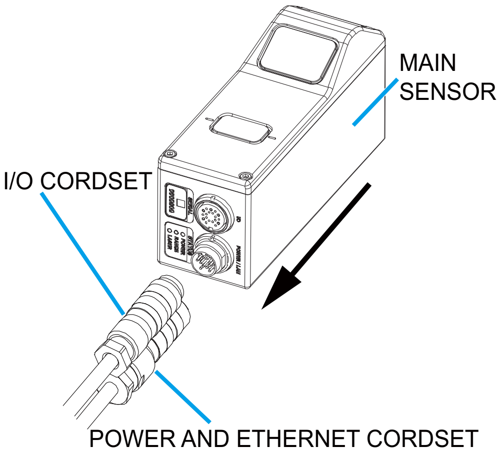
Running a Dual-Sensor System

All sensors are shipped with a default IP address of 192.168.1.10. Ethernet networks require a unique IP address for each device, so you must set up a unique address for each sensor.

To configure a dual-sensor system:

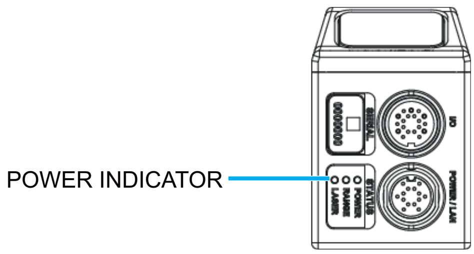
Skip step 1 to 3 if the Buddy sensor's IP address is already set up with an unique address.

1 Turn off the sensors and unplug the Ethernet network connection of the Main sensor.



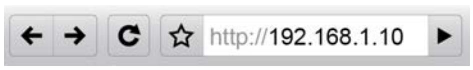
2 Power up the Buddy sensor.

» The power LED (blue) of the Buddy sensor should turn on immediately.

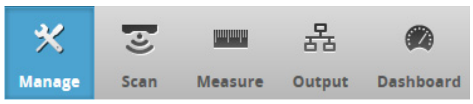


3 Enter the sensor's IP address 192.168.1.10 in a web browser.

» The web interface loads.

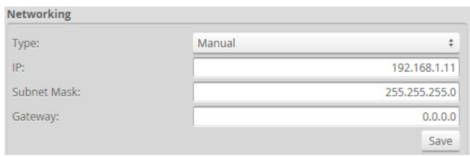


4 Go to the [Manage] Page.

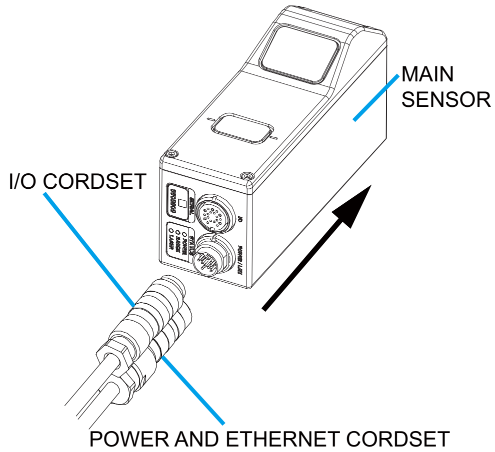


5 Modify the IP address to 192.168.1.11 in the [Networking] category and click the [Save] button.

» When you click the [Save] button, you will be prompted to confirm your selection.



6 **Turn off the sensors, re-connect the Main sensor's Ethernet connection and power-cycle the sensors.**



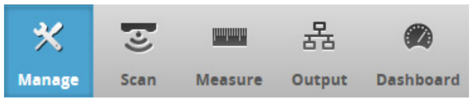
Tips

After changing network configuration, the sensors must be reset or power-cycled before the change will take effect.

7 **Enter the sensor's IP address 192.168.1.10 in a web browser.**

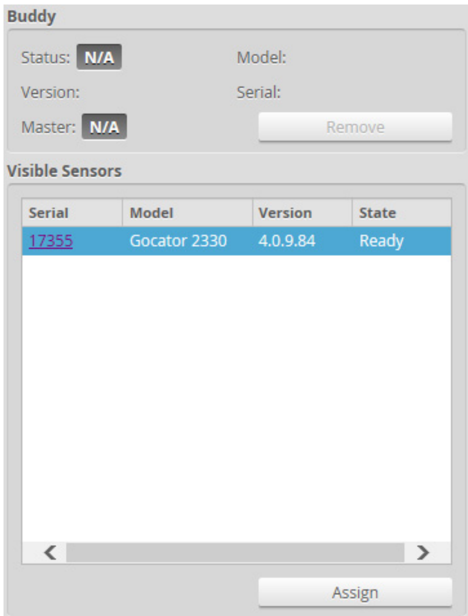
» The web interface loads.

8 **Select the [Manage] page.**



9 **Go to [Manage] page, [Sensor System] panel, and select the [Visible Sensors] panel.**

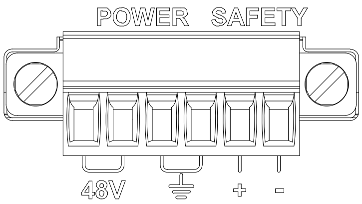
» The serial number of the Buddy sensor is listed in the Available Sensors panel.



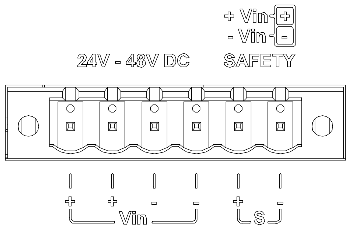
10 **Select the Buddy sensor and click the [Assign] button.**

» The Buddy sensor will be assigned to the Main sensor and its status will be updated in the System panel.

11 **Ensure that the Laser Safety Switch is enabled or the Laser Safety input is high.**



Master 400/800/1200/2400



Master 810/2410

12 **Ensure that [Replay] mode is off (the slider is set to the left).**

13 **Go to the [Scan] page.**

14 **Press the [Start] or the [Snapshot] button on the [Toolbar] to start the sensors.**

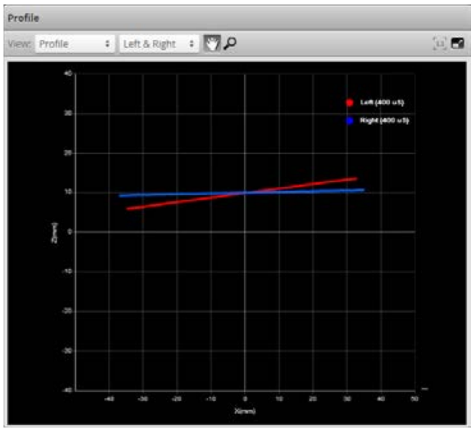
The [Start] button is used to run sensors continuously, while the [Snapshot] button is used to trigger a single profile.

15 **Move a target into the laser plane.**

» If a target object is within the sensor's measurement range, the data viewer will display scan data, and the sensor's range indicator will illuminate.

» If no scan data is displayed in the data viewer,

📖 "13 Troubleshooting" on page 999.



16 **Press the [Stop] button if you used the [Start] button to start the sensors.**

» The laser should turn off.

2.5.3 Required Ports

The following table lists the ports used by sensors, the Ethernet-based protocols, the SDK (software development kit), and the PC-based accelerator. Use this information to determine whether you need to open ports on your network and to understand the traffic that a sensor system will produce over a network.

Ports used

Port	Data Packet Protocol	Description
80	TCP	Server for sensor web interface
502	TCP	Modbus protocol communication
2016	UDP	Internal (protocol-independent)
2017	TCP	Internal (protocol-independent)
2018	TCP	Internal (protocol-independent)
2019	TCP	Internal (protocol-independent)
2020	UDP	SurfaceMeasure1008S protocol discovery; SDK; accelerator
3189	TCP	Flash security policy server (only in SurfaceMeasure1008S 4.7 and earlier releases)
3190	TCP	SurfaceMeasure1008S protocol control channel; SDK; accelerator
3191	TCP	Emulator web port
3192	TCP	SurfaceMeasure1008S protocol upgrade channel; SDK; accelerator
3194	TCP	SurfaceMeasure1008S protocol health channel; SDK; accelerator
3195	TCP	SurfaceMeasure1008S protocol private data
3196	TCP	SurfaceMeasure1008S protocol discovery; SDK; accelerator
3197	UDP	Emulator scenario management (RPC)
3220	UDP	SurfaceMeasure1008S protocol discovery; SDK; accelerator
8190	TCP	ASCII protocol
44818	TCP	EtherNet/IP protocol (standard port)
44818	UDP	EtherNet/IP protocol (standard port)

For more information on how the different protocols use these ports, see the appropriate section in "10.1 Protocols" on page 747.

2.6 Next Steps

After you complete the steps in this section, the sensor system is ready to be configured for an application using the software interface. The interface is explained in the following sections:

📖 "4.3 Management and Maintenance" on page 91

Contains settings for sensor system layout, network, motion and alignment, handling jobs, and sensor maintenance.

📖 "4.4 Scan Setup" on page 114

Contains settings for scan mode, trigger source, detailed sensor configuration, and performing alignment.

📖 "4.6 Models" on page 209

Contains settings for creating part matching models and sections.

📖 "4.7 Measurement and Processing" on page 230

Contains built-in measurement tools and their settings.

📖 "4.8 Output" on page 326

Contains settings for configuring output protocols used to communicate measurements to external devices.

📖 "4.9 Dashboard" on page 337

Provides monitoring of measurement statistics and sensor health.

📖 "4.2.1 Toolbar" on page 79

Controls sensor operation, manages jobs, and replays recorded measurement data.

3 SurfaceMeasure1008S Basic Functions

The following sections provide an overview of how SurfaceMeasure1008S acquires and produces data, detects and measures parts, and controls devices such as PLCs. Some of these concepts are important for understanding how you should mount sensors and configure settings such as active area.

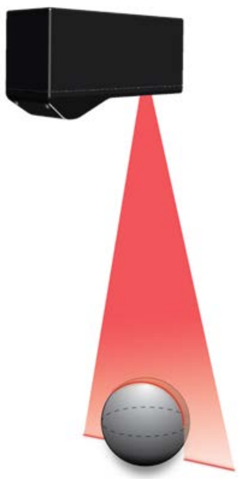
Tips

You can use the Accelerator to speed up processing of data. For more information, see "7 SurfaceMeasure1008S Acceleration" on page 627.

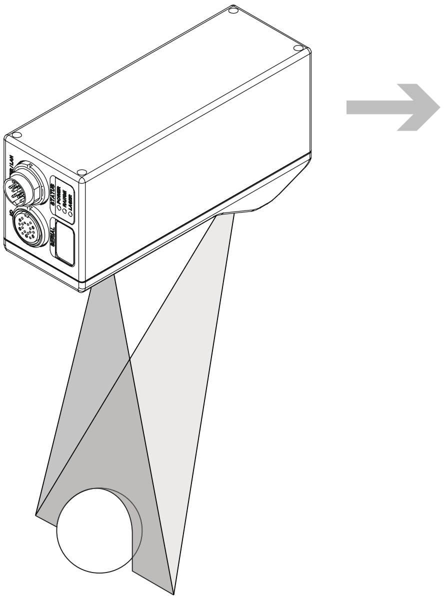
3.1 3D Acquisition

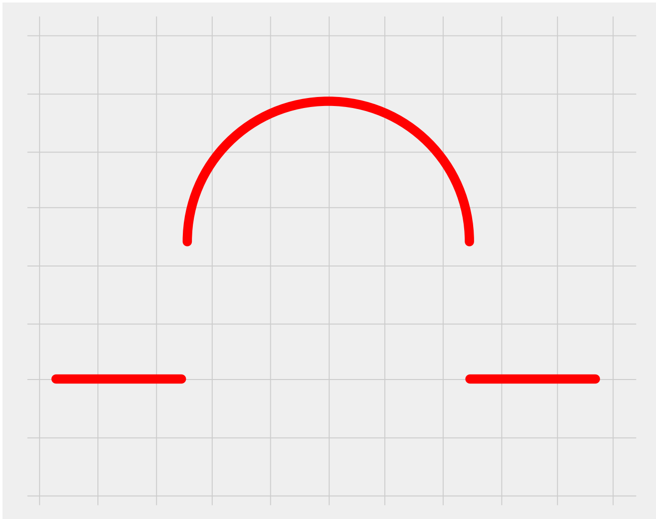
After a sensor system has been set up and is running, it is ready to start capturing 3D data.

Laser profile sensors project a laser line onto the target.



The sensor's camera views the laser line on the target from an angle and captures the reflection of the laser light off the target. The camera captures a single 3D profile—a slice, in a sense—for each camera exposure. The reflected laser light falls on the camera at different positions, depending on the distance of the target from the sensor. The sensor’s laser emitter, its camera, and the target form a triangle. The sensor uses the known distance between the laser emitter and the camera, and two known angles—one of which depends on the position of the laser light on the camera—to calculate the distance from the sensor to the target. This translates to the height of the target. This method of calculating distance is called laser triangulation.





Target objects typically move on a conveyor belt or other transportation mechanism under a sensor mounted in a fixed position. Sensors can also be mounted on robot arms and moved over the target. In both cases, the sensor captures a series of 3D profiles, building up a full scan of the target. Sensor speed and required exposure time to measure the target are typically critical factors in applications with line profile sensors.

Tips

SurfaceMeasure1008S sensors are always pre-calibrated to deliver 3D data in engineering units throughout their measurement range.

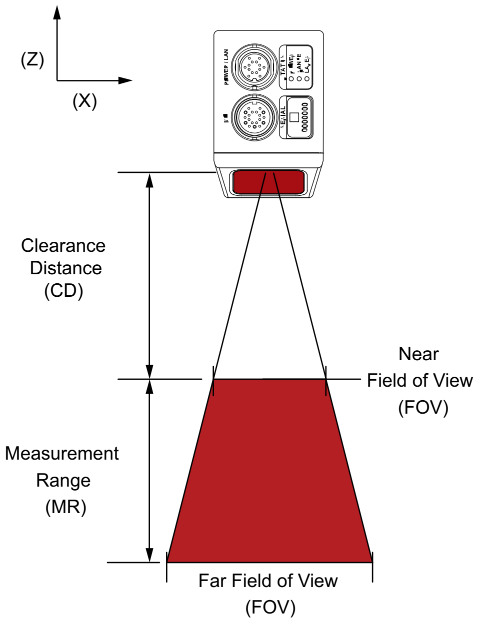
3.1.1 Clearance Distance, Field of View and Measurement Range

Clearance distance (CD), field of view (FOV), and measurement range (MR) are important concepts for understanding the setup of a sensor and for understanding results.

Clearance distance – The minimum distance from the sensor that a target can be scanned and measured. A target closer than this distance will result in invalid data.

Measurement range – The vertical distance, starting at the end of the clearance distance, in which targets can be scanned and measured. Targets beyond the measurement range will result in invalid data.

Field of view – The width on the X axis along the measurement range. At the far end of the measurement range, the field of view is wider, but the X resolution and Z resolution are lower. At the near end, the field of view is narrower, but the X resolution is higher. When resolution is critical, if possible, place the target closer to the near end. (For more information on the relation between target distance and resolution, see "■Z Resolution" on page 55.)



3.1.2 Resolution and Accuracy

The following sections describe X Resolution, Z Resolution, and Z Linearity. These terms are used in the SurfaceMeasure1008S datasheets to describe the measurement capabilities of the sensors.

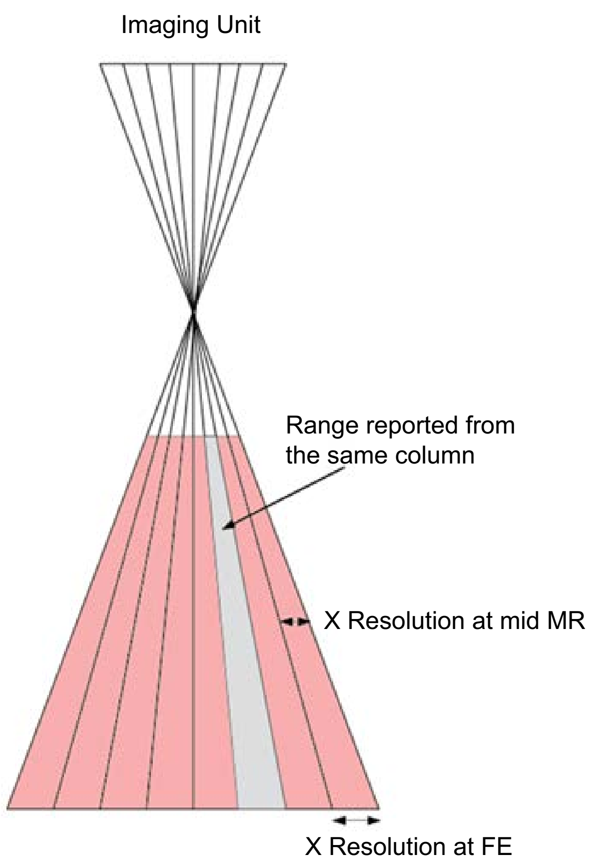
■ X Resolution

X resolution is the horizontal distance between each measurement point along the laser line. This specification is based on the number of camera columns used to cover the field of view (FOV) at a particular measurement range.

Because the FOV is trapezoidal (shown in red, below), the distance between points is closer at the near range than at the far range. This is reflected in the SurfaceMeasure1008S data sheet as the two numbers quoted for X resolution.

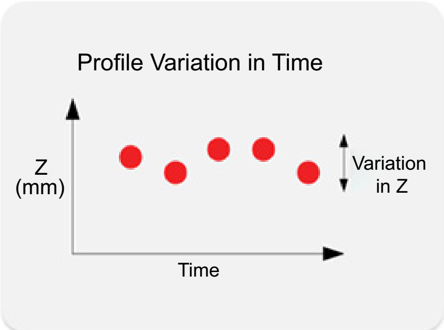
X Resolution is important for understanding how accurately width on a target can be measured.

> **Tips**
> When the sensor runs in Profile mode and Uniform Spacing is enabled, the 3D data is resampled to an X interval that is different from the raw camera resolution. For more information, see 📖 "3.2.2 Uniform Data and Raw Data" on page 61.



Z Resolution

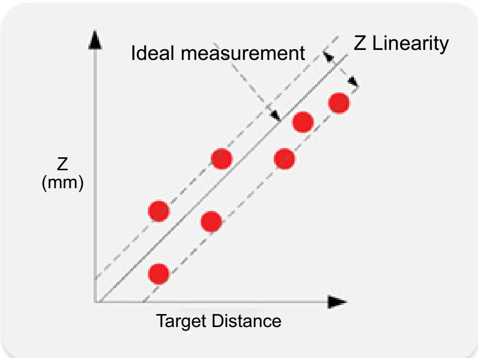
Z Resolution gives an indication of the smallest detectable height difference at each point, or how accurately height on a target can be measured. Variability of height measurements at any given moment, in each individual 3D point, with the target at a fixed position, limits Z resolution. This variability is caused by camera and sensor electronics.



Like X resolution, Z resolution is better closer to the sensor. This is reflected in the SurfaceMeasure1008S datasheets as the two numbers quoted for Z resolution.

Z Linearity

Z linearity is the difference between the actual distance to the target and the measured distance to the target, throughout the measurement range. Z linearity gives an indication of the sensor's ability to measure absolute distance.



Z linearity is expressed in the SurfaceMeasure1008S data sheet as a percentage of the total measurement range.

3.2 Profile Output

The SurfaceMeasure1008S can obtain the measuring points by detecting the reflected light of the irradiated laser with the sensor.

A profile is the aggregate of these measuring points, and the coordinate values are assigned to each measuring points in accordance with the positions which are displayed in the measuring range. Each range consists of a height (on the Z axis) and a position (on the X axis) in the sensor's field of view.

3.2.1 Coordinate Systems

Data points are reported in one of three coordinate systems, which generally depends on the alignment state of the sensor.

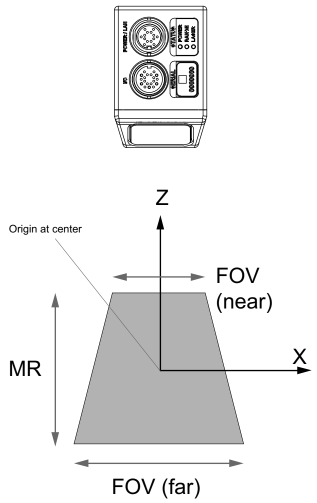
- Sensor coordinates: Used on unaligned sensors.
- System coordinates: Used on aligned sensors. Applies to either standalone or multi-sensor systems.
- Part and section coordinates: Data can optionally be reported using a coordinate system relative to the part itself.

Understanding coordinate systems is an important part of understanding measurement results. These coordinate systems are described below.

Tips

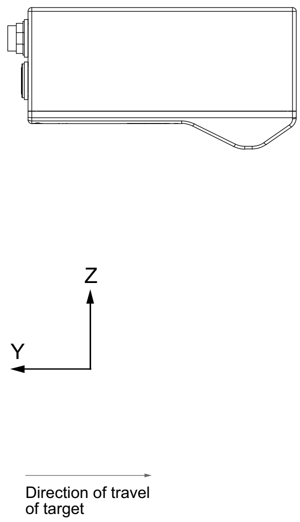
For SurfaceMeasure1008S, Y increases moving from the camera to the laser; for more information, see the coordinate system orientations illustrated in the specification drawings of your sensor in "14.1 Sensors" on page 1001.

■ Sensor Coordinates



SurfaceMeasure1008S

The Y axis represents the relative position of the part in the direction of travel. Y position increases as the object moves forward (increasing encoder position).



SurfaceMeasure1008S

The mounting direction, relative to the direction of travel, can be set using either the Normal or Reverse layout. For more information, see 📖 "4.3.3 Layout" on page 96.

■ System Coordinates

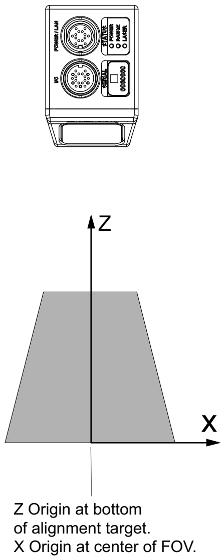
Understanding system coordinates is important for two reasons. First, they are the direct result of performing the built-in alignment procedure. Second, they change how scan data is represented and how measurement results should be interpreted.

Performing the built-in alignment procedure on sensors adjusts the coordinate system in relation to sensor coordinates, resulting in system coordinates (for more information on sensor coordinates, see 📖 "■Sensor Coordinates" on page 57). For more information on aligning sensors, see 📖 "4.5 Aligning Sensors" on page 171.

The adjustments resulting from alignment are called transformations (offsets along the axes and rotations around the axes). Transformations are displayed in the [Sensor] panel on the [Scan] page. For more information on transformations in the web interface, see "●Transformations" on page 128.

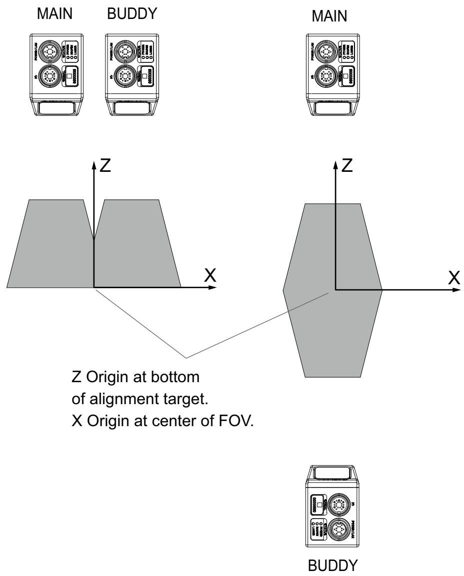
System coordinates are aligned so that the system X axis is parallel to the alignment target surface. The system Z origin is set to the base of the alignment target object. In both cases, alignment determines the offsets in X and Z.

Alignment is used with a single sensor to compensate for mounting misalignment and to set a zero reference, such as a conveyor belt surface.



SurfaceMeasure1008S

Additionally, in multi-sensor systems, alignment sets a common coordinate system. That is, scan data and measurements from the sensors are expressed in a unified coordinate system.

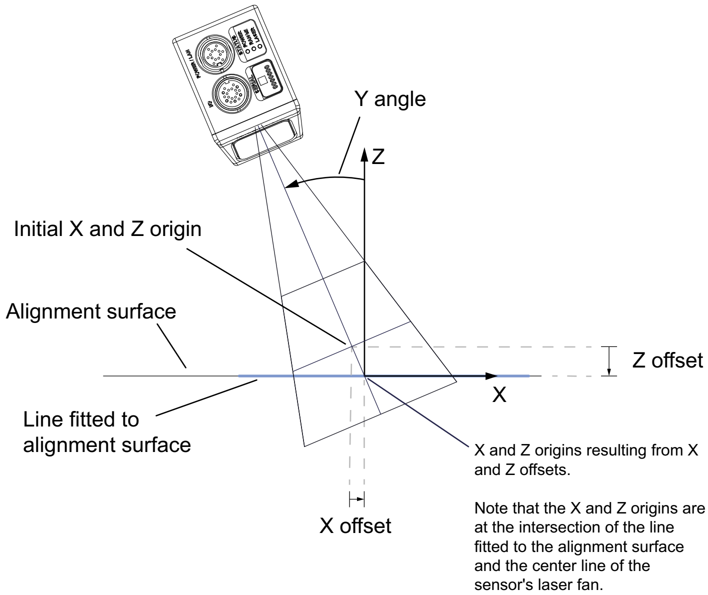


SurfaceMeasure1008S

Alignment can also determine offsets along the Y axis. This allows setting up a staggered layout in multi-sensor systems. This is especially useful in side-by-side mounting scenarios, as it provides full coverage for models with a small scan area.

As with sensor coordinates, in system coordinates, Y position increases as the object moves forward (increasing encoder position).

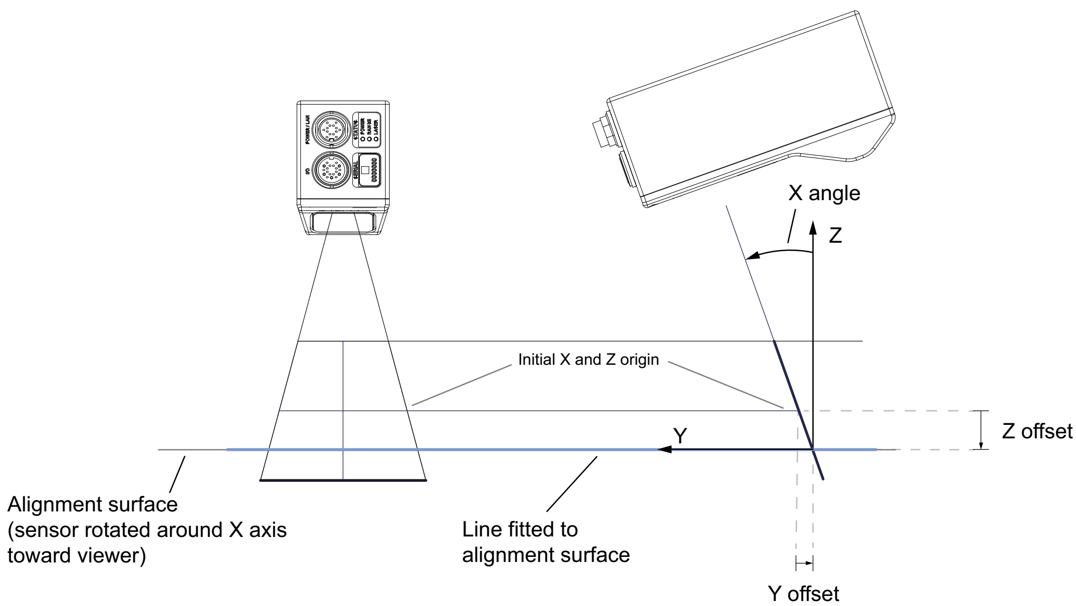
Alignment also determines the Y Angle (angle on the X–Z plane, around the Y axis) needed to align sensor data. This is also sometimes called roll correction.



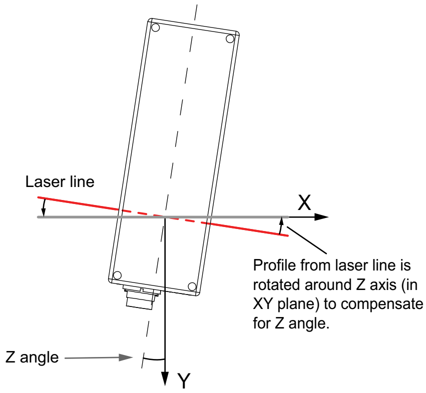
SurfaceMeasure1008S: Y Angle

Y angle is positive when rotating from positive X to positive Z axis.

Similarly, tilt can be determined around the Z and the X axis, which compensates for the angle in height measurements. These are sometimes called yaw correction and pitch correction, respectively. Intentional rotation around the X axis is often used for specular mounting, that is, for scanning targets that are shiny or reflective. Note however that X angle correction can't currently be corrected for using the alignment procedure available on the Alignment panel. X angle can only be manually entered in the Transformations panel. For more information on transformations in the web interface, see 📖 "●Transformations" on page 128.



SurfaceMeasure1008S: X Angle



SurfaceMeasure1008S: Z Angle

X angle is positive when rotating from positive Y to positive Z. Z angle is positive when rotating from positive X to positive Y.

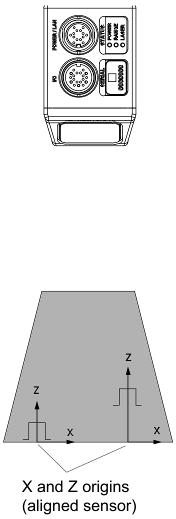
When applying the transformations, the data is first rotated around X (clockwise, with the X axis toward the viewer), then Y (counterclockwise), and then Z (clockwise), and then the offsets are applied.

■ Part and Section Coordinates

When you work with parts or sections extracted from scan data, a different coordinate system is available.

Part data can be expressed in aligned system coordinates or unaligned sensor coordinates. But part data can also be represented in part coordinates: data and measurement results are in a coordinate system that places the X and Y origins at the center of the part. The Z origin is at the surface surrounding the alignment target (if the sensor or system has been aligned) or in the center of the center of the measurement range (if the sensor or system has not been aligned).

Tips
The [Frame of Reference] setting, in the [Part Detection] panel on the [Scan] page, controls whether part data is recorded using sensor/system coordinates or part coordinates.



Sections are always represented in a coordinate system similar to part coordinates: the X origin is always at the center of the extracted profile, and the Z origin is at the bottom of the alignment target (or in the center of the measurement range if the sensor is unaligned).

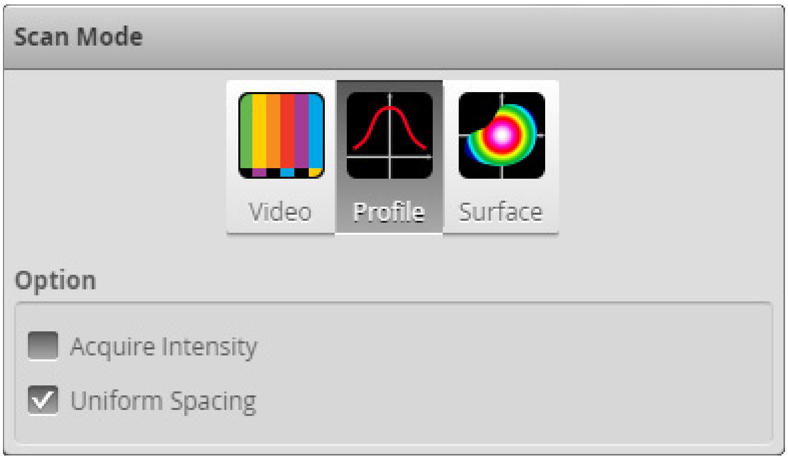
- Switching between Coordinate Systems

  In many situations, when working with part data that has been recorded with [Frame of Reference] set to [Part], it is useful to have access to the "real-world" coordinates, rather than part-relative coordinates. Sensors provide special "global" measurements, in the Bounding Box tools, that you can use in scripts to convert from part coordinates to sensor/system coordinates. Note that the same applies to sections.

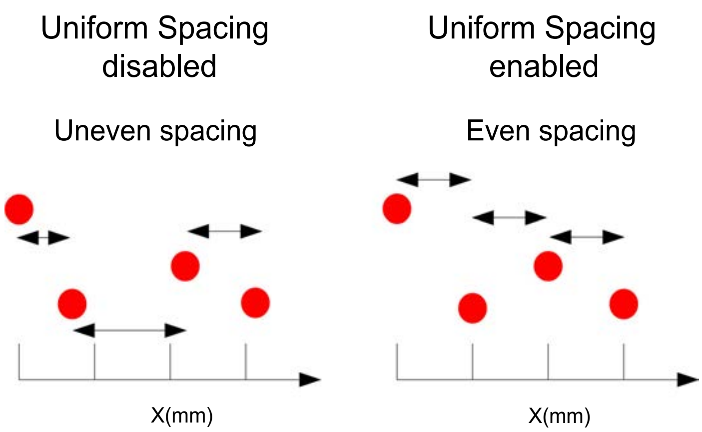
  For more information, see the Profile Bounding Box tool or the Surface Bounding Box tool, and the Script tool.

3.2.2 Uniform Data and Raw Data

The data that a sensor produces in Profile mode is available in two formats: as uniform (resampled) data and as raw data. The sensor produces uniform data when [Uniform Spacing] is enabled and produces raw data when [Uniform Spacing] is disabled. The setting is available in the [Scan Mode] panel, on the [Scan] page.



When [Uniform Spacing] is enabled, the ranges that make up a profile are resampled so that the spacing is uniform along the laser line (X axis). The resampling divides the X axis into fixed size "bins." Profile points that fall into the same bin are combined into a single range value (Z).



The size of the spacing interval is set under the [Spacing] tab in the [Sensor] panel on [Scan] page.

Resampling to uniform spacing reduces the complexity for downstream algorithms to process the profile data from the sensor, but places a higher processing load on the sensor's CPU.

When uniform spacing is not enabled, no processing is required on the sensor. This frees up processing resources in the sensor, but usually requires more complicated processing on the client side. Ranges in this case are reported in (X, Z) coordinate pairs.

Most built-in measurement tools in the SurfaceMeasure1008S in Profile mode operate on profiles with uniform spacing. A limited number of tools can operate on profiles without uniform spacing. For more information on the profile tools, see 📖 "5 Profile Measurement" on page 343.

A drawback of uniform spacing is that if sensors are angled to scan the sides of a target, data on the "verticals" is lost because points falling in the same "bin" are combined. When [Uniform Spacing] is disabled, however, all points are preserved on the sides. In this case, the data can be processed by the subset of tools that work on profiles without uniform spacing. Alternatively, the data can be processed externally using the SDK.

Tips

When uniform spacing is enabled, in the Ethernet output, only the range values (Z) are reported. The X positions can be reconstructed through the array index at the receiving end (the client). For more information on Ethernet output, see 📖 "4.8.2 Ethernet Output" on page 327.

For information on enabling uniform spacing, see 📖 "4.4.2 Scan Modes" on page 116.

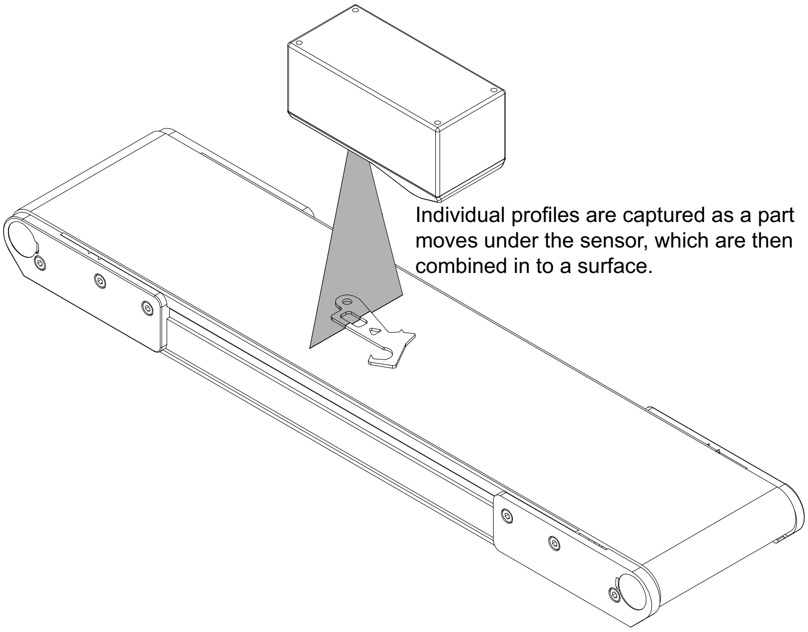
3.3 Data Generation and Processing

After scanning a target, a sensor can process the scan data to allow the use of more sophisticated measurement tools. This section describes the following concepts:

- Surface generation
- Part detection
- Sectioning

3.3.1 Surface Generation

Laser profile sensors create a single profile with each exposure. These sensors can combine a series of profiles gathered as a target moves under the sensor to generate a height map, or surface, of the entire target. This height map is called a surface.

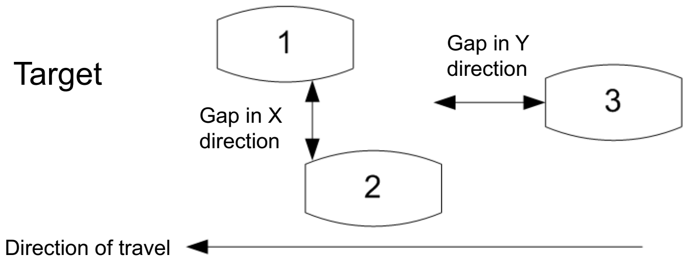


For more information, see "4.4.6 Surface Generation" on page 146.

3.3.2 Part Detection

Part detection function allows the sensor to combine multiple single exposures in large data units to generate data, and then the firmware can isolate discrete parts on the generated surface into separate scans representing parts.

SurfaceMeasure1008S can then perform measurements on these isolated parts.

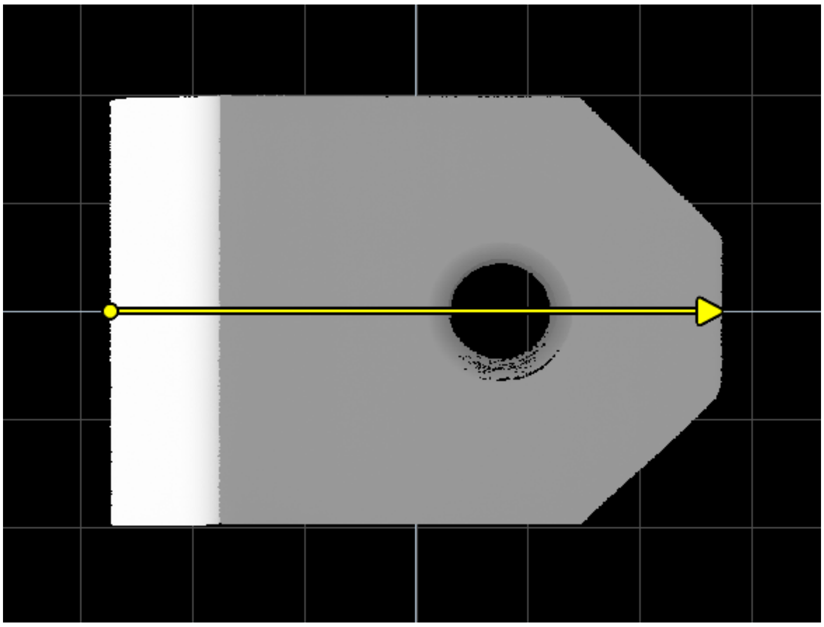


Part detection is useful when measurements on individual parts are needed and for robotic pick and place applications.

For more information on part detection, see "4.4.7 Part Detection" on page 149.

3.3.3 Sectioning

In Surface mode, the sensor can also extract a profile from a surface or part using a line you define on that surface or part. The resulting profile is called a “section.” A section can have any orientation on the surface, but its profile is parallel to the Z axis.



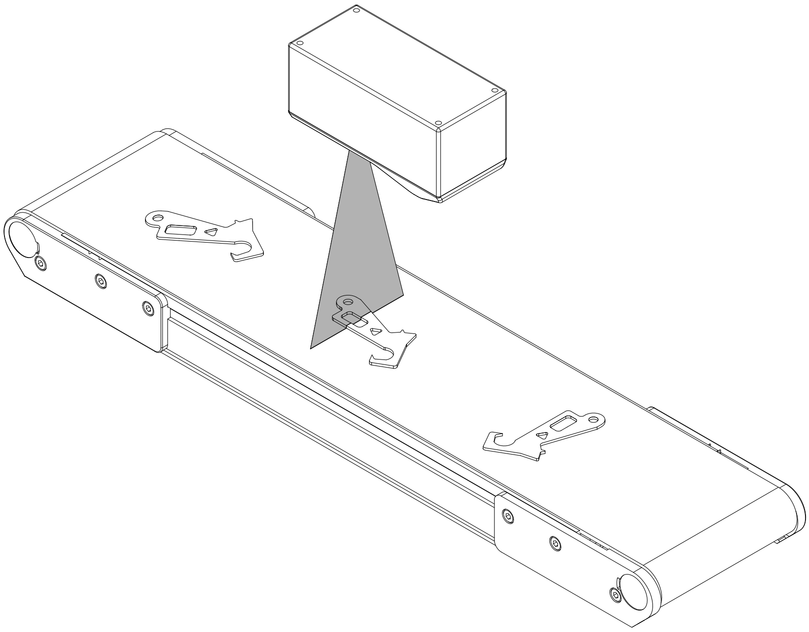
Since most of the [Profile Measuring Tools] can be used in the SurfaceMeasure1008S's sections, it allows you to make measurements that are not possible with [Surface Measurement Tools].

The profile measuring tools and surface measuring tools are the various calculation and point cloud processing functions that are inside the tool diagram.

For more information on sections, see "4.6.3 Sections" on page 224.

3.4 Part Matching

The sensor can match scanned parts to the edges of a model based on a previously scanned part (📖 "■Using Edge Detection" on page 210) or to the dimensions of a fitted bounding box or ellipse that encapsulate the model (📖"■Using Bounding Box and Ellipse" on page 221). When parts match, the sensor can rotate scans so that they are all oriented in the same way. This allows measurement tools to be applied consistently to parts, regardless of the orientation of the part you are trying to match.



3.5 Measurement

After SurfaceMeasure1008S scans a target and, optionally, further processes the data, the sensor is ready to take measurements on the scan data.

SurfaceMeasure1008S provides several measurement tools, each of which provides a set of individual measurements, giving you dozens of measurements ideal for a wide variety of applications to choose from. The configured measurements start returning pass/fail decisions, as well as the actual measured values, which are then sent over the enabled output channels to control devices such as PLCs, which can in turn control ejection or sorting mechanisms. (For more information on measurements and configuring measurements, see 📖 "4.7 Measurement and Processing" on page 230. For more information on output channels, see 📖 "3.7 Output and Digital Tracking" on page 74.)

> **Tips**
> You can create custom tools that run your own algorithms. For more information, see 📖 "11.2 GDK" on page 958.

A part's position can vary on a transport system. To compensate for this variation, SurfaceMeasure1008S can anchor a measurement to the positional measurement (X, Y, or Z) or Z angle of an easily detectable feature, such as the edge of a part. The calculated offset between the two ensures that the anchored measurement will always be properly positioned on different parts.

3.6 Tool Chaining

SurfaceMeasure1008S's measurement and processing tools can be linked together: one tool uses another tool's output as input. This gives you a great deal of control and flexibility when it comes to implementing your application.

The following table lists the available outputs from SurfaceMeasure1008S's tools:

SurfaceMeasure1008S tool outputs

	Data Type	Supported Output Protocol	Visualization in Data Viewer	Input for Other Tools
Measurement	Single 64-bit value	SDK, PLC protocols	Rendered on tool's input data	Not supported as input, positional and Z angle measurements can be used by some tools for anchoring
Geometric Features	Structured data values: for example, point or line	Cannot be output via protocols	Rendered on tool's input data	Tools that accept the specific features
Tool Data	Binary data structure: Profile, Surface, or Generic	SDK	Rendered separately	Tools that accept the specific data type

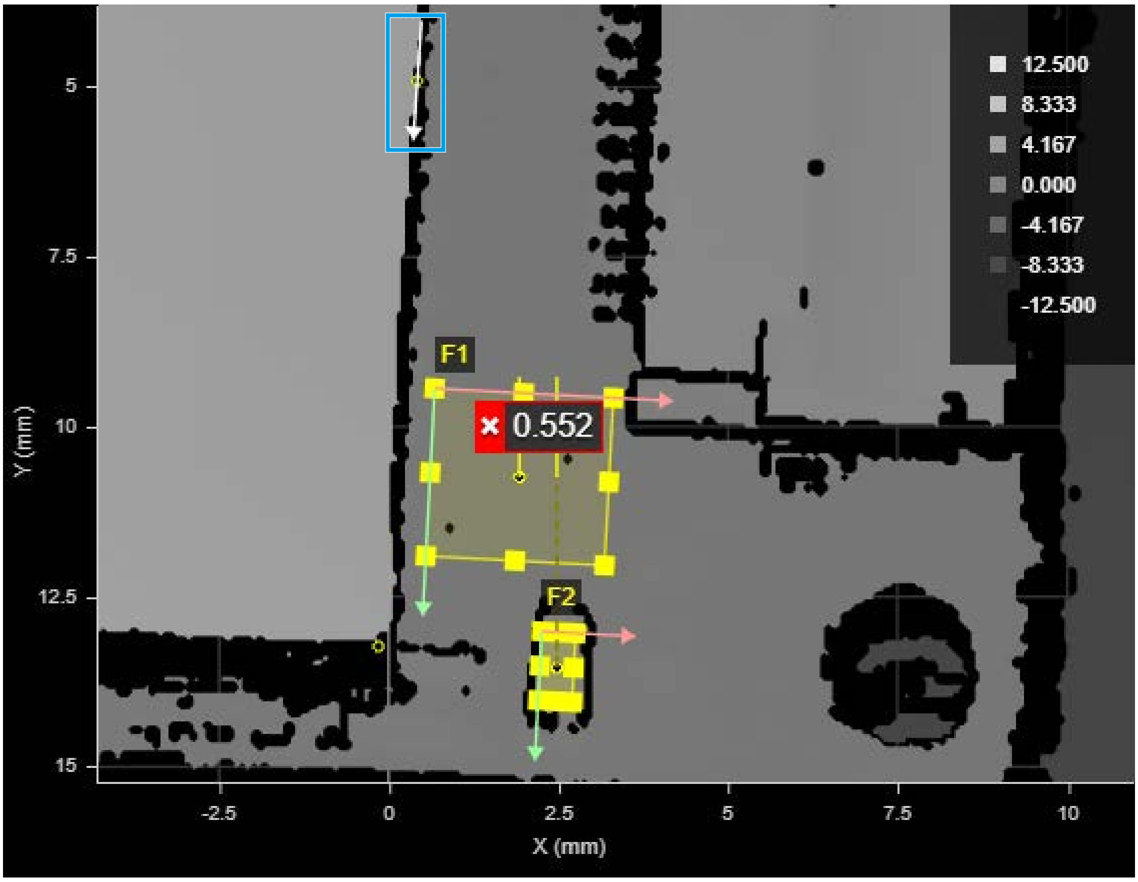
The following sections describe these types of output and how you use them as input.

3.6.1 Anchoring Measurements

Tools can use the positional measurements (X, Y, or Z) of other tools as anchors to compensate for minor shifts of parts: anchored tools are “locked” to the positional measurements of the anchoring tool's measurements. Some tools can also use a Z Angle measurement as an anchor.

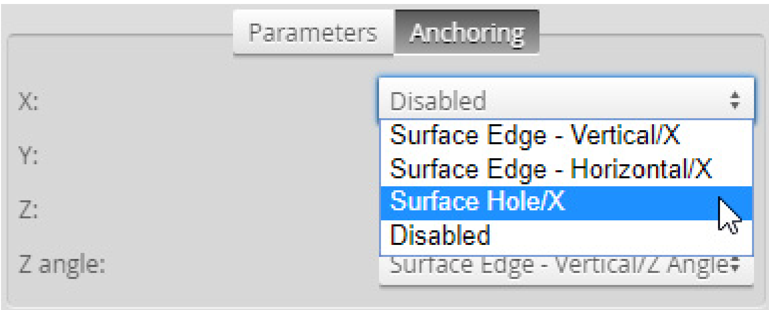
Typically, you will use measurements from more easily found features on a target—such as an edge or a hole—as anchors to accurately place other positional and dimensional measurements. This can help improve repeatability and accuracy in the anchored tools. Note that anchoring measurements are used to calculate the offsets of the anchored tools: the results from these measurements are not used as part of the anchored tool's measurements.

Anchoring measurements are rendered as overlays on a tool's input data.



Height measurements rendered a tool's input: a small PCB component (F2) relative to nearby surface (F1), anchored to positional (X and Y) measurements of the hole (lower right) and to the Z angle of a larger component to the left (white arrow)

You enable anchoring on the [Anchoring] tab on the [Tools] panel:



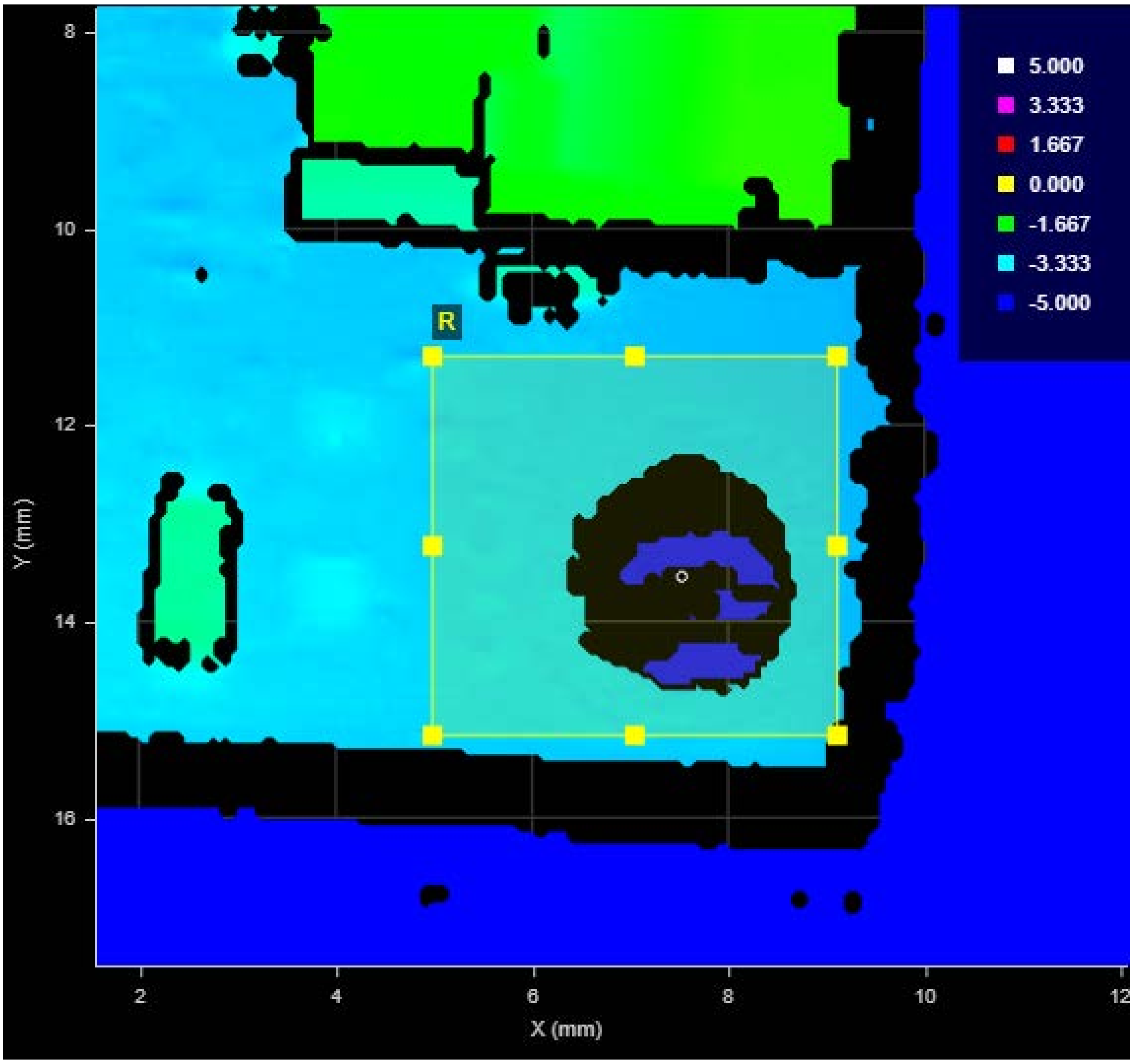
Tips
Note that anchoring is visualized on the anchored tool's input.

When combined with the matching and rotation capabilities of part matching, anchoring accounts for most sources of variation in part position and orientation and, consequently, avoids many measurement errors. For more information on anchoring, see "●Measurement Anchoring" on page 254.

3.6.2 Geometric Features

Many of SurfaceMeasure1008S's measurement tools can output data structures such as points, lines, planes, and circles. These structures are called geometric features and contain the components you would expect: a point geometric feature contains X, Y, and Z components (representing the location of the point in 3D space). Examples of point geometric features output by SurfaceMeasure1008S's measurement tools are hole center points, the tip and base of studs, or a position on a surface.

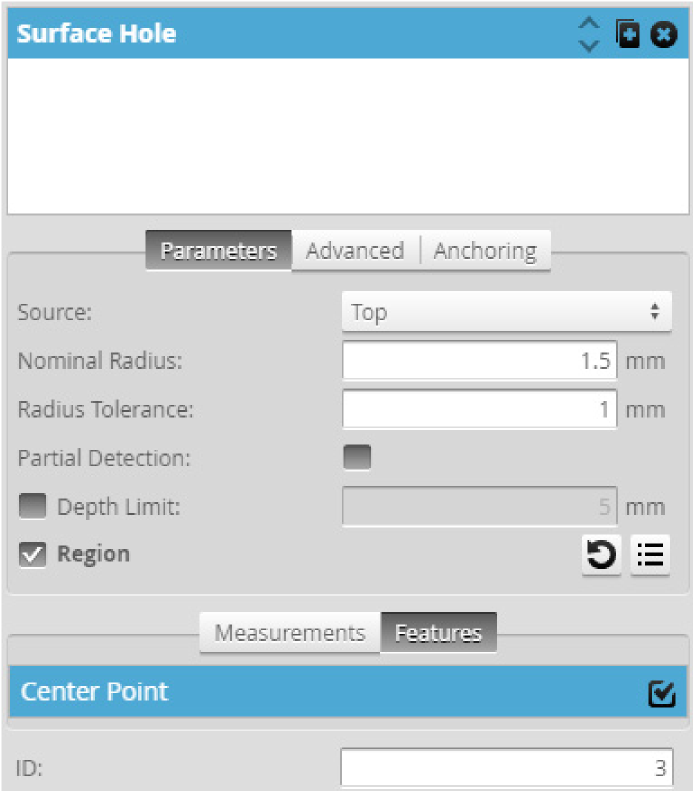
Geometric features overlay the results of calculations on the input data from the tool.



Point geometric feature (a hole's Center Point) rendered on a tool's input as a small white circle

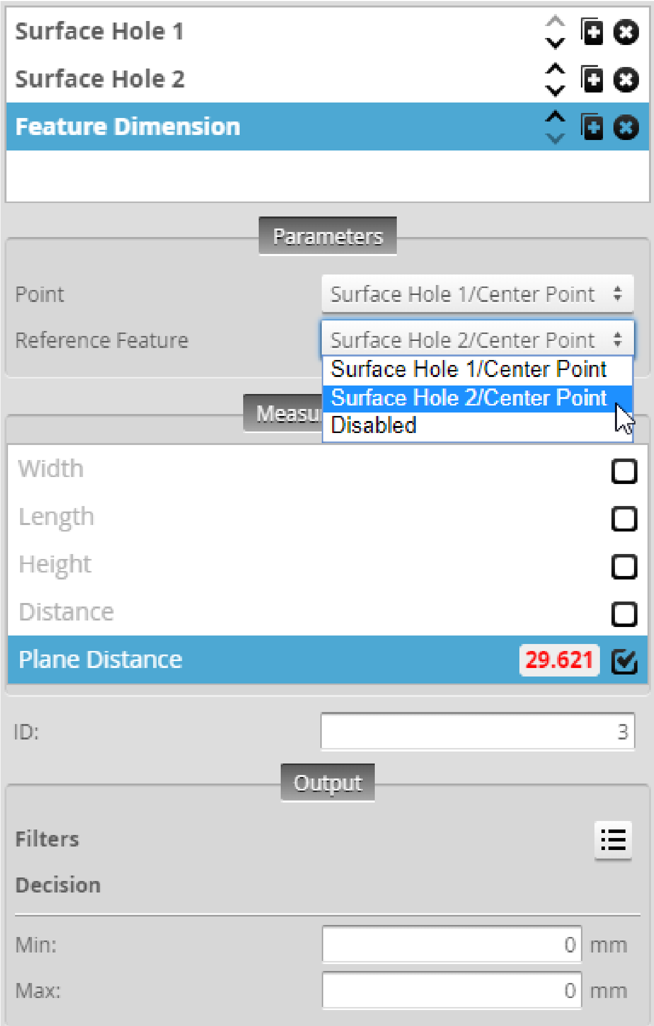
SurfaceMeasure1008S's "Feature" tools (such as Feature Dimension and Feature Intersect) use geometric features as inputs. For example, because the point geometric feature representing the center of a hole has X, Y, and Z components, you can perform dimensional measurements between it and another geometric feature, such as another hole or an edge. The Feature Create tool takes one or more geometric features as input and generates new geometric features (for example, creating a line from two point geometric features). You can then perform measurements on those features directly in the tool or in other Feature measurement tools. You can also use angle measurements on the newly created features for anchoring. For more information on Feature tools, see "4.7.9 Feature Measurement" on page 301.

You enable geometric feature output on a tool's [Features] tab:



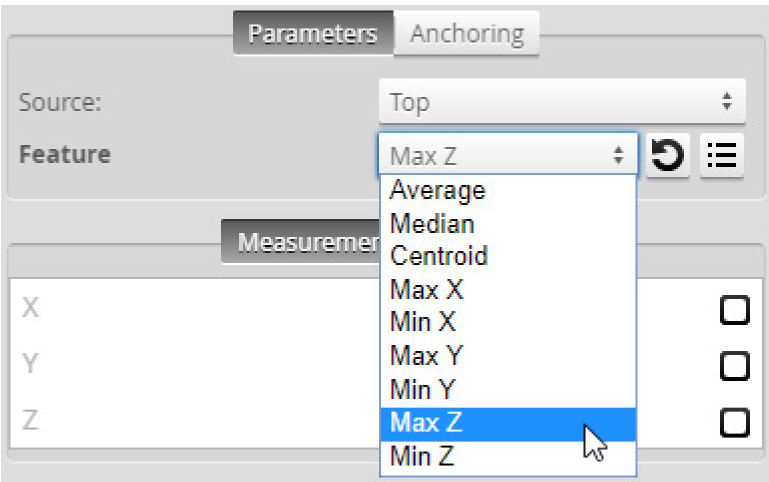
Center Point geometric feature of a Surface Hole tool enabled on Features tab

You enable geometric feature inputs on a Feature tool's [Parameters] tab:



Setting the Point and Reference Feature to the Center Point geometric features of two different holes

Geometric features are distinct from the "feature points" used by certain tools to determine which data point in a region should be used in a measurement, for example, the maximum versus the minimum on the Z axis of a data point in a region of interest:



For more information on feature points, see 📖 "●Feature Points" on page 247.

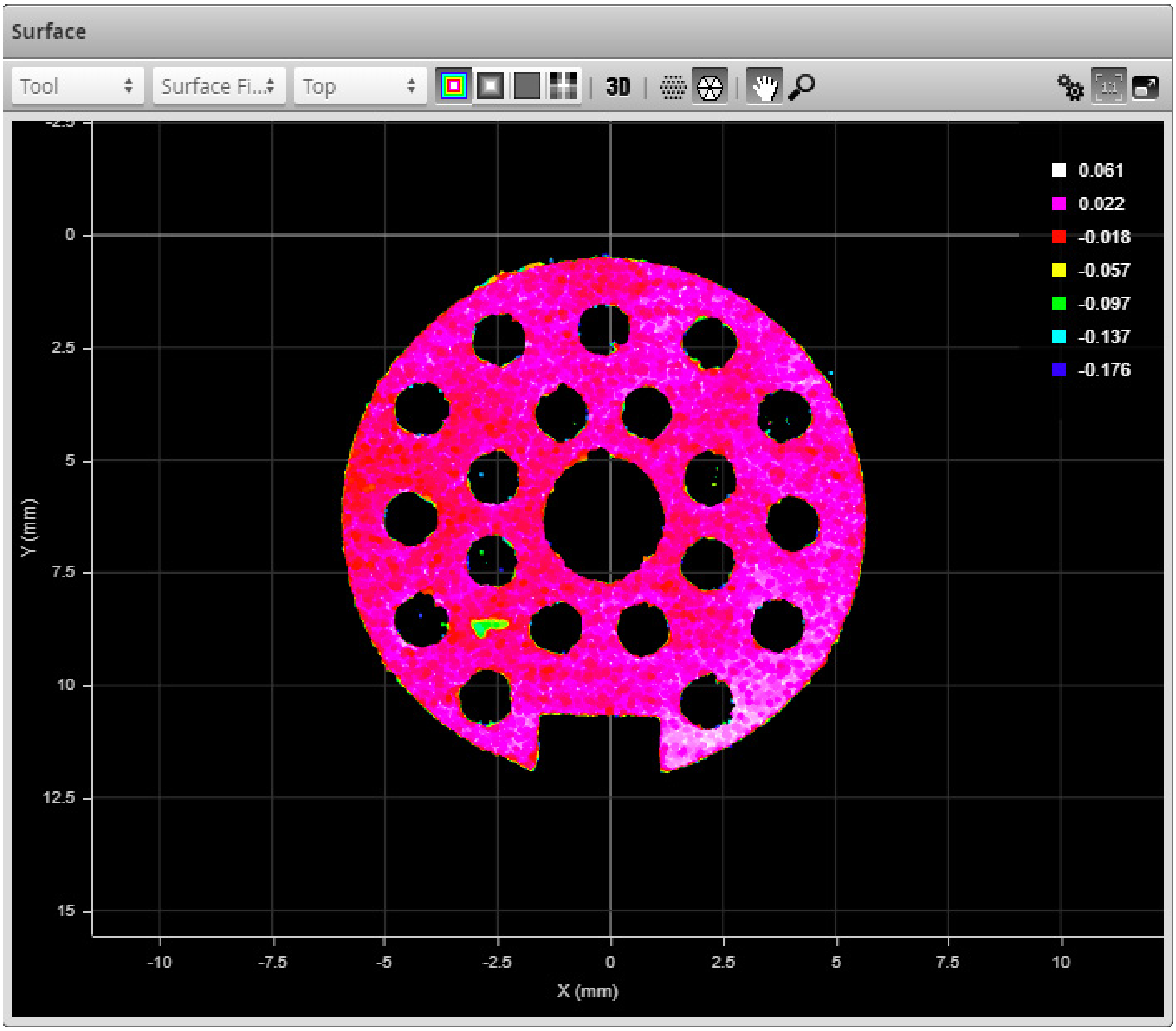
3.6.3 Tool Data

Some measurement and processing tools can output more complex data, which can be used as input by other tools or SDK applications. The following types of data are available: Profile, Surface, and Generic.

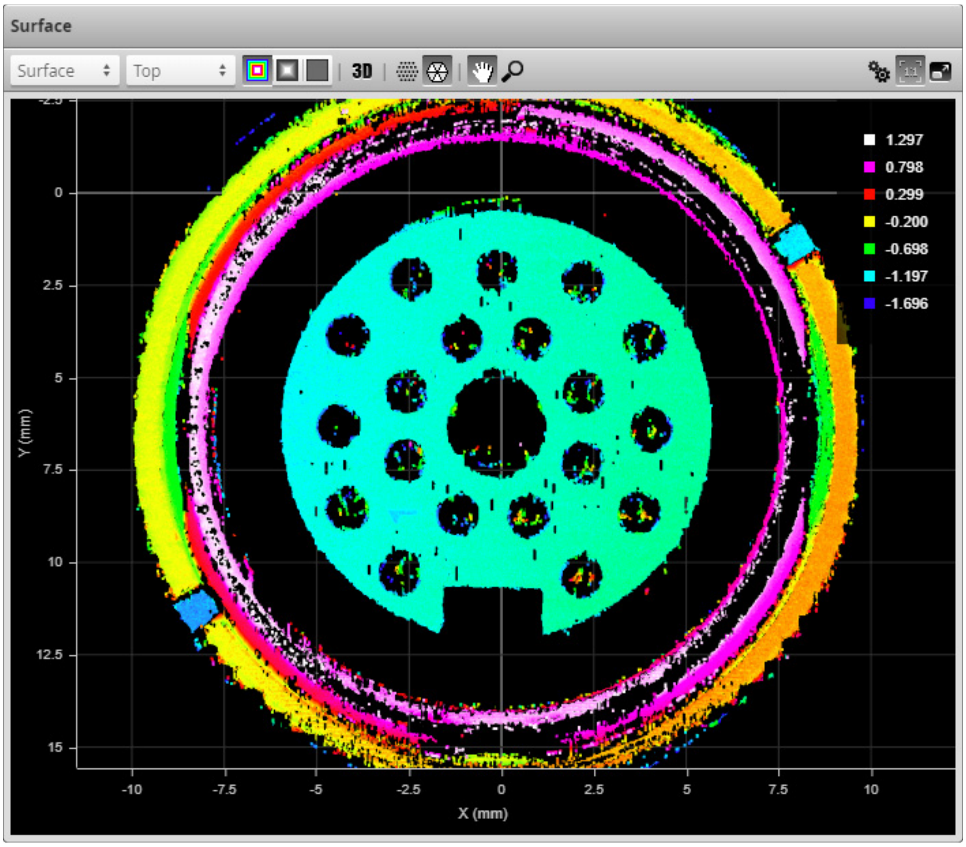
Profile and Surface tool data are identical in nature to the data produced by a sensor scan, except that they are the processed result from a tool. This kind of data can be used as input in compatible tools. Examples of this kind of this kind of data are the Stitched Surface output from the Surface Stitch tool, or the Filtered Surface output from the Surface Filter tool. Another important kind of data is the Transformed Surface produced by the Surface Transform tool, which transforms (shifting or rotating on the X, Y, and Z axes) the sensor's scan data; the Surface Transform tool supports a full 6 degrees of freedom.

For more information, see "6.35 Transform" on page 609.

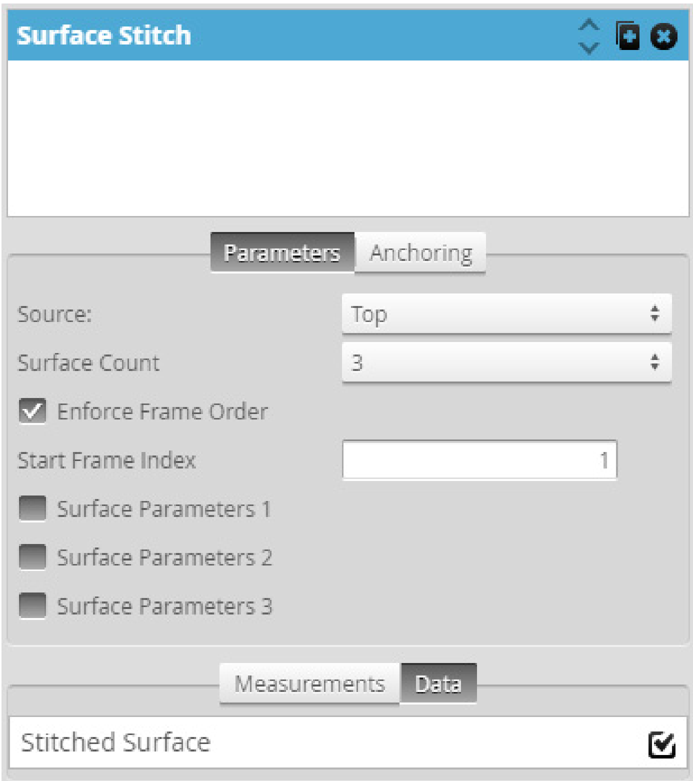
Both Profile and Surface tool data can be visualized in the data viewer, not as an overlay, however, but as independent data. The following is the output of the Surface Filter tool. Note that the first drop-down is set to Tool, to tell the sensor to display the tool data output, rather than the sensor output:



The following shows the scan data coming directly from the sensor's scan engine. Note that the first drop-down is set to [Surface], rather than [Tool].

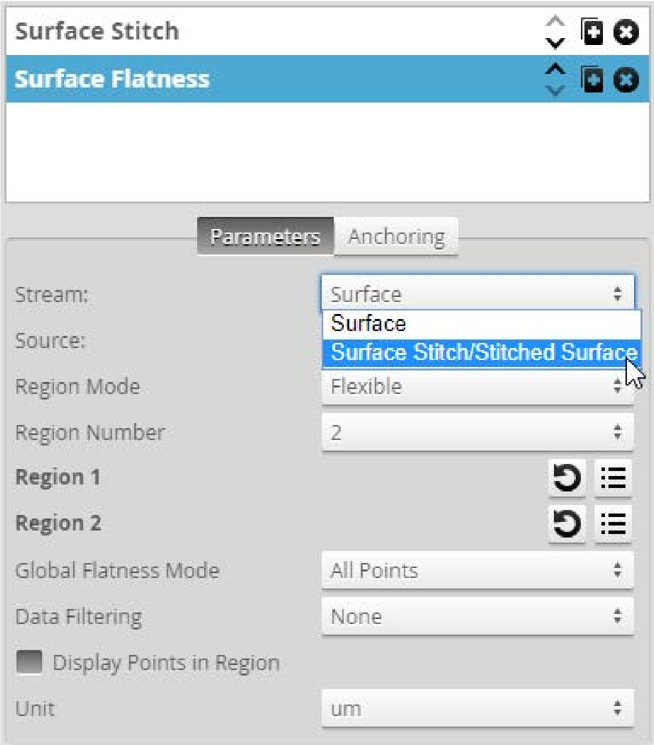


You enable this processed output in a tool's [Data] tab:



Stitched Surface tool enabled in Surface Stitch tool

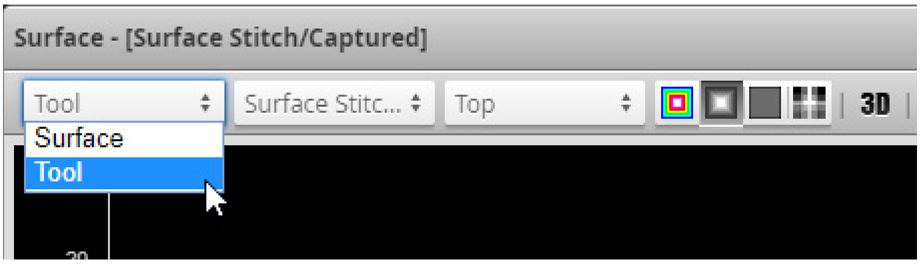
You enable tool data input on a tool’s [Parameters tab], using the [Stream] drop-down:



Setting a Surface Flatness tool's input to a Surface Stitch tool's data output

Generic tool data can’t be visualized. It can however be accessed from GDK tools or SDK applications you create. Examples of Generic tool data are the Segments Array data produced by the Surface Segmentation tool, or the Output Measurement data produced by the Surface Flatness. For more information on the SDK, see 📖 "11.1 GoSDK" on page 947. Generic tool data is enabled in the same way as Profile and Surface tool data, from the tool’s [Data] tab.

You may need to switch the first data viewer drop-down to “Tool” to view Profile or Surface tool data:



3.7 Output and Digital Tracking

After SurfaceMeasure1008S has scanned and measured parts, the last step in the operation flow is to output the results and/or measurements.

One of the main functions of SurfaceMeasure1008S is to produce pass/fail decisions, and then control something based on that decision. Typically, this involves rejecting a part through an eject gate, but it can also involve making decisions on good, but different, parts. This is described as “output” in SurfaceMeasure1008S. SurfaceMeasure1008S supports the following output types:

- Ethernet (which provides industry-standard protocols such as Modbus, EtherNet/IP, and ASCII, in addition to the SM1008S protocol)
- Digital
- Analog
- Serial interfaces

An important concept is digital output tracking. Production lines can place an ejection or sorting mechanism at different distances from where the sensor scans the target.

For this reason, SurfaceMeasure1008S lets you schedule a delayed decision over the digital interfaces. Because the conveyor system on a typical production line will use an encoder or have a known, constant speed, targets can effectively be “tracked” or "tagged."

WSurfaceMeasure1008S will know when a defective part has traveled far enough and trigger a PLC to activate an ejection/sorting mechanism at the correct moment. For more information on digital output tracking, see "4.8.3 Digital Output" on page 332.

4 SurfaceMeasure1008S Web Interface

The following sections describe how to configure sensors using the web interface.

4.1 Browser Compatibility and Performance

Mitutoyo recommends Google Chrome, Mozilla Firefox, Microsoft Edge for use with the web interface. If you choose to use other browsers, please note the following limitations.

4.1.1 Internet Explorer 11 Switches to Software Rendering

If you use sensors with large datasets on Internet Explorer 11, you may encounter the following issue.

If the PC connected to a sensor is busy, Internet Explorer may switch to software rendering after a specific amount of time. If this occurs, data is not displayed in the data viewer, and the only reliable way to recover from the situation is to restart the browser.

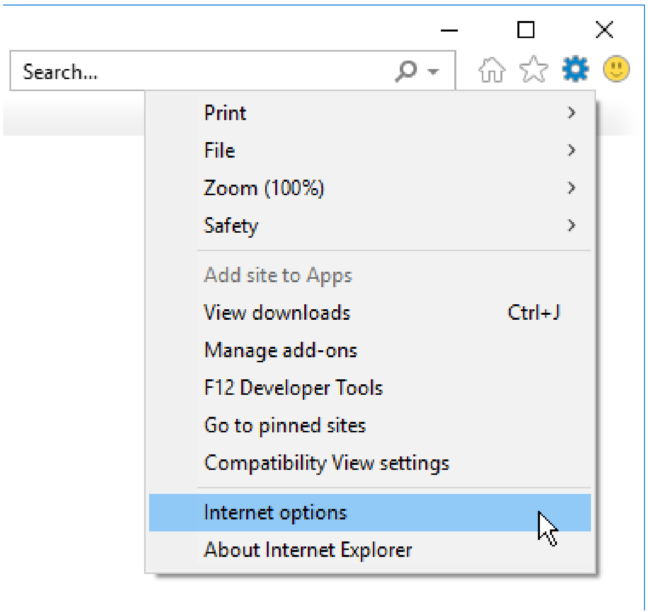
It is possible to remove the time limit that causes this issue, but you must modify the computer's registry. To do so, follow Microsoft's instructions at https://support.microsoft.com/en-us/help/3099259/update-to-add-a-setting-to-disable-500-msec-time-limit-for-webgl-frame.

4.1.2 Internet Explorer 11 Displays "Out of Memory"

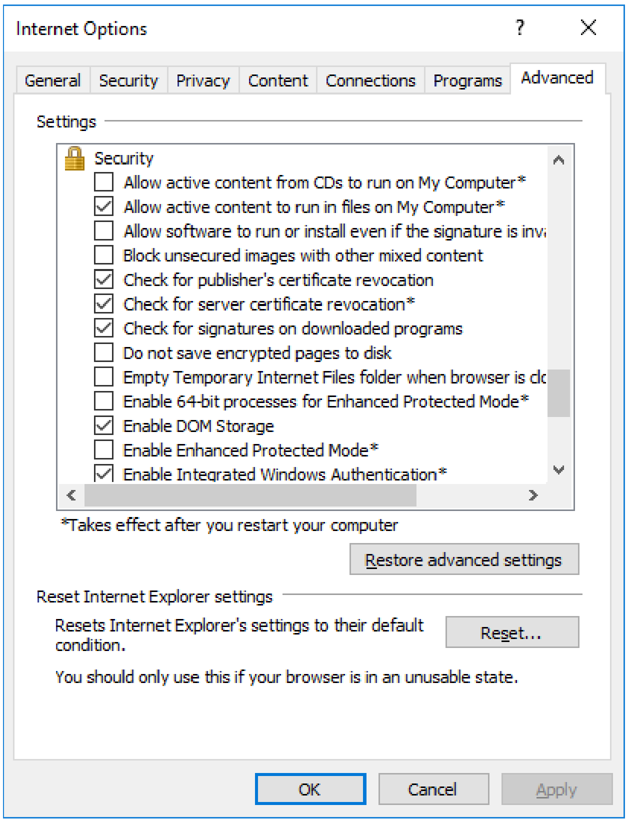
If you use sensors with large datasets on Internet Explorer 11, you may encounter “Out of Memory” errors in the sensor's web interface. This issue can be resolved by checking two options in Internet Explorer.

To correct out of memory issues in Internet Explorer 11:

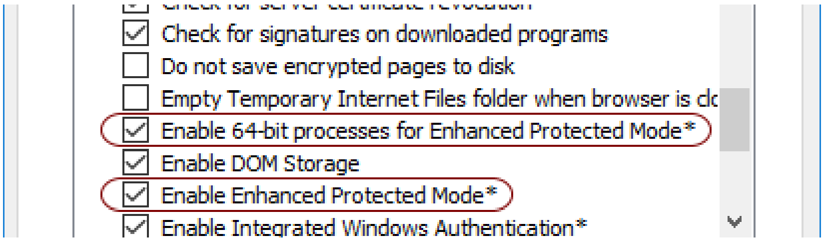
1 In upper right corner, click the settings icon ( ), and choose [Internet options.]



2 In Internet Options, click the [Advanced] tab, and scroll down to the [Security] section.



3 **In the dialog, check both "Enable 64-bit processes for Enhanced Protected Mode" and "Enable Enhanced Protected Mode".**



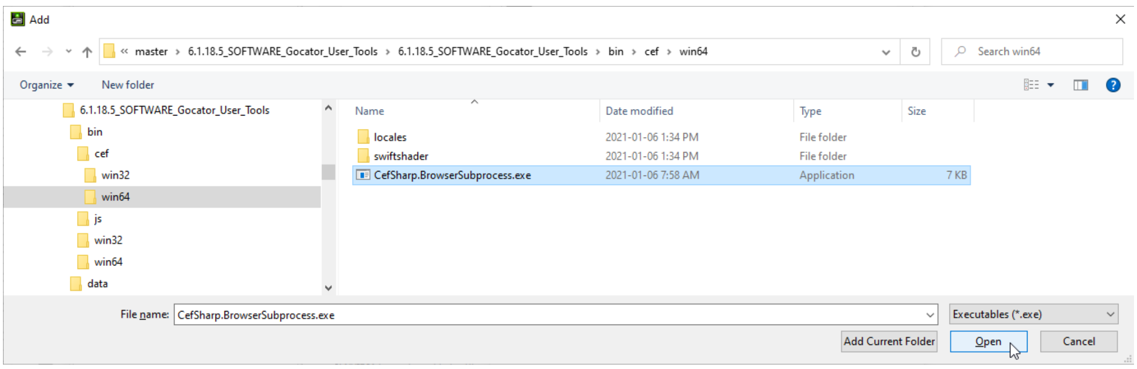
4 **Click [OK] and then restart your computer for the changes to take effect.**

4.1.3 Other Internet Explorer 11 Limitations

Drag-and-drop operations in the Tools Diagram panel are not supported in Internet Explorer 11 (for more information, see "4.7.4 Working with the Tools Diagram" on page 263).
You may also experience significant performance issues when using multiple data viewers in Internet Explorer 11 (for more information, see "4.7.2 Using Multiple Data Viewer Windows" on page 232).

4.1.4 Setting up a Dedicated Graphics Card for Internet Browser or Emulator Viewing

Many laptops contain two different graphics cards: a lower-performance graphics card integrated into the CPU and a higher-performance dedicated graphics card. When working with scan data containing a large amount of data, you may see low frame rates in the data viewer if the laptop uses the integrated graphics card. To get the best performance, you can choose the dedicated graphics card as the default for the browser you use or for the emulator. For the emulator, you choose the default for Cef-Sharp.BrowserSubprocess.exe in the \bin\cef\win64 folder in the tools folder:



For the browser, choose the executable for your browser.

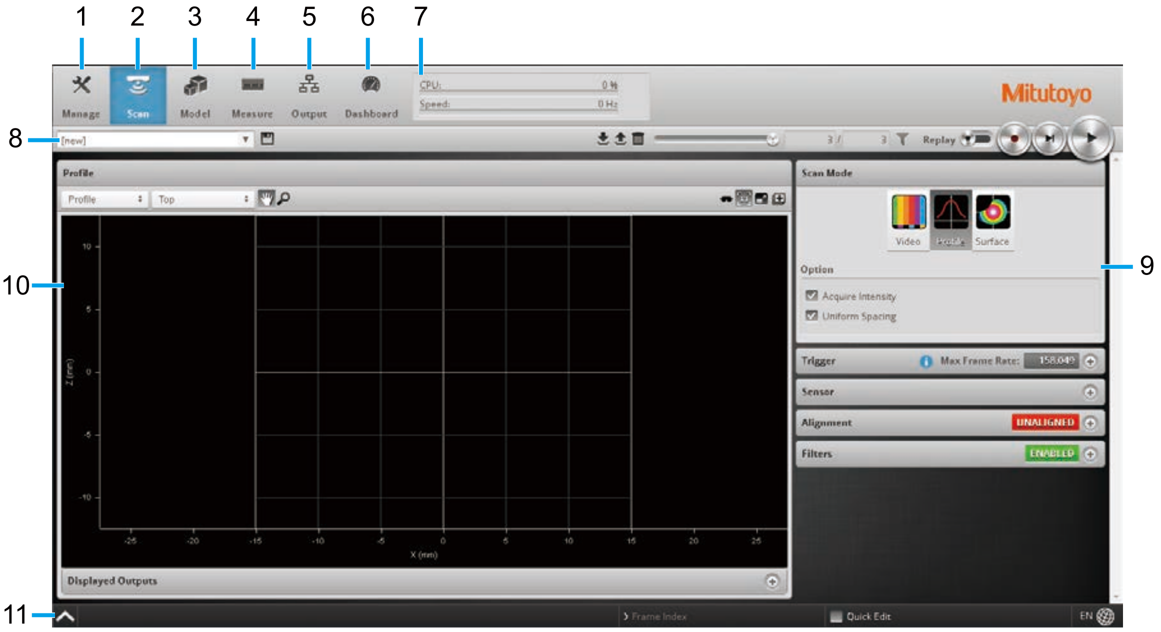
The following links provide steps to choose a default (use CefSharp.BrowserSubprocess.exe or your browser's executable instead):

- https://www.addictivetips.com/windows-tips/force-app-to-use-dedicated-gpu-windows/
- https://thegeekpage.com/how-to-force-your-game-or-app-to-use-the-dedicated-gpu-on-windows-10/

4.2 User Interface Overview

SurfaceMeasure1008S are configured by connecting to the IP address of a sensor with a web browser.

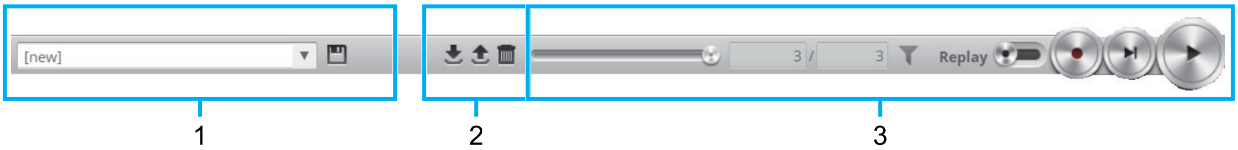
The web interface is shown below.



	Element	Description
1	[Manage] page	Contains settings for sensor system layout, network, motion and alignment, handling jobs, and sensor maintenance. See "4.3 Management and Maintenance" on page 91.
2	[Scan] page	Contains settings for scan mode, trigger source, detailed sensor configuration, and performing alignment. See "4.4 Scan Setup" on page 114.
3	[Model] page	Lets you set up sections and part matching. See "4.6 Models" on page 209
4	[Measure] page	Contains built-in measurement tools and their settings. See "4.7 Measurement and Processing" on page 230.
5	[Output] page	Contains settings for configuring output protocols used to communicate measurements to external devices. See "4.8 Output" on page 326.
6	[Dashboard] page	Provides monitoring of measurement statistics and sensor health. See "4.9 Dashboard" on page 337
7	[CPU] Load and [Speed]	Provides important sensor performance metrics. See "4.2.2 Metrics Area" on page 87.
8	Toolbar	Controls sensor operation, manages jobs, and filters and replays recorded data. See "4.2.1 Toolbar" on page 79.
9	Configuration area	Provides controls to configure scan and measurement tool settings.
10	Data viewer	Displays sensor data, tool setup controls, and measurements. See "4.4.8 Data Viewer" on page 156 for its use when the [Scan] page is active and on page 250 for its use when the [Measure] page is active.
11	Status bar	Displays log messages from the sensor (errors, warnings, and other information) and frame information, and lets you switch the interface language. For more information, see "4.2.4 Status Bar" on page 88.

4.2.1 Toolbar

The toolbar is used for performing operations such as managing jobs, working with replay data, and starting and stopping the sensor.



	Element	Description
1	Job controls	For saving and loading jobs.
2	Replay data controls	For downloading, uploading, and exporting recorded data.
3	Sensor operation / replay control	Use the sensor operation controls to start sensors, enable and filter recording, and control recorded data.

■ Creating, Saving and Loading Jobs (Settings)

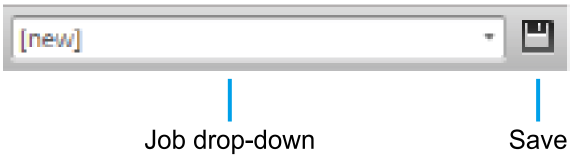
A sensor can store several hundred jobs. Being able to switch between jobs is useful when a sensor is used with different constraints during separate production runs. For example, width decision minimum and maximum values might allow greater variation during one production run of a part, but might allow less variation during another production run, depending on the desired grade of the part.

Most of the settings that can be changed in the sensor's web interface, such as the ones in the [Manage], [Measure], and [Output] pages, are temporary until saved in a job file. Each sensor can have multiple job files. If there is a job file that is designated as the default, it will be loaded automatically when the sensor is reset.

When you change sensor settings using the sensor web interface in the emulator, some changes are saved automatically, while other changes are temporary until you save them manually. The following table lists the types of information that can be saved in a sensor.

Setting Type	Behavior
Job	Most of the settings that can be changed in the sensor's web interface, such as the ones in the [Manage], [Measure], and [Output] pages, are temporary until saved in a job file. Each sensor can have multiple job files. If there is a job file that is designated as the default, it will be loaded automatically when the sensor is reset.
Alignment	Alignment can either be fixed or dynamic, as controlled by the [Alignment Reference] setting in [Motion and Alignment] in the [Manage] page. • Alignment is saved automatically at the end of the alignment procedure when [Alignment Reference] is set to [Fixed]. • When [Alignment Reference] is set to [Dynamic], you must manually save the job to save alignment.
Network Address	Network address changes are saved when you click the [Save] button in [Networking] on the [Manage] page. The sensor must be reset before changes take effect.

The job drop-down list in the toolbar shows the jobs stored in the sensor. The job that is currently active is listed at the top. The job name will be marked with "[unsaved]" to indicate any unsaved changes.



To create a job:

1 Choose [New] in the job drop-down list and type a name for the job.

2 Click the [Save] button or press [Enter] to save the job.

» The job is saved to sensor storage using the name you provided. Saving a job automatically sets it as the default, that is, the job loaded when then sensor is restarted.

To load (switch) jobs:

1 Select an existing file name in the job drop-down list.

» The job is activated. If there are any unsaved changes in the current job, you will be asked whether you want to discard those changes.

You can perform other job management tasks—such as downloading job files from a sensor to a computer, uploading job files to a sensor from a computer, and so on—in the [Jobs] panel in the [Manage] page. "4.3.6 Jobs" on page 107 for more information.

■ Recording, Playback, and Measurement Simulation

Sensors can record and replay recorded scan data, and also simulate measurement tools on recorded data. This feature is most often used for troubleshooting and fine-tuning measurements, but can also be helpful during setup.

Recording and playback are controlled using the toolbar controls.

Recording and playback controls when replay is off

To record live data:

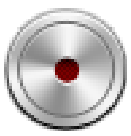
1 Toggle [Replay] mode off by setting the slider to the left in the [Toolbar].

> **Tips**
> Replay mode disables measurements.

2 (Optional) Configure recording filtering.

For more information on recording filtering, see 📖"●[Recording Filtering]" on page 83.

3 Click the [Record] button to enable recording.



» The center of the Record button turns red.

When recording is enabled (and replay is off), the sensor will store the most recent data as it runs. Remember to disable recording if you no longer want to record live data. (Press the Record button again to disable recording).

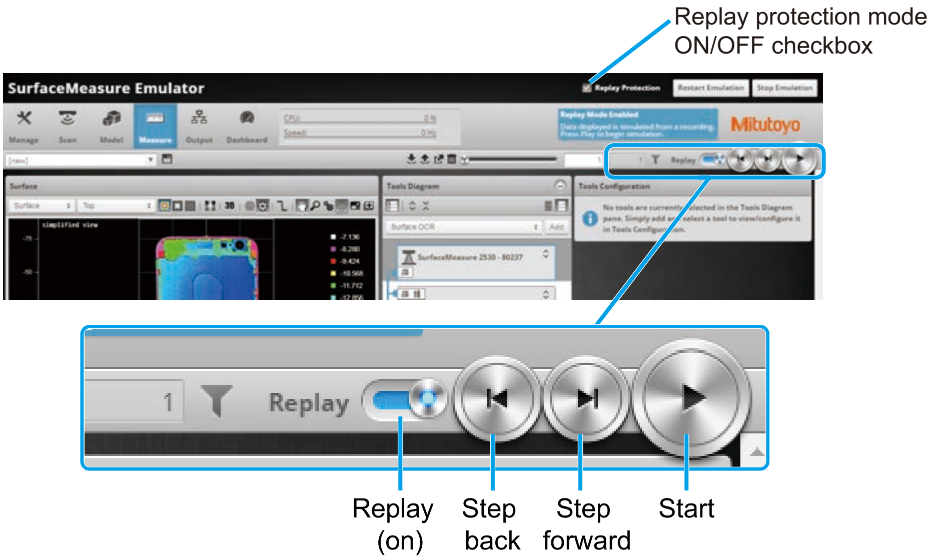
4 Press the [Snapshot] button or [Start] button.

» The [Snapshot] button records a single frame.

» The [Start] button will run the sensor continuously and all frames will be recorded, up to available memory.

When the memory limit is reached, the oldest data will be discarded.

> **Tips**
> Newly recorded data is appended to existing replay data unless the sensor job has been modified.



Playback controls when replay is on

To replay data:

1 **Toggle [Replay] mode on by setting the slider to the right in the [Toolbar.]**

» The slider's background turns blue and a Replay Mode Enabled message is displayed.

2 **Use the [Replay] slider or click the [Step Forward], [Step Back], or [Play] buttons to review data.**

» The [Step Forward] and [Step Back] buttons move the current replay location forward and backward by a single frame, respectively.

» The [Play] button advances the replay location continuously, animating the playback until the end of the replay data.

» The [Stop] button (replaces the [Play] button while playing) can be used to pause the replay at a particular location.

The [Replay] slider (or [Replay Position] box) can be used to go to a specific replay frame.

To simulate measurements on replay data:

1 **Toggle [Replay] mode on by setting the slider to the right in the [Toolbar].**

» The slider's background turns blue and a Replay Mode Enabled message is displayed.

To change the mode, [Replay Protection] must be unchecked.

2 **Go to the [Measure] page.**

Modify settings for existing measurements, add new measurement tools, or delete measurement tools as desired. For information on adding and configuring measurements, see "4.7 Measurement and Processing" on page 230.

3 **Use the [Replay Slider], or click [Step Forward], [Step Back], or [Play] button to simulate measurements.**

» Step or play through recorded data to execute the measurement tools on the recording.

Individual measurement values can be viewed directly in the data viewer. Statistics on the measurements that have been simulated can be viewed in the [Dashboard] page; for more information on the dashboard, see "4.9 Dashboard" on page 337.

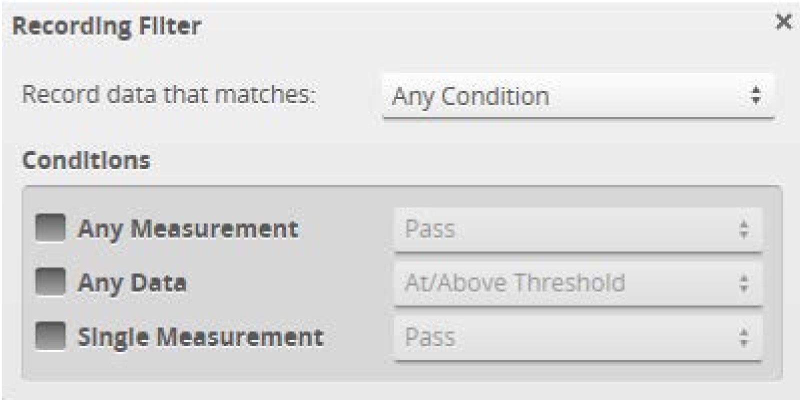
To clear replay data:

1 **Stop the sensor if it is running by clicking the Stop button.**

2 **Click the [Clear Replay Data] button .**

- [Recording Filtering]

Replay data is often used for troubleshooting. But replay data can contain thousands of frames, which makes finding a specific frame to troubleshoot difficult. Recording filtering lets you choose which frames the sensor records, based on one or more conditions, which makes it easier to find problems.



How a sensor treats conditions

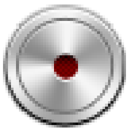
Setting	Description
[Any Condition]	The sensor records a frame when any condition is true.
[All Conditions]	The sensor only records a frame if all conditions are true.

Conditions

Setting	Description
[Any Measurement]	The sensor records a frame when any measurement is in the state you select. The following states are supported: • [pass] • [fail or invalid] • [fail and valid] • [valid] • [invalid]
[Single Measurement]	The sensor records a frame if the measurement with the ID you specify in ID is in the state you select. This setting supports the same states as the [Any Measurement] setting (see above).
[Any Data]	[At/Above Threshold]: The sensor records a frame if the number of valid points in the frame is above the value you specify in [Range Count Threshold]. [Below Threshold]: The sensor records a frame if the number of valid points is below the threshold you specify. In Surface mode, the number of valid points in the surface is compared to the threshold, not any sections that may be defined.

To set recording filtering:

1 Make sure recording is enabled by clicking the Record button.



2 Click the Recording Filtering button .

3 In the Recording Filtering dialog, choose how the sensor treats conditions:

For information on the available settings, see "How a sensor treats conditions" on page 83.

4 Configure the conditions that will cause the sensor to record a frame:

For information on the available settings, see "Conditions" on page 83.

5 Click the "x" button or outside of the Recording Filtering dialog to close the dialog.

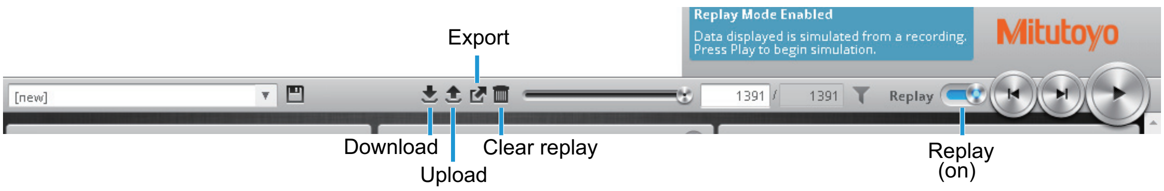
» The recording filter icon turns green to show that recording filters have been set.

When you run the sensor, it only records the frames that satisfy the conditions you have set.

■ Downloading, Uploading, and Exporting Replay Data

Replay data (recorded scan data) can be downloaded from a sensor to a client computer, or uploaded from a client computer to a sensor.

Data can also be exported from a sensor to a client computer in order to process the data using third-party tools.



Tips
Replay data is not loaded or saved when you load or save jobs.

To download replay data:

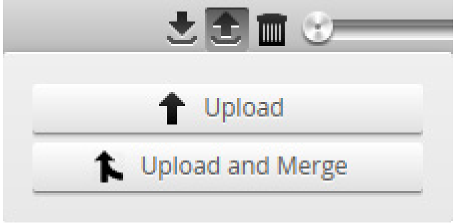
1 Click the Download button.

2 In the [Save As...] dialog, choose a location, optionally change the name, and click [Save].

To upload replay data:

1 Click the Upload button .

» The Upload menu appears.

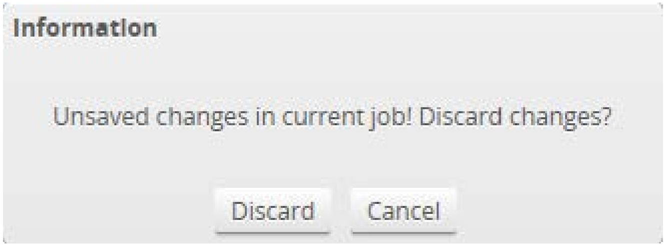


2 In the Upload menu, choose [Upload] or [Upload and merge].

» [Upload]: Unloads the current job and creates a new unsaved and untitled job from the content of the replay data file.

» [Upload and merge]: Uploads the replay data and merges the data's associated job with the current job. Specifically, the settings on the [Scan] page are overwritten, but all other settings of the current job are preserved, including any measurements or models.

If you have unsaved changes in the current job, the firmware asks whether you want to discard the changes.



3 Choose [Discard] or [Cancel].

» [Discard]: Discard any unsaved changes.

» [Cancel]: Return to the main window to save your changes.

4 If you clicked [Discard], navigate to the replay data to upload from the client computer and click [OK].

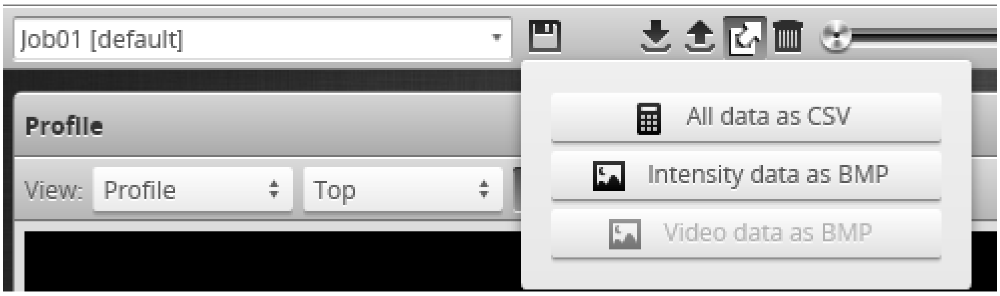
» The replay data is loaded, and a new unsaved, untitled job is created.

Replay data can be exported using the CSV format. If you have enabled [Acquire Intensity] in the [Scan Mode] panel on the [Scan] page, the exported CSV file includes intensity data.

For information about [Scan Mode], see "4.4.2 Scan Modes" on page 116.

Tips

Surface intensity data cannot be exported to the CSV format. It can only be exported separately as a bitmap.



To export replay data in the CSV format:

1 **Switch to Replay mode.**

2 **Click the Export button and select [All Data as CSV].**

» In Profile mode, all data in the record buffer is exported.

» In Surface mode, only data at the current replay location is exported.

Use the playback control buttons to move to a different replay location; for information on playback, see To replay data in "■Recording, Playback, and Measurement Simulation" on page 81.

(Optional) Convert exported data to another format using the CSV Converter Tool. For information on this tool, see "12.2 CSV Converter Tool" on page 974.

Tips

The decision values in the exported data depend on the current state of the job, not the state during recording. For example, if you record data when a measurement returns a pass decision, change the measurement's settings so that a fail decision is returned, and then export to CSV, you will see a fail decision in the exported data.

Recorded intensity data can be exported to a bitmap (.BMP format). [Acquire Intensity] must be checked in the [Scan Mode] panel while data was being recorded in order to export intensity data.

For information about [Scan Mode], see "4.4.2 Scan Modes" on page 116.

To export recorded intensity data to the BMP format:

1 **Switch to Replay mode and click the [Export] button and select [Intensity data as BMP].**

» Only the intensity data in the current replay location is exported.

Use the playback control buttons to move to a different replay location; for information on playback, see To replay data in "■Recording, Playback, and Measurement Simulation" on page 81.

To export video data to a BMP file:

1 **Switch to Replay mode.**

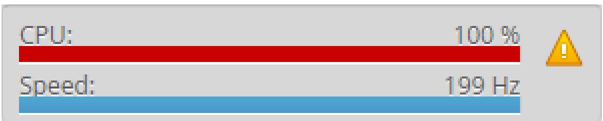
2 **Click the Export button and select [Video data as BMP].**

Use the playback control buttons to move to a different replay location; for information on playback, see To replay data in "■Recording, Playback, and Measurement Simulation" on page 81.

4.2.2 Metrics Area

The [Metrics] area displays two important sensor performance metrics: CPU load and speed (current frame rate).

The [CPU] bar in the [Metrics] panel (at the top of the interface) displays how much of the CPU is being utilized. A warning symbol ( ) will appear next to the [CPU] bar if the sensor drops data because the CPU is over-loaded.



CPU at 100%

The [Speed] bar displays the frame rate of the sensor. A warning symbol ( ) will appear next to it if triggers (external input or encoder) are dropped because the external rate exceeds the maximum frame rate.

Open the log for details on the warning. For more information on logs, see "■Log" on page 88.

When a sensor is accelerated a "rocket" icon appears in the metrics area.

4.2.3 Data Viewer

The data viewer is displayed in both the [Scan] and the [Measure] pages, but displays different information depending on which page is active.

- When the [Scan] page is active, the data viewer displays sensor data and can be used to adjust the active area and other settings. Depending on the selected operation mode, the data viewer can display video images, profiles, sections, or surfaces. For details, 📖"4.4.8 Data Viewer" on page 156.
- When the [Measure] page is active, the data viewer displays sensor data onto which representations of measurement tools and their measurements are superimposed. For details, see 📖"■Data Viewer" on page 232.

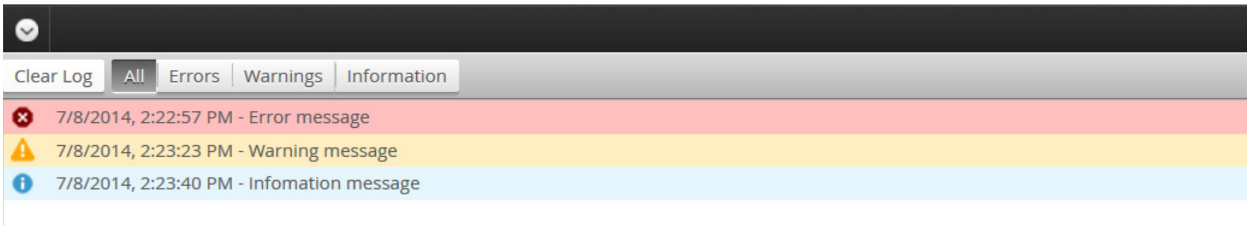
4.2.4 Status Bar

The status bar lets you do the following:

- See sensor messages in the log.
- See frame information.
- Change the interface language.
- Switch to Quick Edit mode.

■ Log

The log, located at the bottom of the web interface, is a centralized location for all messages that the sensor displays, including warnings and errors.



A number indicates the number of unread messages:

To use the log:

1 Click on the Log open button at the bottom of the web interface.

2 Click on the appropriate tab for the information you need.

Frame Information

The area to the right of the status bar displays useful frame information, both when the sensor is running and when viewing recorded data.

This information is especially useful when you have enabled recording filtering. If you look at a recording playback, when you have enabled recording filtering, some frames can be excluded, resulting in variable "gaps" in the data.

The following information is available:

- [Frame Index]: Displays the index in the data buffer of the current frame. The value resets to 0 when the sensor is restarted or when recording is enabled.
- [Master Time]: Displays the recording time of the current frame, with respect to when the sensor was started.
- [Encoder Index]: Displays the encoder value at the time of the last encoder Z index pulse. Note this is not the same as the encoder value at the time the frame was captured.
- [Timestamp]: Displays the timestamp the current frame, in microseconds from when the sensor was started.

To switch between types of frame information:

- Click the frame information area to switch to the next available type of information.

Quick Edit Mode

When working with a very large number of measurement tools (for example, a few dozen) or a very complex user-created GDK tool, you can switch to a "Quick Edit" mode to make configuration faster.

When this mode is enabled, the data viewer and measurement results are not refreshed after each setting change. Also, when Quick Edit is enabled, in Replay mode, stepping through frames or playing back scan data does not change the displayed frame.

Tips

When a sensor is running, Quick Edit mode is ignored: all changes to settings are reflected immediately in the data viewer.

■ Interface Language

The language button on the right side of the status bar at the bottom of the web interface lets you change the language of the web interface.

To change the language:

1 Click the language button at the bottom of the web interface.

2 Choose a language from the list.

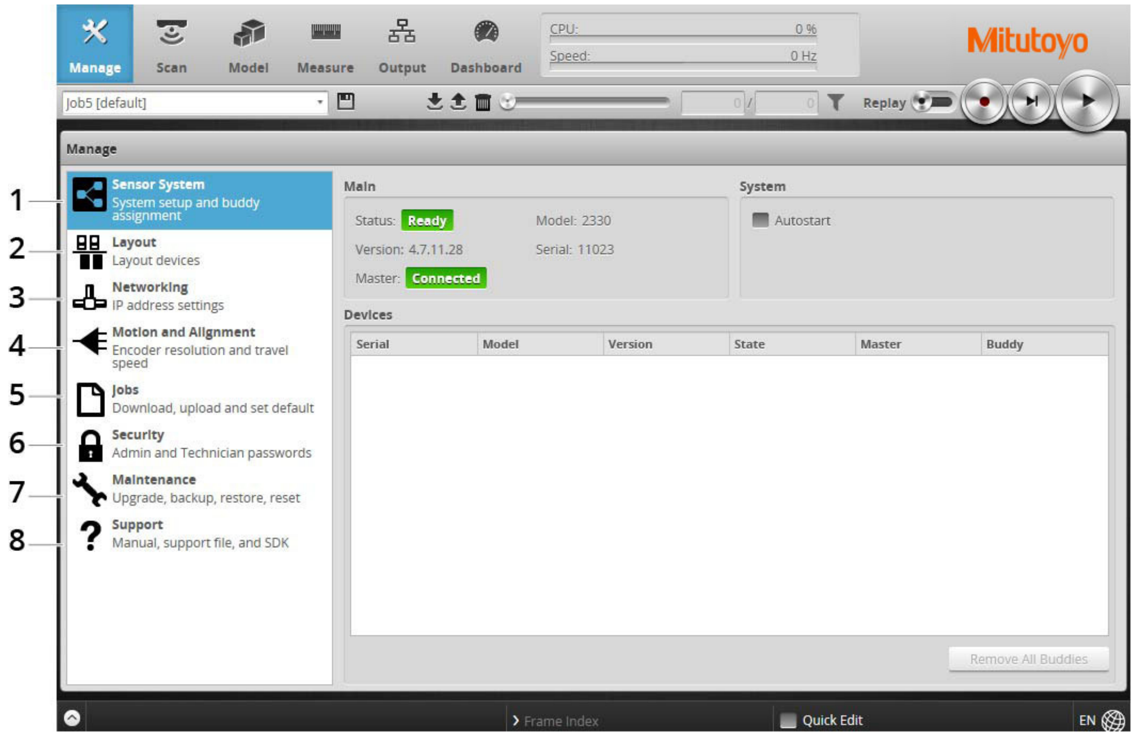
» The interface reloads on the page you were working in, displaying the page using the language you chose. The sensor state is preserved.

4.3 Management and Maintenance

The following sections describe how to set up the sensor connections and networking, how to calibrate encoders and choose the alignment reference, and how to perform maintenance tasks.

4.3.1 Manage Page Overview

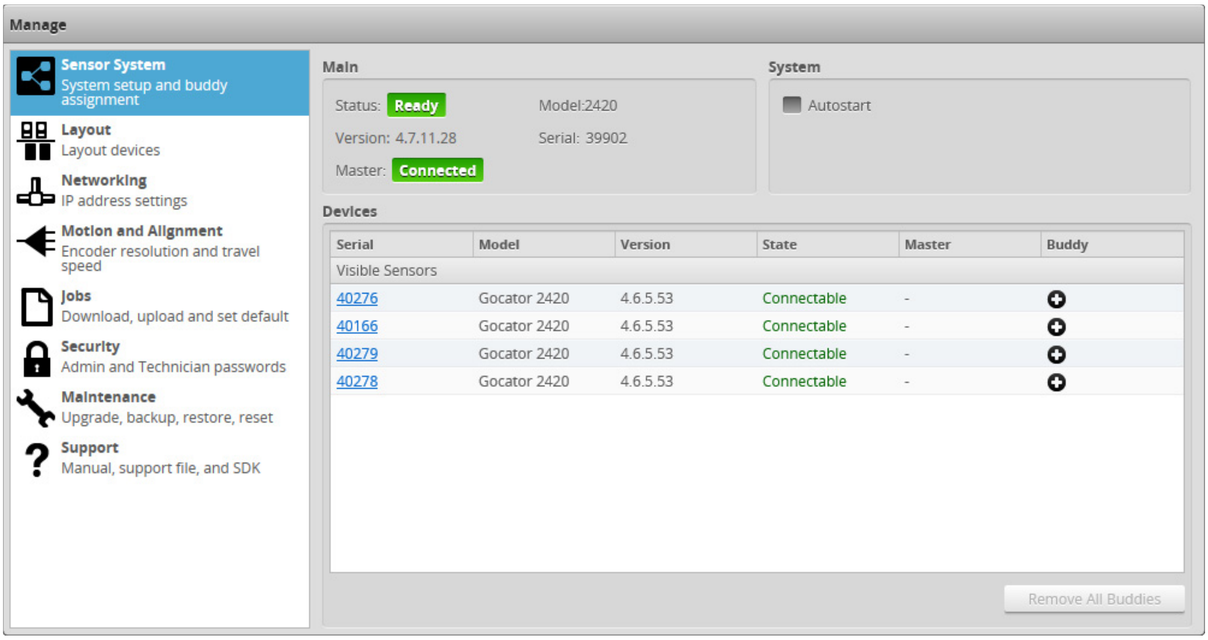
The sensor's system and maintenance tasks are performed on the [Manage] page.



	Element	Description
1	[Sensor System]	Contains sensor information, buddy assignment, and the autostart setting. See "4.3.2 Sensor System" on page 92.
2	[Layout]	Contains settings for configuring dual- and multi-sensor system layouts.
3	[Networking]	Contains settings for configuring the network. See "4.3.4 Networking" on page 104.
4	[Motion and Alignment]	Contains settings to configure the encoder. See "4.3.5 Motion and Alignment" on page 105.
5	[Jobs]	Lets you manage jobs stored on the sensor. See "4.3.6 Jobs" on page 107.
6	[Security]	Lets you change passwords. See "4.3.7 Security" on page 109.
7	[Maintenance]	Lets you upgrade firmware, create/restore backups, and reset sensors. See "4.3.8 Maintenance" on page 110.
8	[Support]	Lets you open an HTML version or download a PDF version of the manual, download the SDK, or save a support file. Also provides device information. See "4.3.9 Support" on page 112

4.3.2 Sensor System

The following sections describe the [Sensor System] category on the [Manage] page. This category provides sensor information and the autostart setting. It also lets you choose which sensors to add to a dual- or multi-sensor system.



■ Dual- and Multi-sensor Systems

SurfaceMeasure1008S supports dual- and multi-sensor systems. In these systems, data from each sensor is combined into a single profile or surface, effectively creating a wider field of view. Any measurements you configure work on the combined data.

You set up dual- and multi-sensor systems from the web interface. Setting up these systems involves two steps:

1 Assigning one or more additional sensors, called Buddy sensors, to the Main sensor.

For more information, see 📖 "●Buddy Assignment" on page 93

2 Choosing the layout of the dual- or multi-sensor system.

For more information, see 📖 "4.3.3 Layout" on page 96.

● Mixed-Model Systems

Tips

When combining different models in a single system that uses uniform data point spacing ([Uniform Spacing] is enabled in the [Scan Mode] panel), the minimum X resolution of the lowest resolution sensor limits the minimum X spacing of the entire system.

When combining non-matching models in a system that does not use uniform spacing, all sensors use their native X resolution. Typically, when using different models in a single system, you will want to use non-uniform spacing.

For more information on setting X spacing, see 📖 "●Spacing Interval" on page 136. For more information on uniform spacing, see 📖 "3.2.2 Uniform Data and Raw Data" on page 61.

It's important to note that when you assign Buddy sensors in a mixed-model system, SurfaceMeasure1008S uses the Main sensor's default scanning values for the Buddy sensors, which may be incompatible with the Buddy sensors and may prevent the system from starting or performing an alignment. For this reason, after assigning Buddy sensors in a mixed-model system, ensure that the settings for each Buddy sensor in the [Sensor] panel on the [Scan] page all have valid and in-range value (no errors indicated in the setting fields). For more information, see 📖 "4.4.4 Sensor" on page 123.

● Buddy Assignment

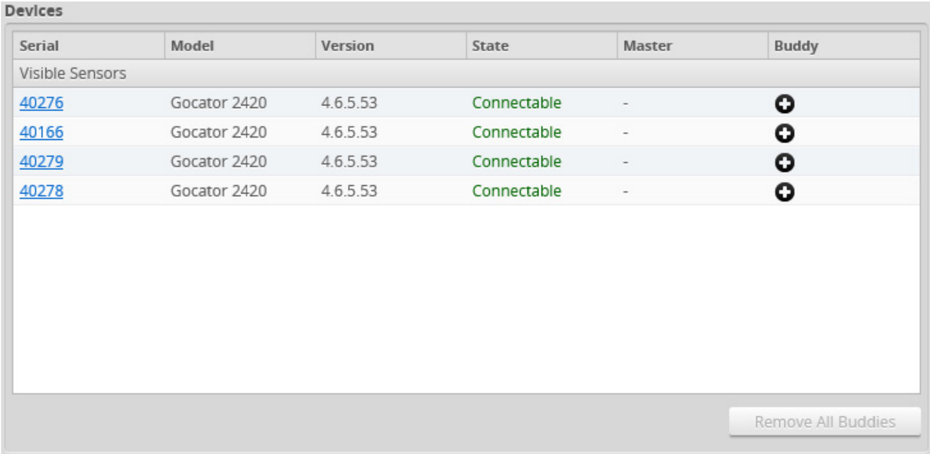
In a dual- or multi-sensor system, the Main sensor controls the other sensors, called the Buddy sensors, after a Buddy sensor is assigned to the Main sensor. You configure both sensors through the Main sensor's interface.

For information on mixed-model systems, see 📖 "●Mixed-Model Systems" on page 93.

Tips

Main and Buddy sensors must be assigned unique IP addresses before they can be used on the same network. Before proceeding, connect the Main and Buddy sensors one at a time (to avoid an address conflict) and use the steps described in Running a Dual-Sensor System (page 30) to assign each sensor a unique address.

Tips
When a sensor is acting as a Buddy, it is not discoverable and its web interface is not accessible.


Devices

Serial	Model	Version	State	Master	Buddy
Visible Sensors					
40276	Gocator 2420	4.6.5.53	Connectable	-	
40166	Gocator 2420	4.6.5.53	Connectable	-	
40279	Gocator 2420	4.6.5.53	Connectable	-	
40278	Gocator 2420	4.6.5.53	Connectable	-	

Remove All Buddies

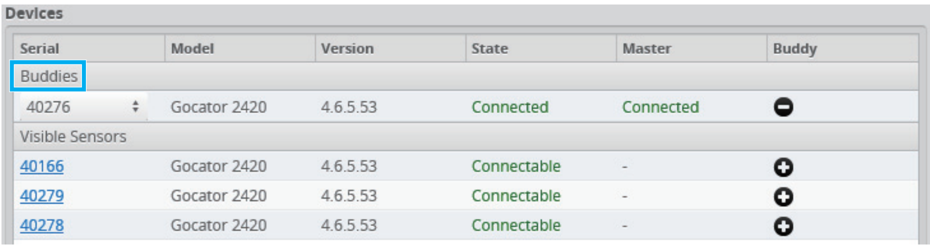
Tips
A sensor can only be assigned as a Buddy if its firmware matches the firmware of the Main sensor and it belongs to the same series as the Main sensor.

To assign a Buddy sensor:

1 **Go to the [Manage] page and click on the [Sensor System] category.**

2 **In the [Visible Sensors] list, click the "plus" icon next to the sensor you want to add as a Buddy.**

» The sensor you added to the system appears in a [Buddies] list.


Devices

Serial	Model	Version	State	Master	Buddy
Buddies					
40276	Gocator 2420	4.6.5.53	Connected	Connected	
Visible Sensors					
40166	Gocator 2420	4.6.5.53	Connectable	-	
40279	Gocator 2420	4.6.5.53	Connectable	-	
40278	Gocator 2420	4.6.5.53	Connectable	-	

3 **Repeat the previous step to add more sensors to the system.**

After you have assigned the desired number of Buddy sensors, you must specify system's layout. For more information, see "4.3.3 Layout" on page 96. Additionally, after assigning Buddy sensors in a mixed-model system, ensure that the settings for each Buddy sensor in the [Sensor] panel on the [Scan] page all have valid and in-range value (no errors indicated in the setting fields). For more information, see "4.4.4 Sensor" on page 123.

To remove a Buddy, click the "minus" icon next to the sensor you want to remove. To remove all Buddies, click [Remove All Buddies].

■ Over Temperature Protection

Sensors equipped with a 3B-N laser by default will turn off the laser if the temperature exceeds the safe operating range. You can override the setting by disabling the overheat protection.

⚠ Disabling the setting is not recommended. Disabling the overheat protection feature could lead to premature laser failure if the sensor operates outside the specified temperature range.

To enable/disable overheat temperature protection:

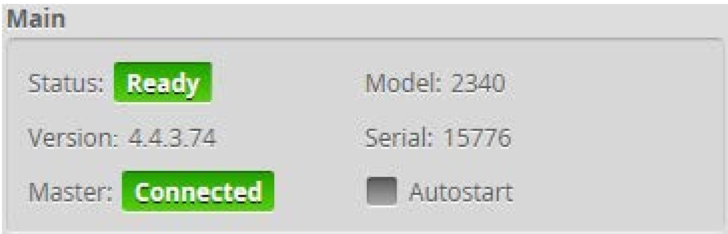
1 Check/uncheck the [Over Temperature Shutoff] option.

2 Save the job file.

■ Sensor Autostart

With the [Autostart] setting enabled, scanning and measurements begin automatically when the sensor is powered on.

Autostart must be enabled if the sensor will be used without being connected to a computer.



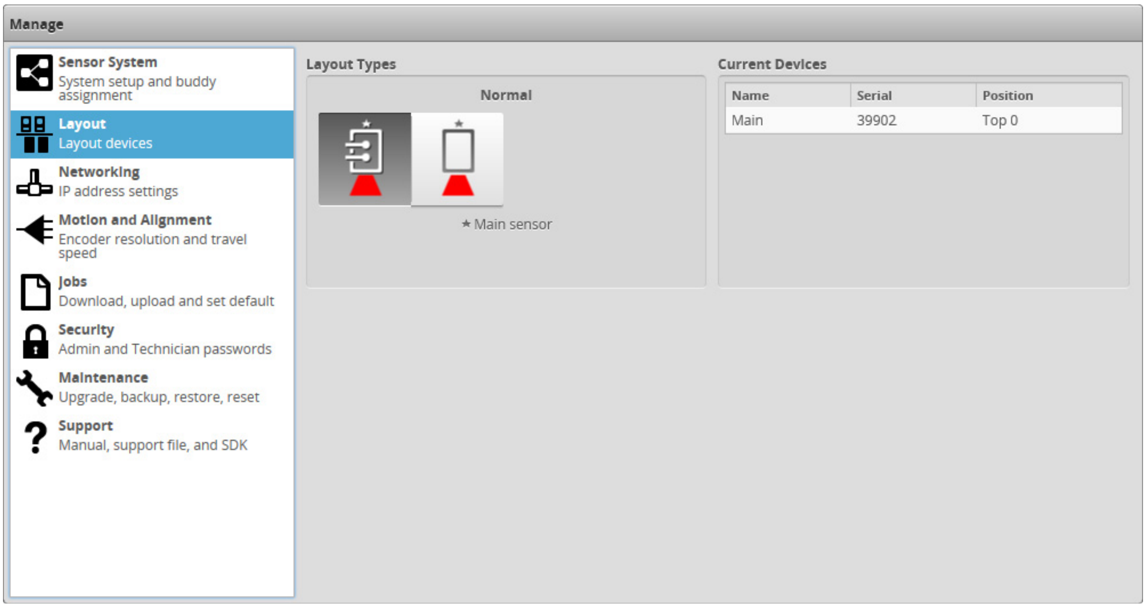
To enable/disable Autostart:

1 Go to the [Manage] page and click on the [Sensor System] category.

2 Check/uncheck the [Autostart] option in the [Main] section.

4.3.3 Layout

The following sections describe the [Layout] category on the [Manage] page. This category lets you configure dual- and multi-sensor systems.

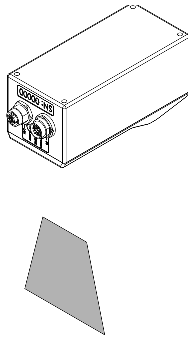
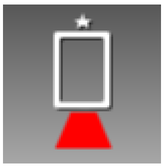
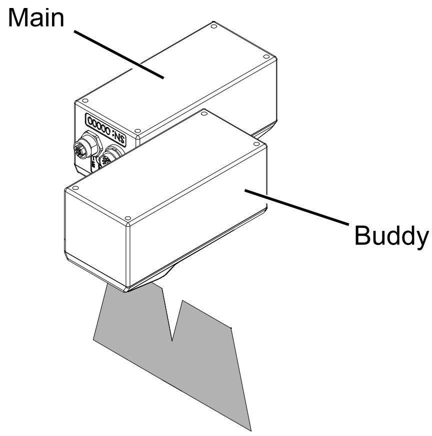
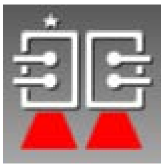
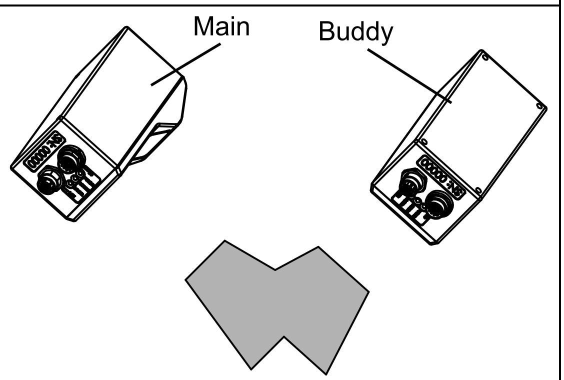
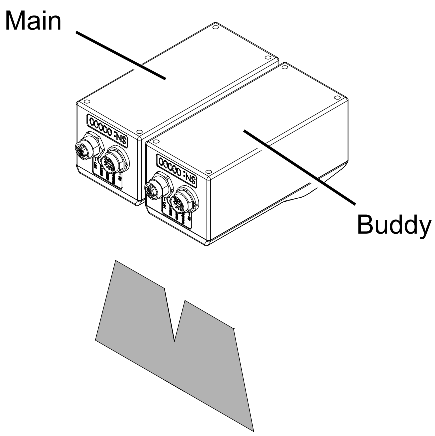


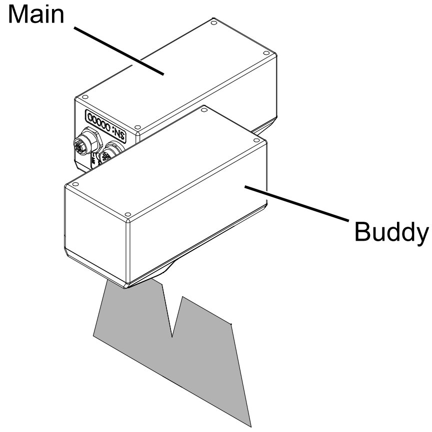
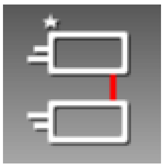
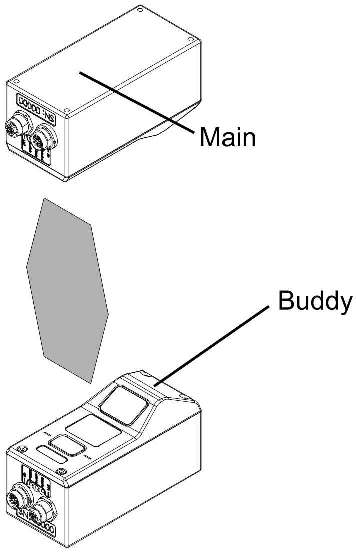
Mounting orientations must be specified for a dual- or multi-sensor system. This information allows the alignment procedure to determine the correct system-wide coordinates for laser profiling and measurements. For more information on sensor and system coordinates, see 📖 "3.2.1 Coordinate Systems" on page 56.

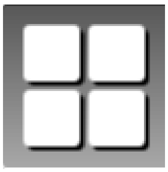
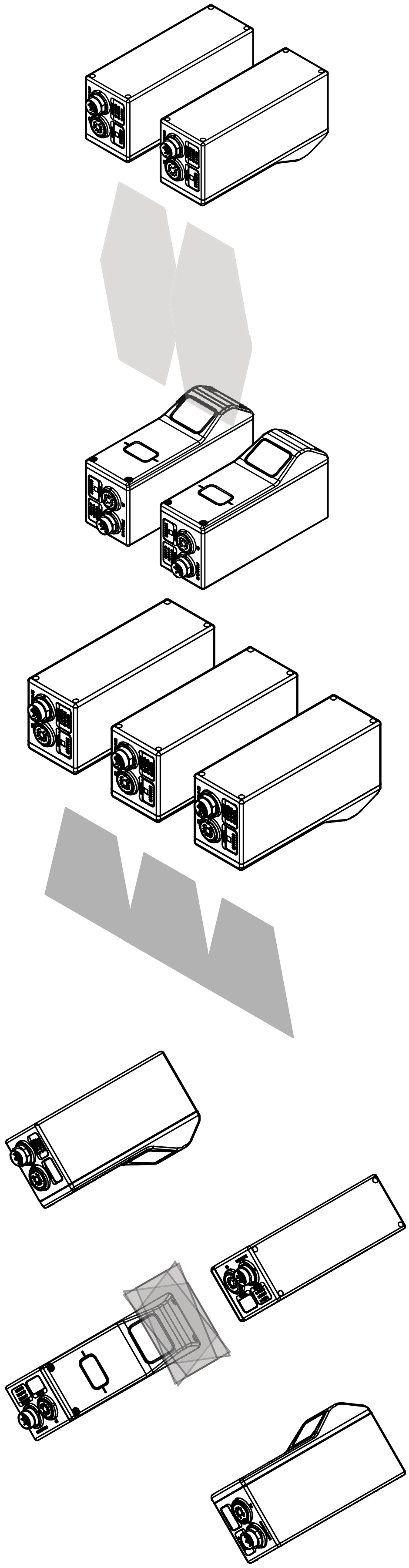
Tips
Dual- and multi-sensor layouts are only displayed when a Buddy sensor has been assigned.

Tips
For multi-sensor layouts with sensors angled around the Y axis, to get "side" data, you must uncheck Uniform Spacing before scanning. The Y offset, X angle, and Z angle transformations cannot be non-zero when Uniform Spacing is unchecked. Therefore, when aligning a sensor using a bar alignment target with [Uniform Spacing] unchecked, set the [Degrees of Freedom] setting to [X, Z, Y Angle], which prevents these transformations from being non-zero.

Supported Layouts

	Layout Type	Example
	[Normal] The sensor operates as an isolated device.	
	[Reverse] The sensor operates as an isolated device, but in a reverse orientation. You can use this layout to change the handedness of the data.	
	[Wide] Sensors are mounted in Left (Main) and Right (Buddy) positions. This allows for a larger combined field of view. Sensors may be angled around the Y axis to avoid occlusions.	 

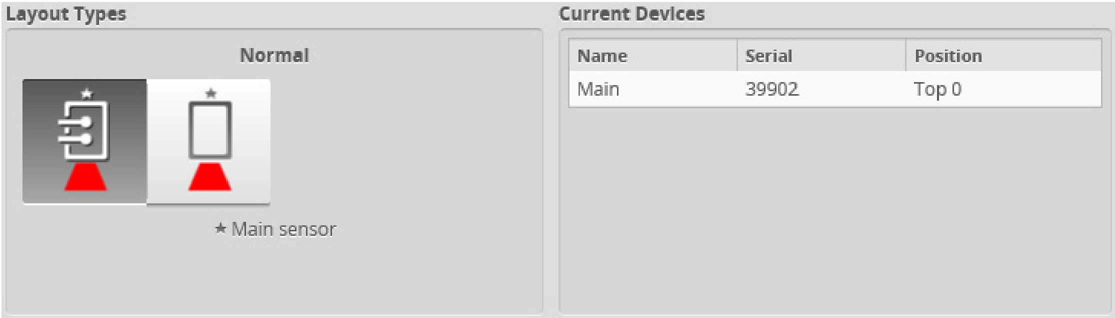
	Layout Type	Example
	[Reverse] Sensors are mounted in a left-right layout as with the Wide layout, but the Buddy sensor is mounted such that it is rotated 180 degrees around the Z axis to prevent occlusion along the Y axis. Sensors should be shifted along the Y axis so that the laser lines align.	
	[Opposite] Sensors are mounted in Top (Main) and Bottom (Buddy) positions for a larger combined measurement range and the ability to perform Top/Bottom differential measurements.	

	Layout Type	Example
	[Grid] For systems composed of three or more sensors. Sensors can be mounted in a 2-dimensional grid using the settings in the [Layout Grid] area below. Side-by-side and top-bottom configurations are supported, as well as combinations of these and reversed orientations.	

To specify a standalone layout:

1 **Go to the [Manage] page and click on the [Layout] category.**

2 **Under [Layout Types], choose Normal or Reverse layout by clicking one of the layout buttons.**



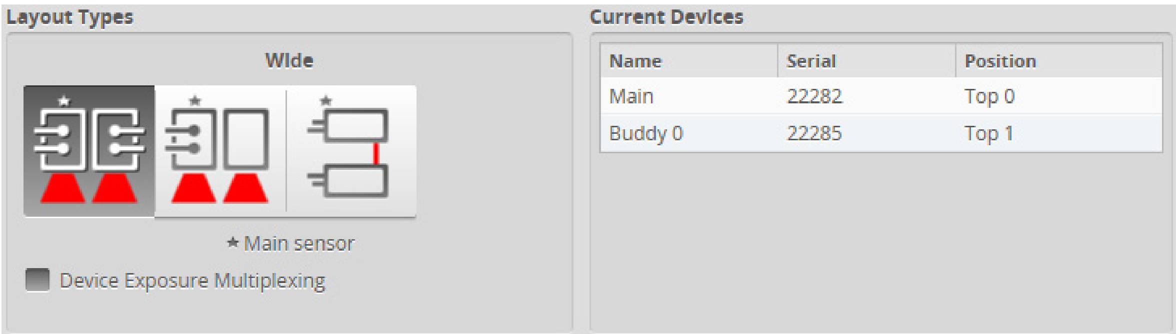
See the table above for information on layouts.

Tips
Before you can select a dual-sensor layout, you must assign a second sensor as the Buddy sensor. For more information, see 📖 "■Dual- and Multi-sensor Systems" on page 92.

To specify a dual-sensor layout:

1 **Go to the [Manage] page and click on the [Layout] category.**

2 **Under [Layout Types], choose a layout by clicking one of the layout buttons.**



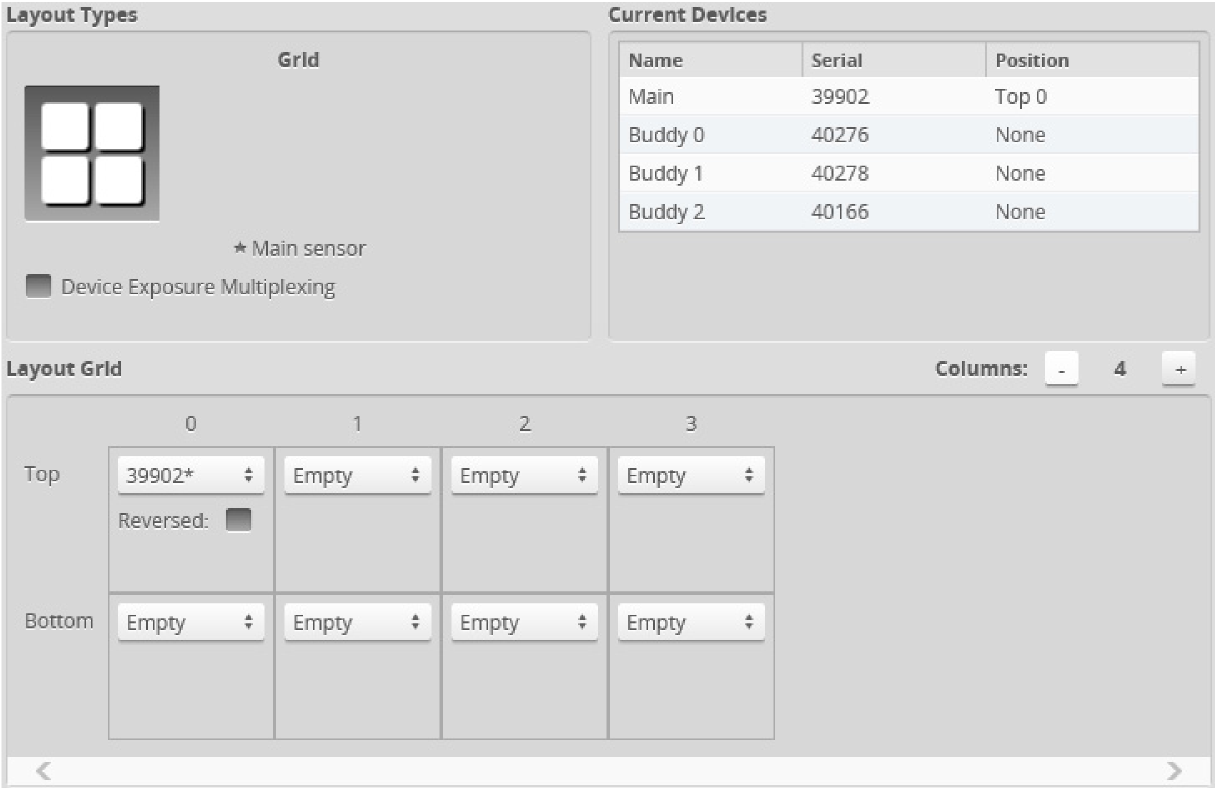
See the table above for information on layouts.

Tips
Before you can select a multi-sensor layout, you must assign two or more additional sensors as Buddy sensors. For more information, see 📖 "■Dual- and Multi-sensor Systems" on page 92.

To specify a multi-sensor layout:

1 **Go to the [Manage] page and click on the [Layout] category.**

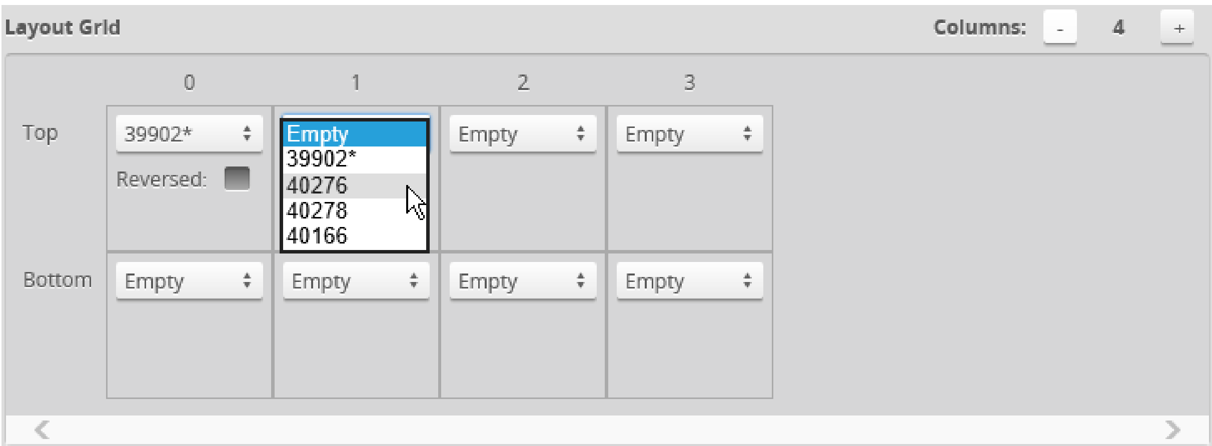
2 **Under [Layout Grid], click the "plus" icon to the right to add the desired number of columns in the grid.**



» The Main sensor is automatically assigned to the first cell.

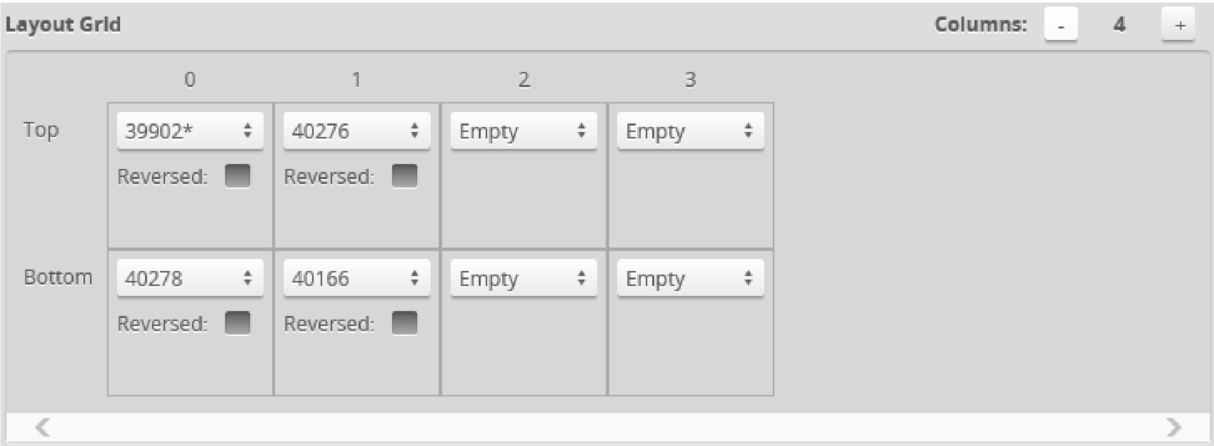
You can however assign the Main sensor to any cell.

3 **Choose a sensor from the drop-down in each cell you want to populate.**



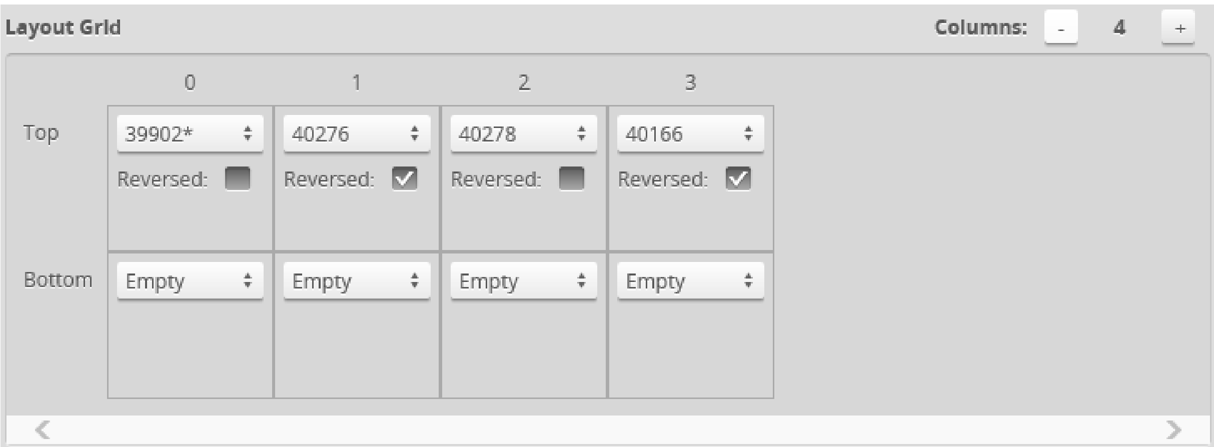
The following shows the layout of a four-sensor Wide system:

The following shows the layout of a four-sensor system, with two sensors on the top and two sensors on the bottom:



See the table above for more information on layouts.

4 **(Optional) For each sensor mounted in a reversed orientation in relation to the Main sensor (rotated 180 degrees around the Z axis to avoid occlusions), check the [Reversed] option.**

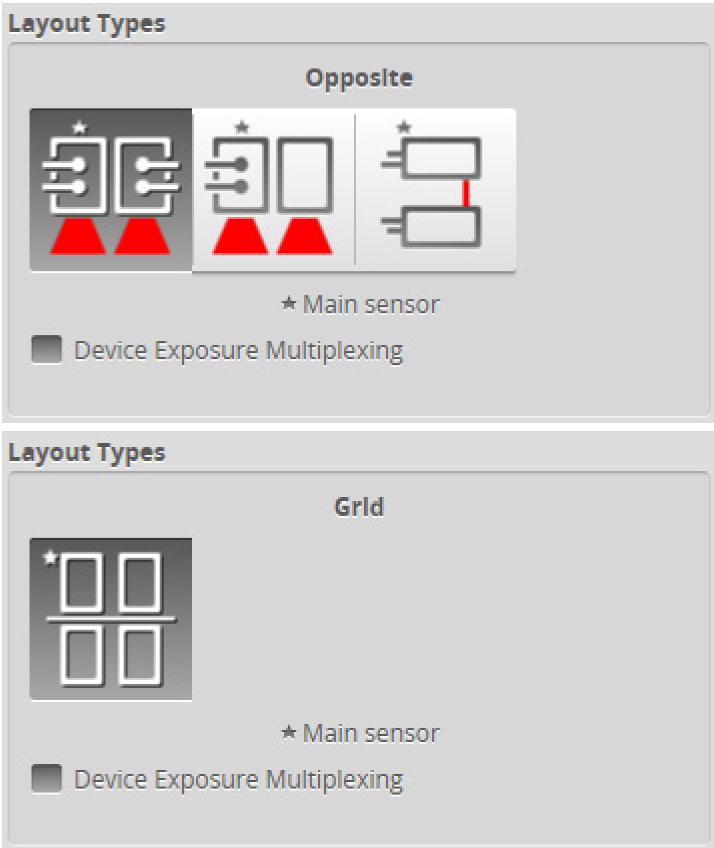


You must assign all Buddy sensors to a cell in the layout grid. Otherwise, the system will not run.

You can configure dual- and multi-sensor systems so that there is a slight delay between the exposures of sensors or groups of sensors to eliminate laser interference, using the [Device Exposure Multiplexing] setting. For more information, see 📖 "■Device Exposure Multiplexing" on page 103.

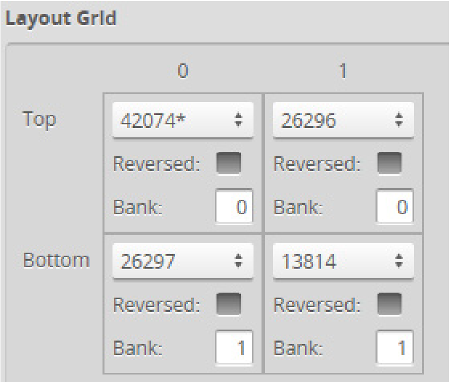
■ Device Exposure Multiplexing

If the sensors in a dual- or multi-sensor system are mounted such that the camera from one sensor can detect the laser line from the other sensor, the [Device Exposure Multiplexing] option should be used to eliminate laser interference. This setting creates a time offset for laser exposures and ensures that interfering lasers are not triggered at the same time. Using this setting may reduce the maximum frame rate.



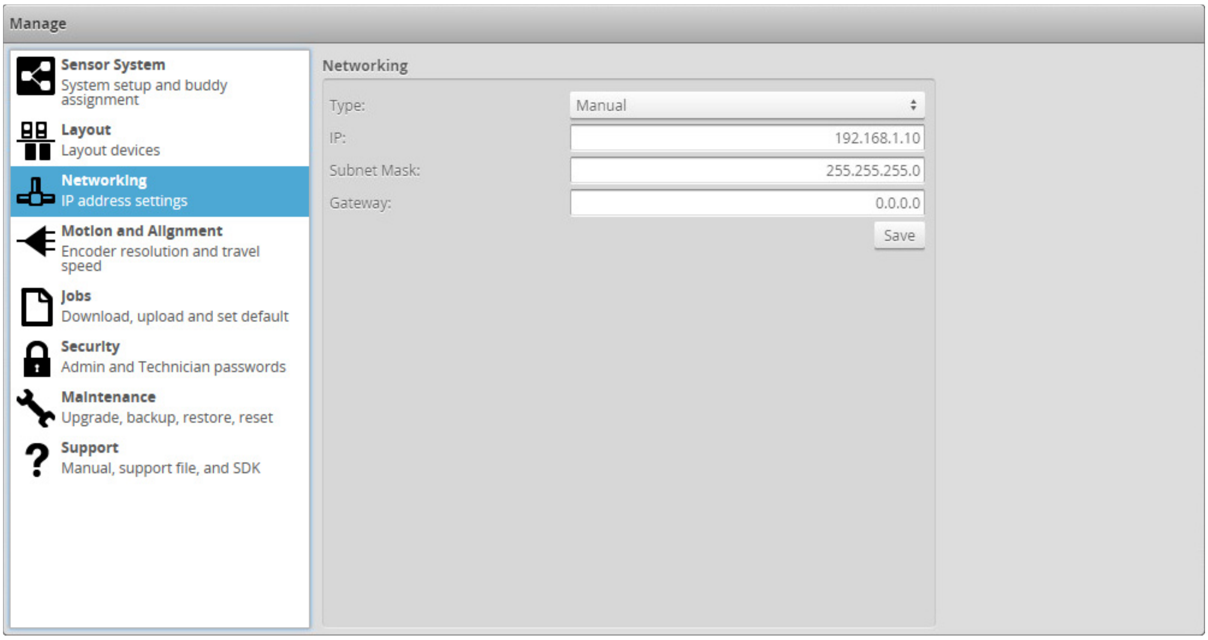
To enable/disable exposure multiplexing:

1. **Go to the [Manage] page and click on the [Sensor System] category.**
2. **In the Layout section, check/uncheck the [Device Exposure Multiplexing] option.**
   This option is only displayed if a buddy is assigned.
3. **(Optional) If the system contains more than two sensors, assign the sensors to different banks.**



4.3.4 Networking

The [Networking] category on the [Manage] page provides network settings. Settings must be configured to match the network to which the sensors are connected.



To configure the network settings:

1 Go to the [Manage] page.

2 In the [Networking] category, specify the Type, IP, Subnet Mask, and Gateway settings.

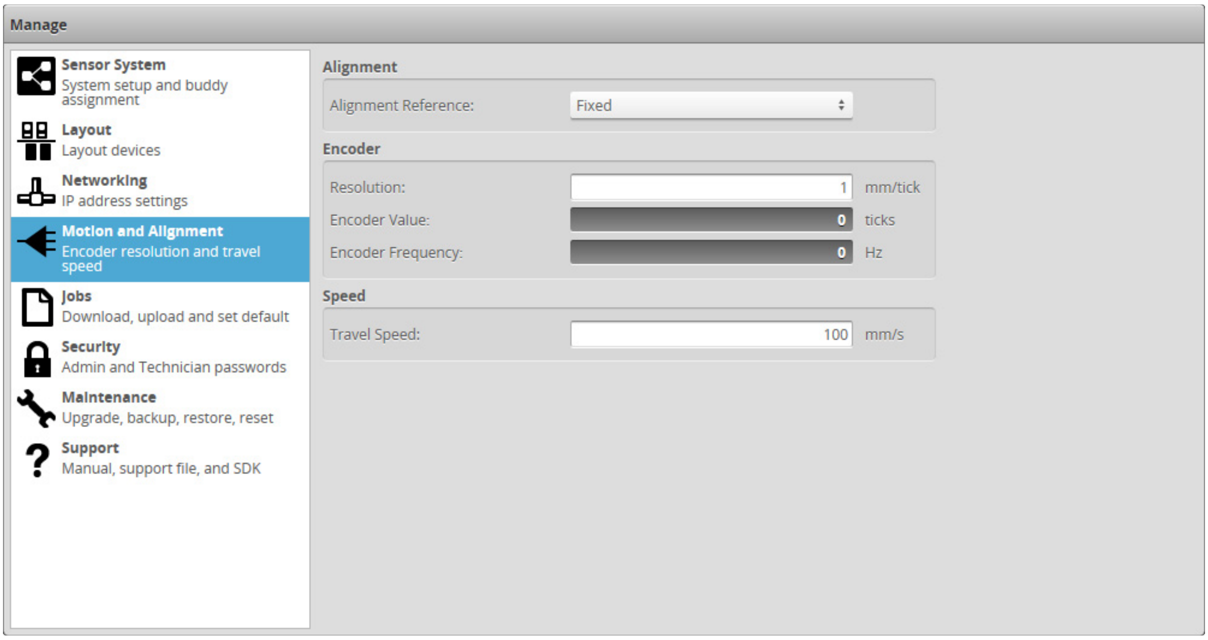
The sensor can be configured to use DHCP or assigned a static IP address by selecting the appropriate option in the [Type] drop-down.

3 Click on the [Save] button.

You will be prompted to confirm your selection.

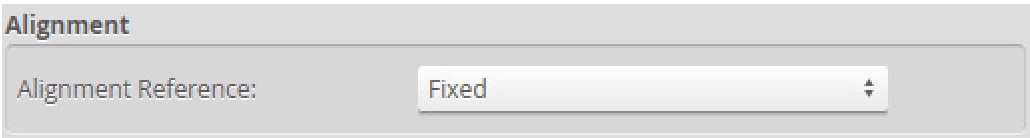
4.3.5 Motion and Alignment

The [Motion and Alignment] category on the [Manage] page lets you configure alignment reference, encoder resolution, and travel speed, and confirm that encoder signals are being received by the sensor.



■ Alignment Reference

The [Alignment Reference] setting can have one of two values: [Fixed] or [Dynamic].



Setting	Description
[Fixed]	A single, global alignment is used for all jobs. This is typically used when the sensor mounting is constant over time and between scans, for example, when the sensor is mounted in a permanent position over a conveyor belt.
[Dynamic]	A separate alignment is used for each job. This is typically used when the sensor's position relative to the object scanned is always changing, for example, when the sensor is mounted on a robot arm moving to different scanning locations.

To configure alignment reference:

1 Go to the [Manage] page and click on the [Motion and Alignment] category.

2 In the Alignment section, choose [Fixed] or [Dynamic] in the [Alignment Reference] dropdown.

■ Encoder Resolution

You can manually enter the encoder resolution in the [Resolution] setting, or it can be automatically set by performing an alignment with [Type] set to [Moving] and enabling [Encoder or Speed Calibration]; for more information on performing alignment, see "4.5 Aligning Sensors" on page 171.

Establishing the correct encoder resolution is required for correct scaling of the scan of the target object in the direction of travel.

Encoder resolution is expressed in millimeters per tick, where one tick corresponds to one of the four encoder quadrature signals (A+ / A- / B+ / B-).

> **Tips**
> Encoders are normally specified in pulses per revolution, where each pulse is made up of the four quadrature signals (A+ / A- / B+ / B-). Because the sensor reads each of the four quadrature signals, you should choose an encoder accordingly, given the resolution required for your application.

To configure encoder resolution:

1. **Go to the [Manage] page and click on the [Motion and Alignment] category.**

2. **In the [Encoder] section, enter a value in the [Resolution] field.**

● Encoder Value and Frequency

The encoder value and frequency are used to confirm the encoder is correctly wired to the sensor and to manually calibrate encoder resolution (that is, by moving the conveyor system a known distance and making a note of the encoder value at the start and end of movement).

■ Travel Speed

The [Travel Speed] setting is used to correctly scale scans in the direction of travel in systems that lack an encoder but have a conveyor system that is controlled to move at constant speed. Establishing the correct travel speed is required for correct scaling of the scan in the direction of travel.

Travel speed is expressed in millimeters per second.

To manually configure travel speed:

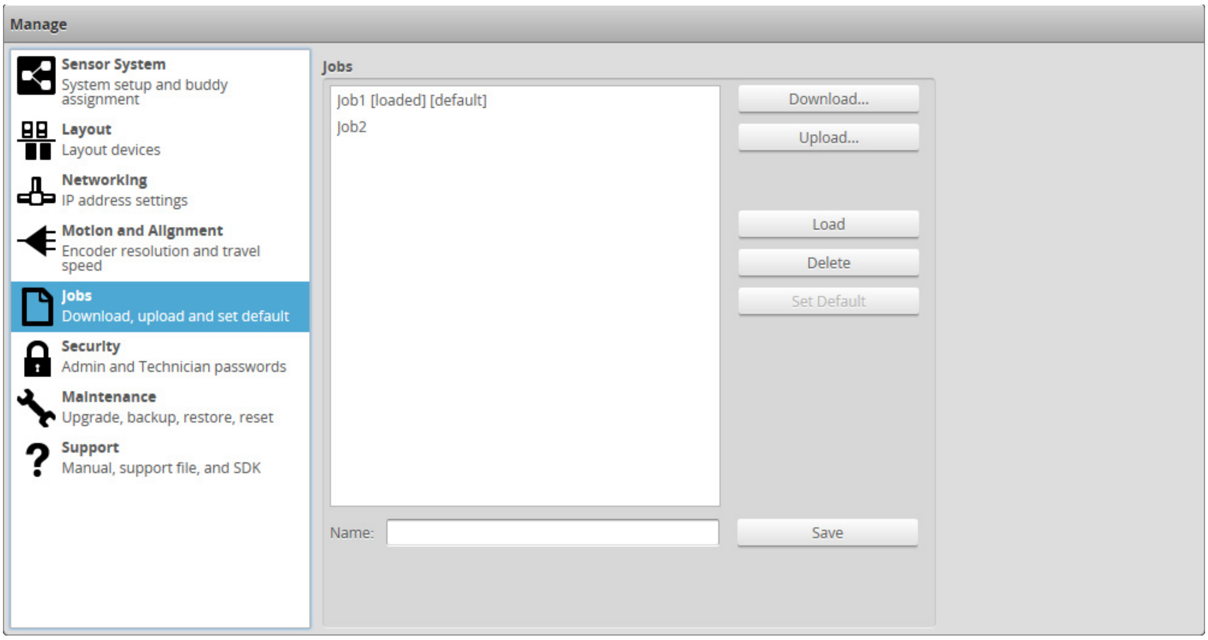
1 Go to the [Manage] page and click on the [Motion and Alignment] category.

2 In the [Speed] section, enter a value in the [Travel Speed] field.

Travel speed can also be set automatically by performing an alignment with [Type] set to [Moving] (see "4.5 Aligning Sensors" on page 171).

4.3.6 Jobs

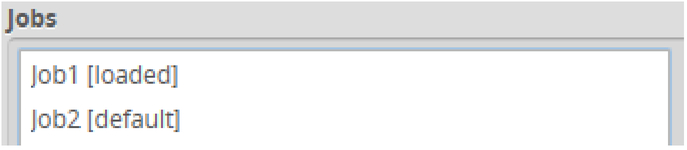
The [Jobs] category on the [Manage] page lets you manage the jobs stored on a sensor.



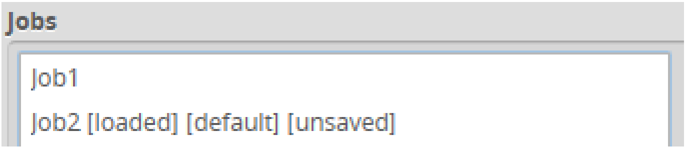
Element	Description
[Name] field	Used to provide a job name when saving files.
[Jobs] list	Displays the jobs that are currently saved in the sensor's flash storage.
[Save] button	Saves current settings to the job using the name in the [Name] field.
[Load] button	Loads the job that is selected in the job list. Reloading the current job discards any unsaved changes.

Element	Description
[Delete] button	Deletes the job that is selected in the job list.
[Set Default] button	Sets the selected job as the default to be loaded when the sensor starts. When the default job is selected, this button is used to clear the default.
[Download...] button	Downloads the selected job to the client computer.
[Upload...] button	Uploads a job from the client computer.

Jobs can be loaded (currently activated in sensor memory) and set as default independently. For example, Job1 could be loaded, while Job2 is set as the default. Default jobs load automatically when a sensor is power cycled or reset.



Unsaved jobs are indicated by "[unsaved]".



To save a job:

1. **Go to the [Manage] page and click on the [Jobs] category.**
2. **Provide a name in the [Name] field.**

   To save an existing job under a different name, click on it in the [Jobs] list and then modify it in the [Name] field.
3. **Click on the [Save] button or press [Enter].**

   » Saving a job automatically sets it as the default, that is, the job loaded when then sensor is restarted.

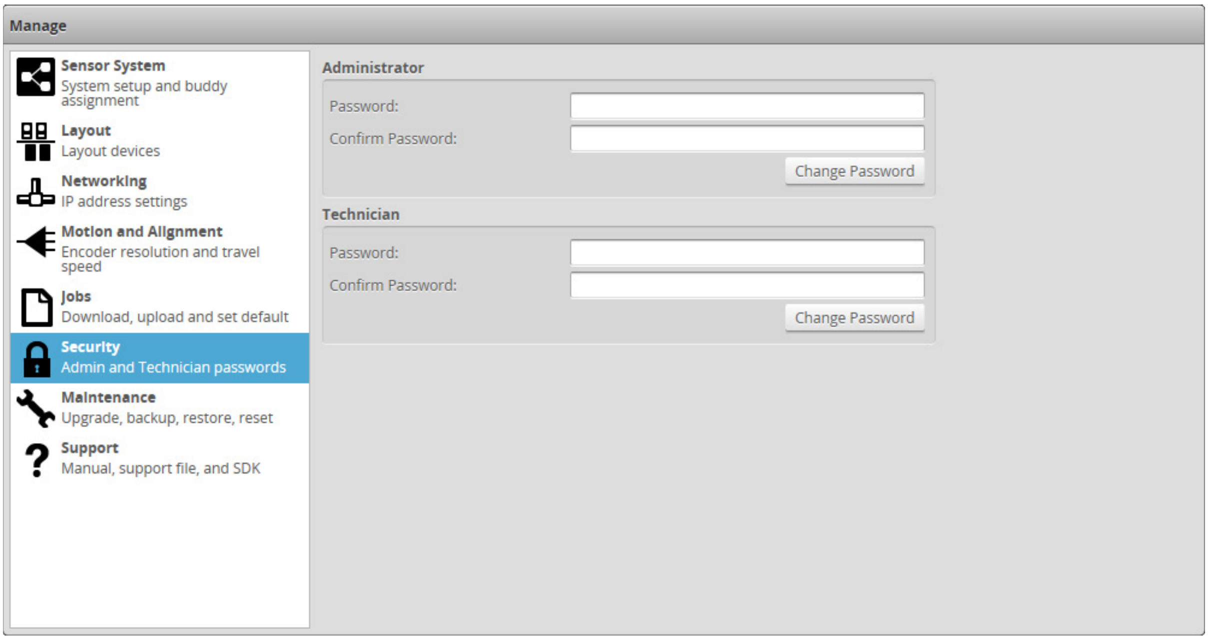
To download, load, or delete a job, or to set one as a default, or clear a default:

1. **Go to the [Manage] page and click on the [Jobs] category.**
2. **Select a job in the [Jobs] list.**
3. **Click on the appropriate button for the operation.**

4.3.7 Security

You can prevent unauthorized access to a sensor by setting passwords. Each sensor has two accounts: Administrator and Technician.

By default, no passwords are set. When you start a sensor, you are prompted for a password only if a password has been set.



Account Types

Account	Description
[Administrator]	The Administrator account has privileges to use the toolbar (loading and saving jobs, recording and viewing replay data), to view all pages and edit all settings, and to perform setup procedures such as sensor alignment.
[Technician]	The Technician account has privileges to use the toolbar (loading and saving jobs, recording and viewing replay data), to view the [Dashboard] page, and to start or stop the sensor.

The Administrator and Technician accounts can be assigned unique passwords.

To set or change the password for the Administrator account:

1 **Go to the [Manage] page and click on the [Security] category.**

2 **In the [Administrator] section, enter the Administrator account password and password confirmation.**

3 **Click [Change Password].**

The new password will be required the next time that an administrator logs in to the sensor.

To set or change the password for the Technician account:

1. **Go to the [Manage] page and click on the [Security] category.**

2. **In the [Technician] section, enter the Technician account password and password confirmation.**

3. **Click [Change Password].**

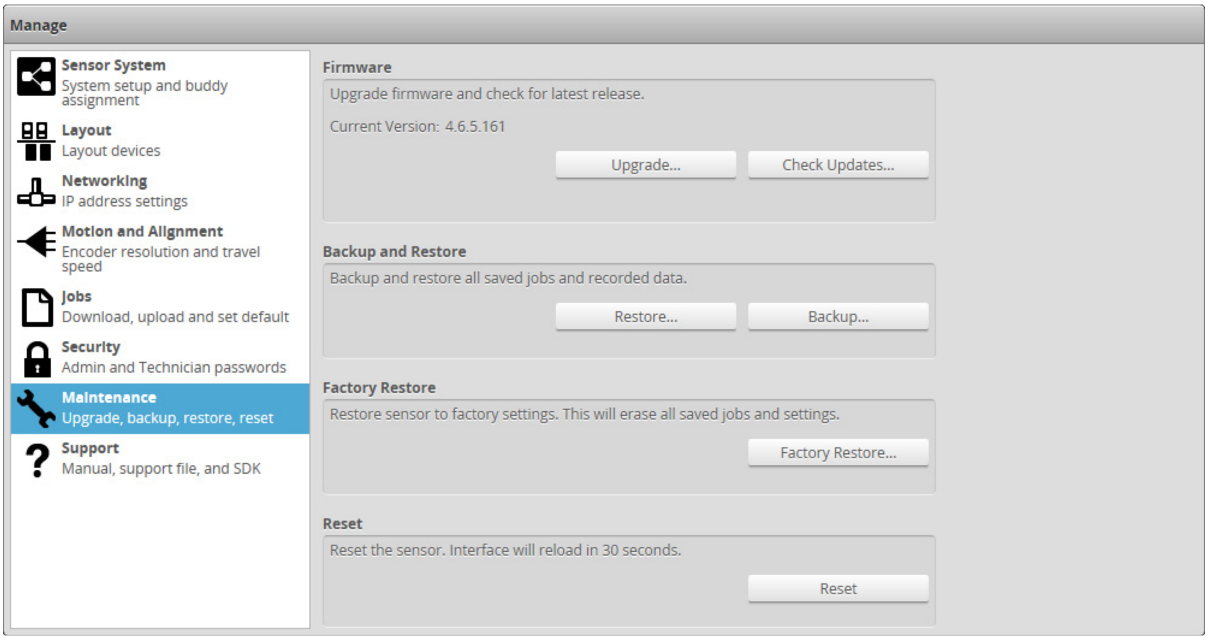
   The new password will be required the next time that a technician logs in to the sensor.

If the administrator or technician password is lost, the sensor can be recovered using a special software tool. "12.1 Sensor Discovery Tool" on page 973 for more information.

4.3.8 Maintenance

The [Maintenance] category in the [Manage] page is used to do the following:

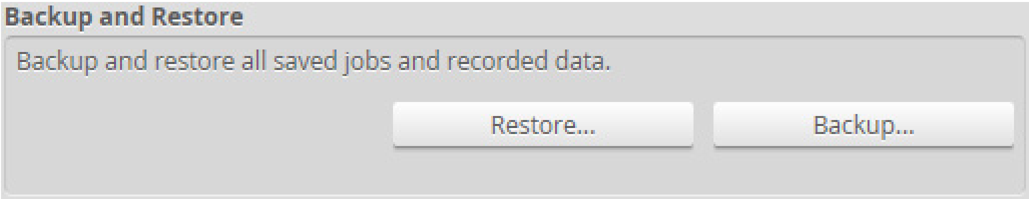
- upgrade the firmware and check for firmware updates;
- back up and restore all saved jobs and recorded data;
- restore the sensor to factory defaults;
- reset the sensor.



■ Sensor Backups and Factory Reset

You can create sensor backups, restore from a backup, and restore to factory defaults in the [Maintenance] category.
Backup files contain all of the information stored on a sensor, including jobs and alignment.

> **Tips**
> An Administrator should create a backup file in the unlikely event that a sensor fails and a replacement sensor is needed. If this happens, the new sensor can be restored with the backup file.



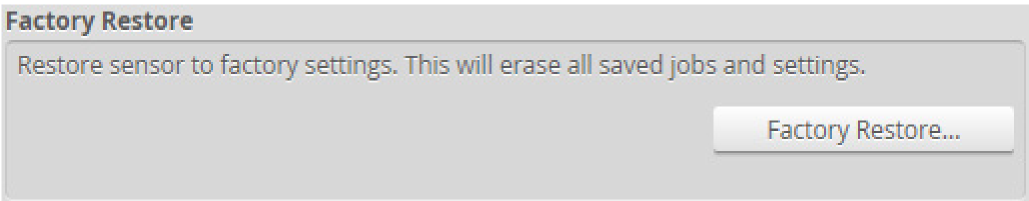
To create a backup:

1. **Go to the [Manage] page and click on the [Maintenance] category.**

2. **Click the [Backup...] button under [Backup and Restore].**

3. **When you are prompted, save the backup.**

   » Backups are saved as a single archive that contains all of the files from the sensor.



To restore from a backup:

1. **Go to the [Manage] page and click on the [Maintenance] category.**

2. **Click the [Restore...] button under [Backup and Restore].**

3. **When you are prompted, select a backup file to restore.**

   » The backup file is uploaded and then used to restore the sensor. Any files that were on the sensor before the restore operation will be lost.

To restore a sensor to its factory default settings:

1. **Go to the [Manage] page and click on [Maintenance].**

2. **Consider making a backup.**

   Before proceeding, you should perform a backup. Restoring to factory defaults cannot be undone.

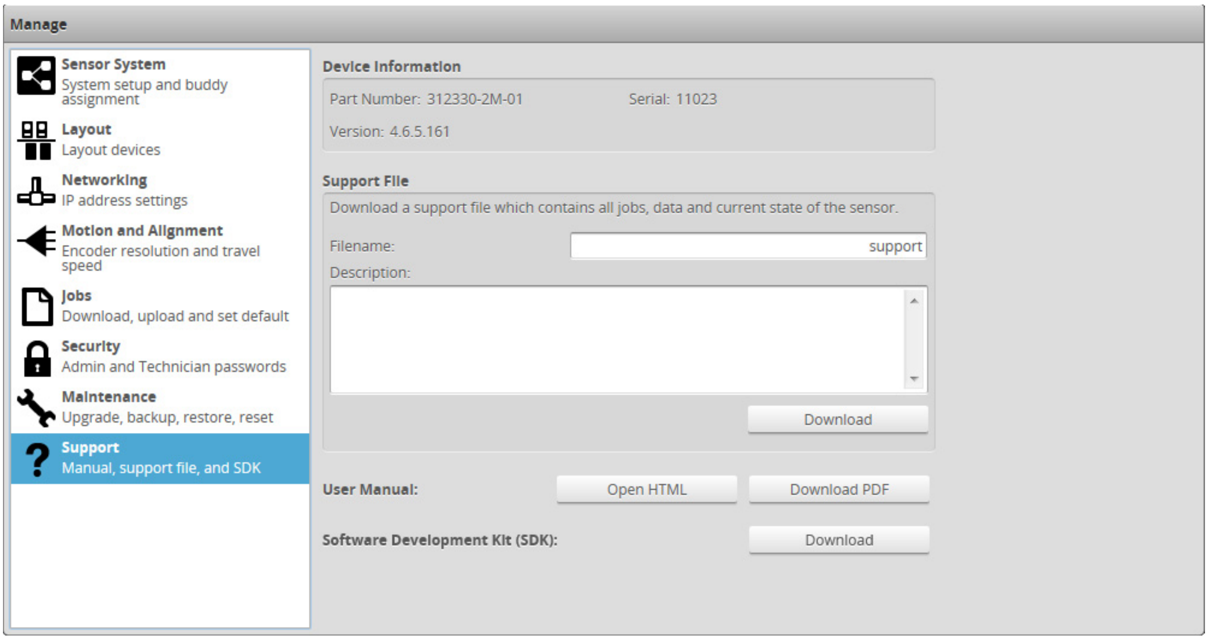
3. **Click the [Factory Restore...] button under [Factory Restore].**

   » You will be prompted whether you want to proceed. Follow the instructions to restore to the factory default configuration.

4.3.9 Support

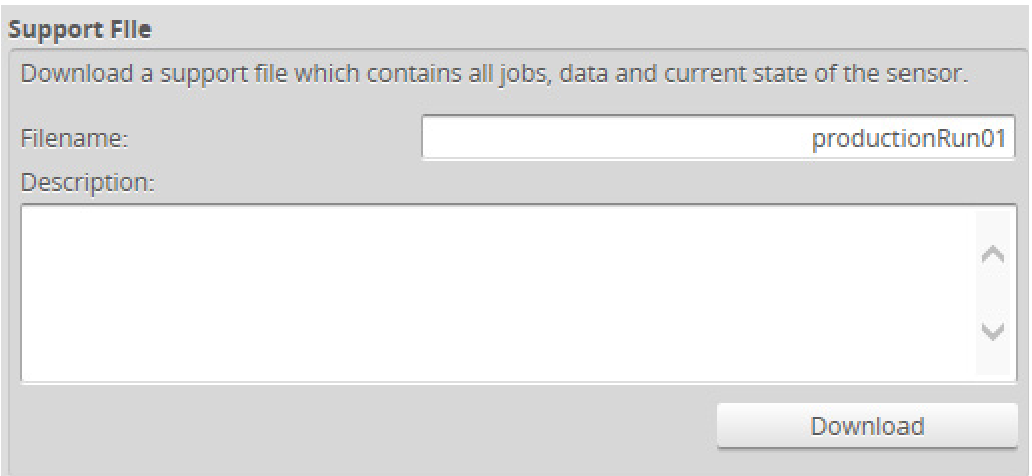
The [Support] category in the [Manage] page is used to do the following:

- Open an HTML version or download a PDF version of the manual.
- Download the SDK.
- Save a support file.
- Get device information.



■ Support Files

You can download a support file from a sensor and save it on your computer. You can then use the support file to create a scenario in the emulator (for more information on the emulator, see "8 SurfaceMeasure1008S Emulator" on page 635). Mitutoyo's support staff may also request a support file to help in troubleshooting.



To download a support file:

1 **Go to the [Manage] page and click on the [Support] category.**

2 **In [Filename], type the name you want to use for the support file.**

When you create a scenario from a support file in the emulator, the filename you provide here is displayed in the emulator's scenario list.
Support files end with the .gs extension, but you do not need to type the extension in [Filename].

3 **(Optional) In [Description], type a description of the support file.**

When you create a scenario from a support file in the emulator, the description is displayed below the emulator's scenario list.

4 **Click [Download], and then when prompted, click [Save].**

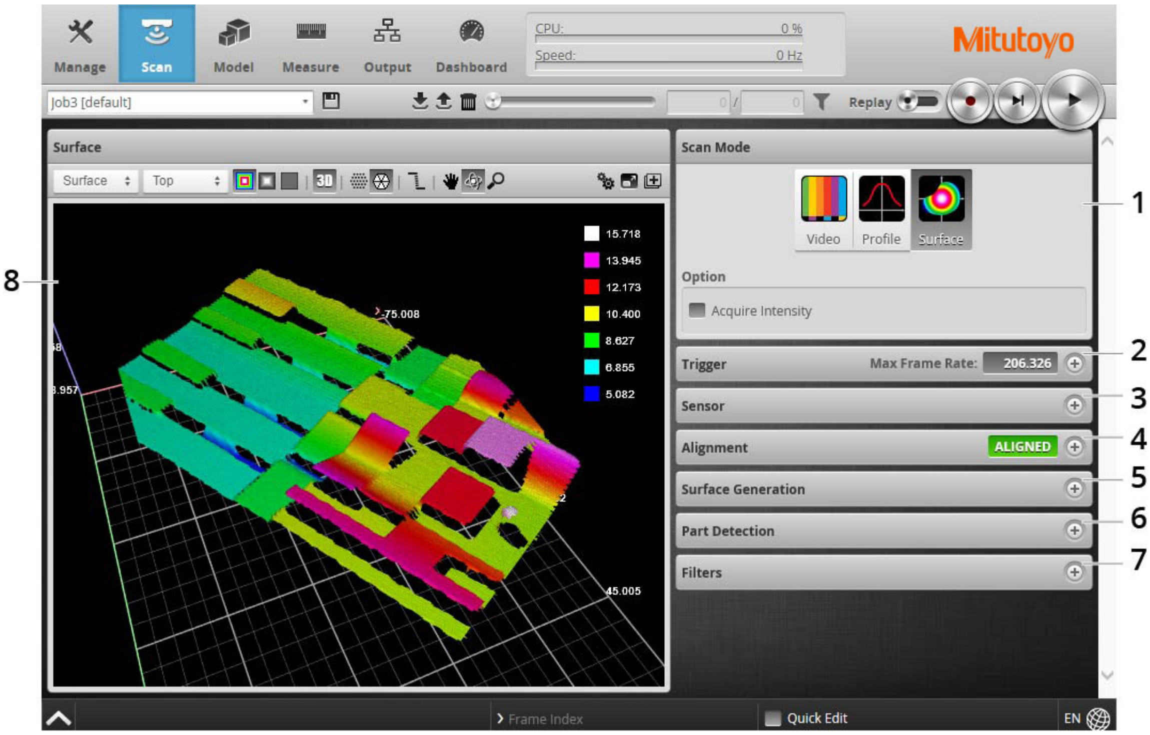
IMPORTANT
Downloading a support file stops the sensor.

4.4 Scan Setup

The following sections describe the steps to configure sensors for data acquisition using the [Scan] page. Scan setup and alignment should be performed before adding and configuring measurements or outputs; for information on alignment, see "4.5 Aligning Sensors" on page 171.

4.4.1 Scan Page Overview

The [Scan] page lets you configure sensors and perform alignment.



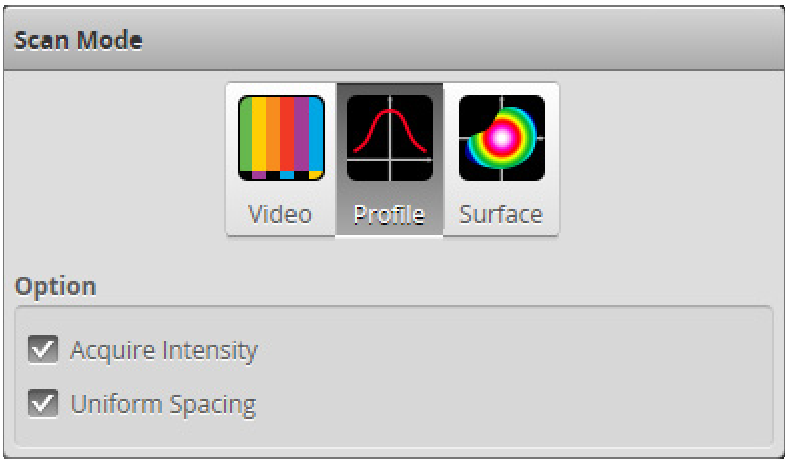
	Element	Description
1	[Scan Mode] panel	Contains settings for the current scan mode and other options. "4.4.2 Scan Modes" on page 116.
2	[Trigger] panel	Contains trigger source and trigger-related settings. "4.4.3 Triggers" on page 117.
3	[Sensor] panel	Contains settings for an individual sensor, such as active area or exposure. "4.4.4 Sensor" on page 123.
4	[Alignment] panel	Used to perform alignment providing up to 5 degrees of freedom. (You can perform high-accuracy alignment using specialized alignment measurement tools.) "4.5 Aligning Sensors" on page 171.
5	[Surface Generation] panel	Contains settings for surface generation. "4.4.6 Surface Generation" on page 146.
6	[Part Detection] panel	Used to set the part detection logic for sorting data into discrete objects. "4.4.7 Part Detection" on page 149.
7	[Filters] panel	Contains settings for post-processing of the profiles. "4.4.5 Filters" on page 141.
8	Data Viewer	Displays sensor data and adjusts regions of interest. Depending on the current operation mode, the data viewer can display video images or scan data. See "4.4.8 Data Viewer" on page 156.

The following table provides quick references for specific goals that you can achieve from the panels in the [Scan] page.

Goal	Reference
Select a trigger source that is appropriate for the application.	"4.4.3 Triggers" on page 117)
Ensure that camera exposure is appropriate for scan data acquisition.	"■Exposure" on page 130
Find the right balance between data quality, speed, and CPU utilization.	"■Active Area" on page 124 "■Exposure" on page 130 "9.2 Job File Structure" on page 655
Specify mounting orientations.	"4.3.3 Layout" on page 96
Align scan data to a common reference and so that values can be correctly scaled along the different axes.	"4.5 Aligning Sensors" on page 171
Set up the part detection logic to create discrete objects from scan data.	"4.4.7 Part Detection" on page 149
Specify smoothing, gap-filling, and resampling parameters to remove effects of occlusions.	"4.4.5 Filters" on page 141

4.4.2 Scan Modes

The sensor web interface supports a video mode and one or more data acquisition modes. The scan mode can be selected in the [Scan Mode] panel.



Mode and Option	Description
[Video]	Outputs video images from the sensor. This mode is useful for configuring exposure time and troubleshooting stray light or ambient light problems.
[Profile]	Outputs profiles and performs profile measurements. Video images are processed internally to produce laser profiles and cross-sectional measurements.
[Surface]	Outputs 3D point clouds and performs surface measurements. The sensor uses various methods to generate a surface (see 📖 "4.4.6 Surface Generation" on page 146). Part detection can be enabled on a surface to identify discrete parts (📖 "4.4.7 Part Detection" on page 149).
[Uniform Spacing]	When this option is enabled, data points are resampled to a uniform spacing (📖 "3.2.2 Uniform Data and Raw Data" on page 61 for more information). Set the size of the spacing in the [Spacing] tab (see 📖 "●Spacing Interval" on page 136). When the option is disabled, the sensor outputs unprocessed range data. The sensor reports data points in (x, z) coordinate pairs. Post-processing is disabled. Only a subset of the measurement tools is available. Disable this option to extract ranges from the sensor at the highest possible rate. **Tips** The Y offset, X angle, and Z angle transformations cannot be non-zero when Uniform Spacing is unchecked. Therefore, when aligning a sensor using a bar alignment target with [Uniform Spacing] unchecked, set the [Degrees of Freedom] setting to [X, Z, Y Angle], which prevents these transformations from being non-zero. **Tips** If you are using a layout in which sensors are angled around the Y axis in order to capture "side" data, you must uncheck [Uniform Spacing]. However, currently, only a limited set of built-in measurement tools are able to perform measurements on the resulting data. If more complex measurements are required, data can be processed using an SDK-based application instead.
[Acquire Intensity]	When this option is enabled, an intensity value will be produced for each data point. For more information on intensity, see 📖 "■Intensity Output" on page 170.

4.4.3 Triggers

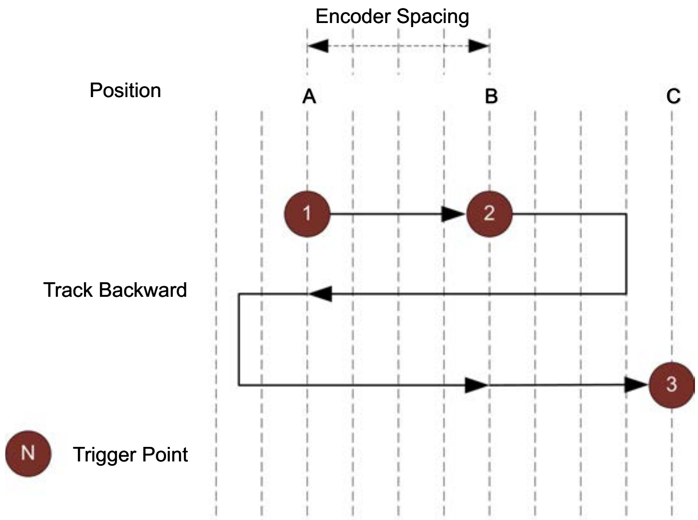
A trigger is an event that causes a sensor to take a single image. Triggers are configured in the [Trigger] panel on the [Scan] page.

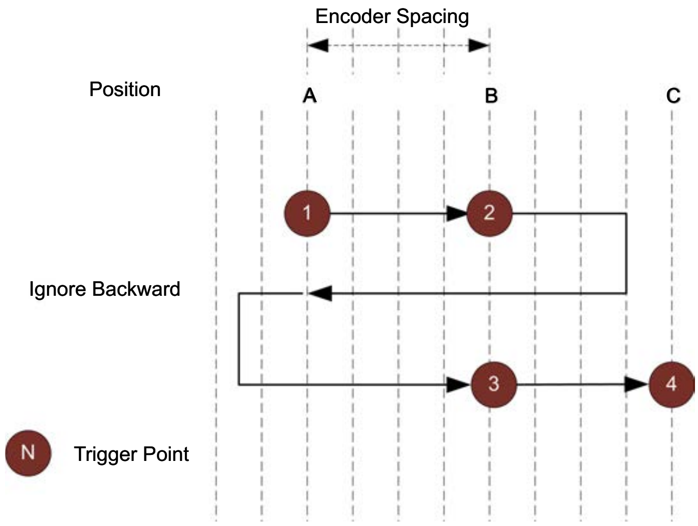
When a trigger is processed, the laser is strobed and the camera exposes to produce an image. The resulting image is processed inside the sensor to yield a profile (range/distance information). The data can then be used for measurement.

The sensor can be triggered by one of the sources described in the table below.

Tips

- If the sensor is connected to a Master 810 or higher, encoder and digital (external) input signals over the IO cordset are ignored. The sensor instead receives these signals from the Master; for encoder and digital input pinouts on Masters, see the section corresponding to your Master in "14.3 Master Network Controllers" on page 1012.
- If the sensor is connected to a Master 100 (or no Master is used), the sensor receives signals over the IO cordset. For information on connecting encoder and digital input signals to a sensor in these cases, see "■Encoder Input" on page 1011 and "■Digital Input" on page 1010, respectively.

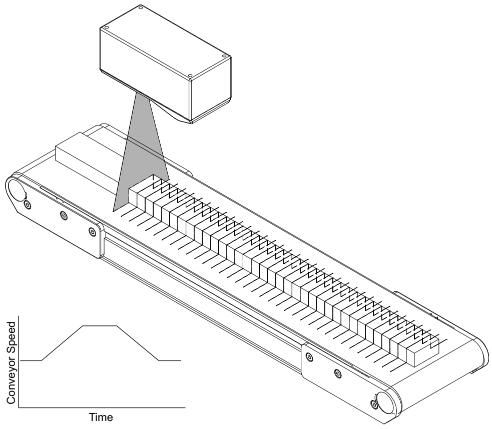
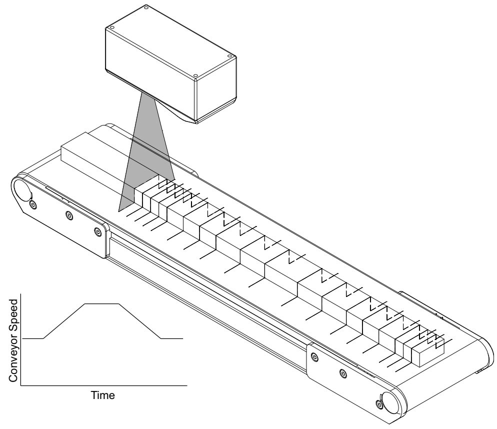
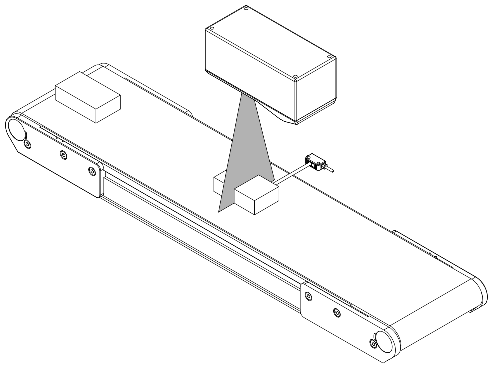
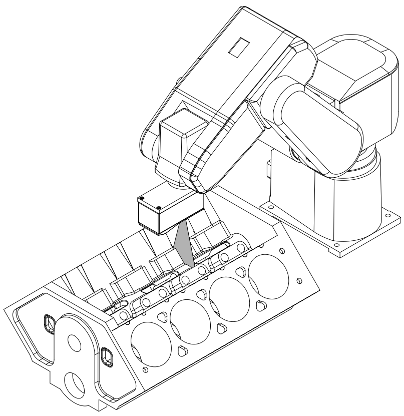
Trigger Source	Description
Time	Sensors have an internal clock that can be used to generate fixed-frequency triggers. The external input can be used to enable or disable the time triggers.
Encoder	An encoder can be connected to provide triggers in response to motion. Three encoder triggering behaviors are supported. These behaviors are set using the [Behavior] setting. [Track Backward] A scan is triggered when the target object moves forward. If the target object moves backward, it must move forward by at least the distance that the target traveled backward (this distance backward is "tracked"), plus one encoder spacing, to trigger the next scan. 

Trigger Source	Description
	[Ignore Backward] A scan is triggered only when the target object moves forward. If the target object moves backward, it must move forward by at least the distance of one encoder spacing to trigger the next scan.  [Bi-directional] A scan is triggered when the target object moves forward or backward. When triggers are received at a frequency higher than the maximum frame rate, some triggers may not be accepted. The [Trigger Drops Indicator] in the [Dashboard] can be used to check for this condition. The external input can be used to enable or disable the encoder triggers. For information on the maximum encoder rate, see 📖 "■Maximum Encoder Rate" on page 122. **Tips** To verify that the sensor is receiving encoder signals, check whether [Encoder Value] is changing in the Motion and Alignment category on the [Manage] page, or in the dashboard.
External Input	A digital input can provide triggers in response to external events (e.g., photocell). The external input triggers on the rising edge of the signal. When triggers are received at a frequency higher than the maximum frame rate, some triggers may not be accepted. The [Trigger Drops Indicator] in the [Dashboard] page can be used to check for this condition. For information on the maximum input trigger rate, see 📖 "■Maximum Input Trigger Rate" on page 122.
Software	A network command can be used to send a software trigger. 📖 "10.1 Protocols" on page 747 for more information.

Depending on the setup and measurement tools used, the CPU utilization may exceed 100%, which reduces the overall acquisition speed.

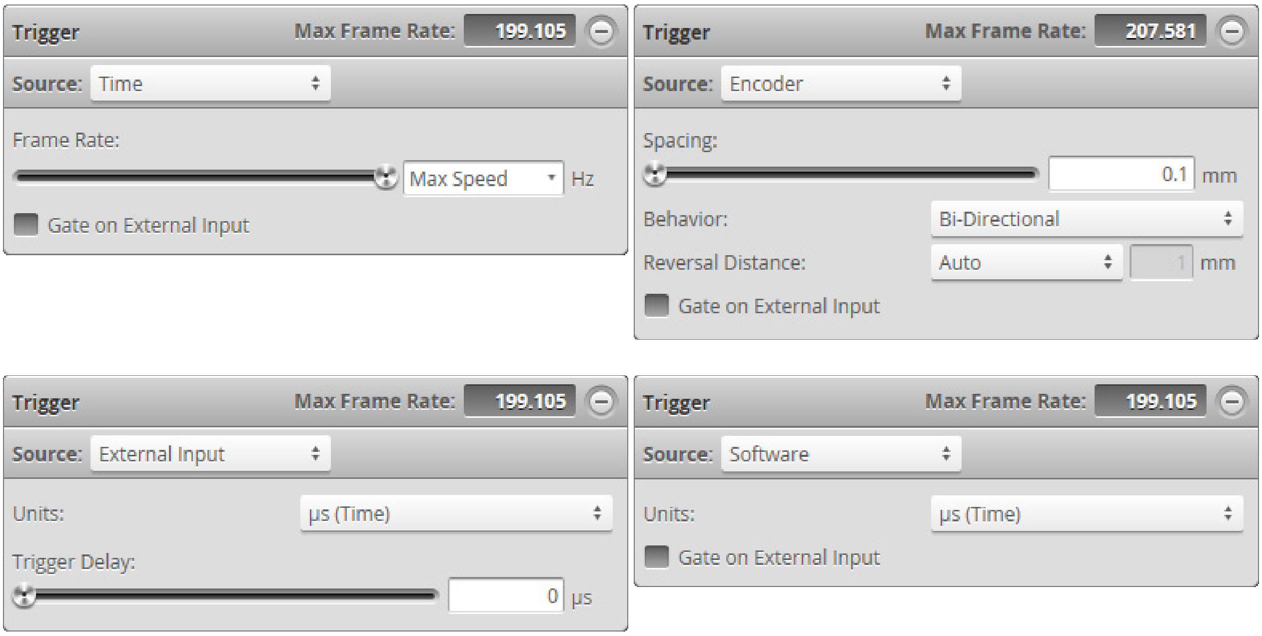
For examples of typical real-world scenarios, see 📖 "■Trigger Examples" on page 119. For information on the settings used with each trigger source, see 📖 "■Trigger Settings" on page 120.

■ Trigger Examples

Example: Encoder + Conveyor Encoder triggering is used to perform profile measurements at a uniform spacing. The speed of the conveyor can vary while the object is being measured; an encoder ensures that the trigger spacing is consistent, independent of conveyor speed.	
Example: Time + Conveyor Time triggering can be used instead of encoder triggering to perform profile measurements at a fixed frequency. Spacing will be non-uniform if the speed of the conveyor varies while the object is being measured. It is strongly recommended to use an encoder with transport-based systems due to the difficulty in maintaining constant transport velocity.	
Example: External Input + Conveyor External input triggering can be used to produce a snapshot for profile measurement. For example, a photocell can be connected as an external input to generate a trigger pulse when a target object has moved into position. An external input can also be used to gate the trigger signals when time or encoder triggering is used. For example, a photocell could generate a series of trigger pulses as long as there is a target in position.	
Example: Software Trigger + Robot Arm Software triggering can be used to produce a snapshot for profile measurement. A software trigger can be used in systems that use external software to control the activities of system components.	

Trigger Settings

The trigger source is selected using the [Trigger] panel in the [Scan] page.



After specifying a trigger source, the [Trigger] panel shows the parameters that can be configured.

Trigger Source	Configurable Parameters	Description
[Source]	[All]	Selects the trigger source ([Time], [Encoder], [External Input], or [Software]).
[Frame Rate]	[Time]	Controls the frame rate. Select [Max Speed] from the drop-down to lock to the maximum frame rate. Fractional values are supported. For example, 0.1 can be entered to run at 1 frame every 10 seconds.
[Gate on External Input]	[Time], [Encoder]	External input can be used to enable or disable data acquisition in a sensor. When this option is enabled, the sensor will respond to time or encoder triggers only when the external input is asserted. This setting is not displayed when [Surface Generation] is set to [Fixed Length], [Variable Length], or [Rotational] ("4.4.6 Surface Generation" on page 146). See "■Digital Input" on page 1010 for more information on connecting external input to sensors.
[Behavior]	[Encoder]	Specifies how the sensor is triggered when the target moves. Can be Track Backward, Ignore Backward, or Bi-Directional. "4.4.3 Triggers" on page 117 for more information on these behaviors.
[Spacing]	[Encoder], [External Input]	Specifies the distance between triggers (mm). Internally the sensor rounds the spacing to a multiple of the encoder resolution.

Trigger Source	Configurable Parameters	Description
[Reversal Distance]	[Encoder]	When encoder triggering is set to [Bi-Directional], use this setting to ignore jitter or vibrations in your transport system by specifying what distance the target must travel before a direction change is triggered. One of the following: [Auto]: The distance is automatically set by multiplying the value in [Spacing] by 3. [Custom]: Set the distance (in millimeters). Various functions in the sensor depend on this value to explicitly determine the point where direction change is triggered. Set this value larger than the maximum vibrations you see in your transport system.
[Units]	[External Input], [Software]	Specifies whether the trigger delay, output delay, and output scheduled command operate in the time or the encoder domain. The unit is implicitly set to microseconds with Time trigger source. The unit is implicitly set to millimeters with Encoder trigger source.
[Trigger Delay]	[External Input]	Controls the amount of time or the distance the sensor waits before producing a frame after the external input is activated. This is used to compensate for the positional difference between the source of the external input trigger (e.g., photocells) and the sensor.

Tips

Depending on the surface generation settings, some trigger options may not be available.

To configure the trigger source:

1. **Go to the [Scan] page.**
2. **Expand the [Trigger] panel by clicking on the panel header.**
3. **Select the trigger source from the drop-down.**
4. **Configure the settings.**

   See the trigger parameters above for more information.
5. **Save the job in the [Toolbar] by clicking the [Save] button.**

■ Maximum Input Trigger Rate

Tips
The maximum external input trigger rate in a system using Master 810 is 20 kHz.

When using a standalone sensor or a sensor connected to a Master 100, the maximum trigger rate is 32 kHz. This rate is limited by the fall time of the signal, which depends on the Vin and duty cycles.

To achieve the maximum trigger rate, the Vin and duty cycles must be adjusted as follows:

Maximum Speed	Vin	Maximum Duty Cycle
32 kHz	3.3 V	88%
32 kHz	5 V	56%
32 kHz	7 V	44%
32 kHz	10 V	34%

At 50% duty cycle, the maximum trigger rates are as follows:

Vin	Maximum Speed
3.3 V	34 kHz
5 V	34 kHz
10 V	22 kHz

■ Maximum Encoder Rate

On a standalone sensor, with the encoder directly wired into the I/O port or through a Master 100, the maximum encoder rate is about 1 MHz.

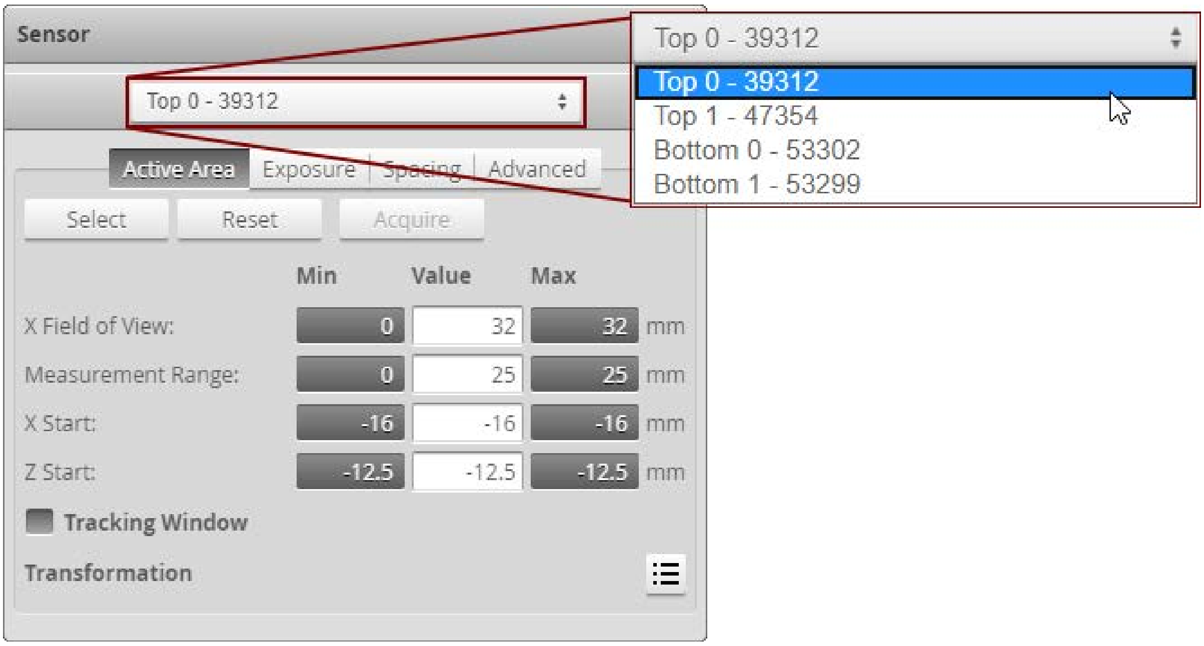
For sensors connected through a Master 810 or higher, with the encoder signal supplied to the Master, the maximum rate is about 300 kHz.

4.4.4 Sensor

The following sections describe the settings that are configured in the [Sensor] panel on the [Scan] page.

If you are using a mixed-model dual- or multi-sensor system, after adding Buddy sensors, you should check in the [Sensor] panel that the settings for each Buddy sensor has a valid and in-range value. Otherwise, the system may not start or be able to perform alignment. A Buddy sensor's settings may become invalid after being added to a system because SurfaceMeasure1008S automatically carries certain settings from the Main sensor to the Buddy sensors, which may be incompatible with a Buddy sensor. For example, if Main sensor were a wide FOV model and its active area is set to be greater than the maximum possible active area of a small FOV Buddy sensor, the Buddy sensor's active area settings would be invalid. If that is the case, then the Buddy sensors' settings need to be changed to the appropriate values.

To check these settings, use the drop-down at the top of the [Sensor] panel to select each sensor, and check that there are no errors indicated in the setting fields for each sensor. Check in all of the tabs in the panel, but especially the [Active Area] tab.



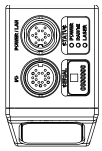
Sensor drop-down in a four-sensor system.

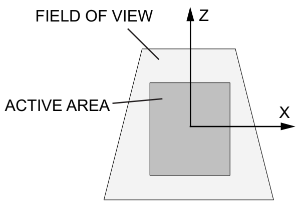
■ Active Area

Active area refers to the region within the sensor's maximum field of view that is used for data acquisition.

By default, the active area covers the sensor's entire field of view. By reducing the active area, the sensor can operate at higher speeds. You can also reduce the active area to exclude areas that are affected by ambient light.

Active area is specified in sensor coordinates, rather than in system coordinates. As a result, if the sensor is already alignment calibrated, press the [Acquire] button to display uncalibrated data before configuring the active area. See 📖 "3.2.1 Coordinate Systems" on page 56 for more information on sensor and system coordinates.





Active area is set in the [Active Area] tab on the [Sensor] panel.

To set the active area:

1 Go to the [Scan] page.

2 Choose a mode other than Video mode.

3 Expand the [Sensor] panel by clicking on the panel header or the ⊕ button.

4 **Click the button corresponding to the sensor you want to configure.**

The button is labeled [Top], [Bottom], [Top-Left], or [Top-Right], depending on the system.
Active area is specified separately for each sensor.

5 **Click on the [Active Area] tab.**

6 **Click [Select].**

7 **Click [Acquire] to see a scan while setting the active area.**

Acquiring a scan while setting the active area can help you determine where to size and place the active area.

8 **Set the active area.**

Adjust the active area graphically in the data viewer or enter the values manually in the fields.
The 2D view lets you adjust the size and position of the active area on the X and Z axis. The 3D view lets you adjust the size and position in the X, Y, and Z axis. For more information, see "●Regions" on page 238.

9 **Click the [Save] button in the [Sensor] panel.**

Click the [Cancel] button to cancel setting the active area.

10 **Save the job in the [Toolbar] by clicking the [Save] button.**

Tips

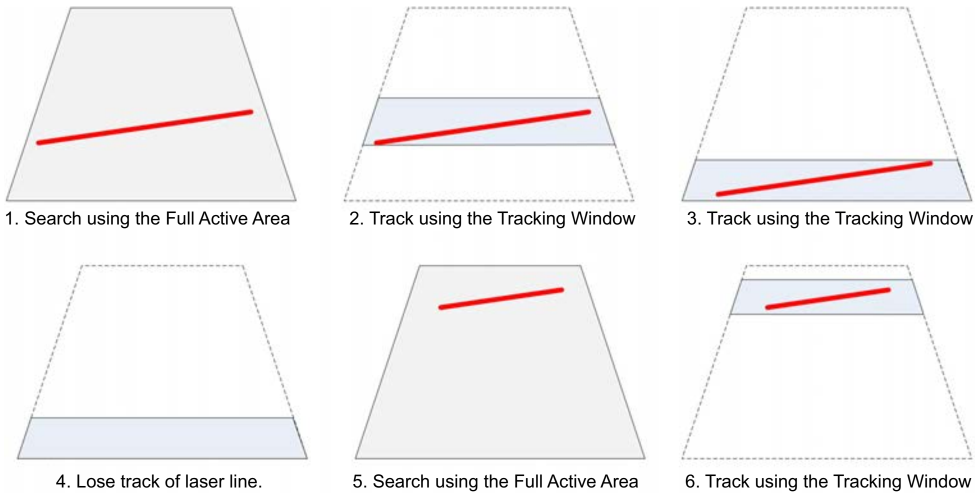
Scanning devices are usually more accurate at the near end of their measurement range. If your application requires a measurement range that is small compared to the maximum measurement range of the sensor, mount the sensor so that the active area can be defined at the near end of the measurement range.

- Tracking Window

A sensor can follow a relatively flat target as it moves up and down beneath the sensor, using a "tracking window." When you define a tracking window, the sensor effectively reduces the active area to match the size of the tracking window, which results in a faster scan rate. The reduced area moves to track the laser line within the area defined in the [Active Area] tab. A tracking window is typically used in road or web scanning applications where the target is a continuous surface.

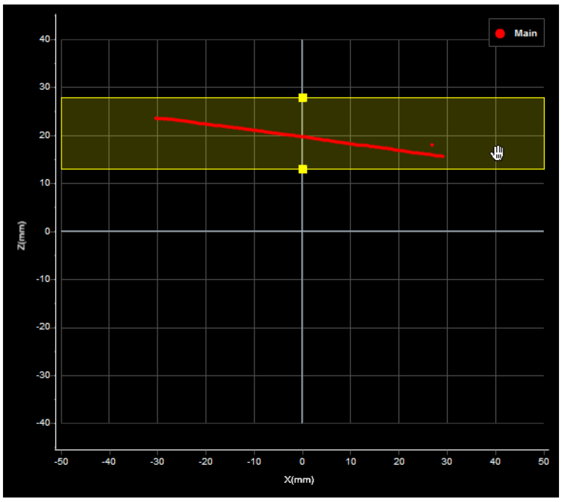
You must balance the gain in speed due to the reduced area of the tracking window and the impact it has on the sensor's tracking ability: a smaller window gives the tracking function less data to predict where the profile is moving.

The sensor adjusts the position of the tracking window to center the area on the average height of the entire visible laser profile. A laser line remains tracked as long as the percentage of detected laser points exceeds the user-defined search threshold. When the sensor loses track of the laser line, the sensor searches for the laser line using the full defined active area.



You should adjust the lighting and the active area to remove all background objects, such as the conveyor belt surface.

The tracking window is defined in the [Active Area] tab, beneath the settings for the active area.



To enable the tracking window:

1 **Go to the [Scan] page.**

2 **Choose Profile or Surface mode in the [Scan Mode] panel.**

If one of these modes is not selected, you will not be able to set the tracking window.

3 **Expand the [Sensor] panel by clicking on the panel header.**

4 **Click on the [Active Area] tab.**

5 **Check the [Tracking Window] box.**

The panel below the checkbox expands and shows the settings for the window used to track the object height.

6 **Click the tracking window's [Select] button.**

7 **Resize the tracking window shown in the data viewer.**

Only the height of the window is required. You can move the position of the tracking window to cover a live profile to help adjust the window height.

8 **Edit the [Search Threshold] setting.**

The search threshold defines the minimum percentage of the points detected across the profile for the laser to be considered tracked. If the number of points falls below this percentage, tracking is lost, and the sensor searches for the laser line using the full active area.

9 **Click the [Save] button in the [Sensor] panel.**

10 **Save the job in the [Toolbar] by clicking the [Save] button .**

- Transformations

The transformation settings determine how data is converted from sensor coordinates to system coordinates (for an overview on coordinate systems, see "3.2.1 Coordinate Systems" on page 56). The transformations are found in the [Transformations] section of the [Active Area] tab on the Sensor panel. Typically, transformations are set when you align a sensor using the alignment procedure on the Alignment panel. However, you can also manually set these values.

Tips

If you perform an alignment using the Surface Align Wide or Surface Align Ring tools, these values are not updated. For more information, see "4.5.4 Aligning Sensors to 6 Degrees of Freedom" on page 195.

Parameter	Description
[X Offset]	Specifies the shift along the X axis. With Normal orientation, a positive value shifts the data to the right. With Reverse orientation, a positive value shifts the data to the left.
[Y Offset]	Specifies the shift along the Y axis.
[Z Offset]	Specifies the shift along the Z axis. A positive value shifts the data toward the sensor.
[Angle X]	Specifies the tilt around the X axis. This creates a skew clockwise around the X axis (pointing toward the viewer).
[Angle Y]	Specifies the tilt around the Y axis. This rotates profiles counter-clockwise around the Y axis (pointing toward the viewer).
[Angle Z]	Specifies the tilt around the Z axis. This creates a skew clockwise around the Z axis (pointing toward the viewer).

When applying the transformations, the data is first rotated around X (clockwise, with the X axis toward the viewer), then Y (counterclockwise), and then Z (clockwise), and then the offsets are applied.

Tips
Setting [Angle X] or [Angle Z], and to a lesser extent [Y Offset], to a non-zero value increases CPU usage when scanning, which reduces the maximum scan speed.

Tips
Artifacts may appear in scan data when [Angle Z] or [Angle X] is set to a non-zero value if encoder trigger spacing is set too high (resulting in a low sampling rate).

To configure transformation settings:

1. **Go to the [Scan] page.**

2. **Choose a mode other than Video mode in the [Scan Mode] panel.**
   If Video mode is selected, you will not be able to change the settings.

3. **Expand the [Sensor] panel by clicking on the panel header.**

4. **Click the button corresponding to the sensor you want to configure.**
   The button is labeled [Top], [Bottom], [Top-Left], or [Top-Right], depending on the system.
   Transformations can be configured separately for each sensor.

5. **Expand the Transformations area by clicking on the expand button ☰.**
   See the table above for more information.

6. **Set the parameter values.**
   See the table above for more information.

   Tips
   The Y offset, X angle, and Z angle transformations cannot be non-zero when Uniform Spacing is unchecked. Therefore, when aligning a sensor using a bar alignment target with [Uniform Spacing] unchecked, set the [Degrees of Freedom] setting to [X, Z, Y Angle], which prevents these transformations from being non-zero.

7. **Save the job in the [Toolbar] by clicking the [Save] button.**

8. **Check that the transformation settings are applied correctly after the sensor is restarted.**

■ Exposure

Exposure determines the duration of camera and light-source on-time. Longer exposures can be helpful to detect light on dark or distant surfaces, but increasing exposure time decreases the maximum speed. Different target surfaces may require different exposures for optimal results. Sensors provide three exposure modes for the flexibility needed to scan different types of target surfaces.

Tips

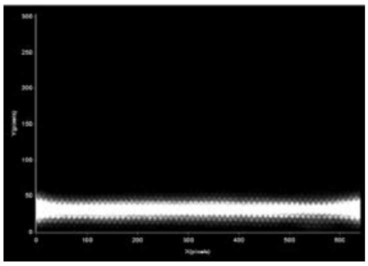
Due to sensor architecture, exposure values provided by the user in the interface are divided by a factor of 1.024 internally. So for example, setting an exposure value of 1000 μs results in the sensor using a 977 μs exposure internally. This, in addition to various overhead factors, can result in a discrepancy between Max Frame Rate displayed on the [Trigger] panel and the speed reported in the metrics area, but this is only obvious at higher frame rates.

Exposure Mode	Description
[Single]	Uses a single exposure for all objects. Used when the surface is uniform and is the same for all targets.
[Dynamic]	Automatically adjusts the exposure after each frame. Used when the target surface varies between scans.
[Multiple]	Uses multiple exposures to create a single profile. Used when the target surface has a varying reflectance within a single profile (e.g., white and black).

For more information on the different types of exposure options, see the sections below.

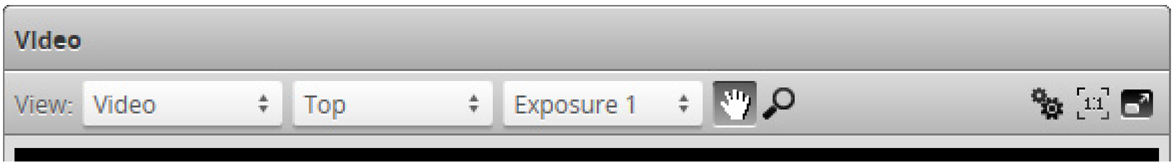
Video mode lets you see how the light appears on the camera and identify any stray light or ambient light problems. When exposure is tuned correctly, the projected light should be clearly visible along the entire length of the viewer. If it is too dim, increase the exposure value; if it is too bright decrease exposure value.

Under-exposure:
Laser line is not detected.
Increase the exposure value.



Over-exposure:
Laser line is too bright.
Decrease the exposure value.

When the sensor is in Multiple exposure mode, select which exposure to view using the drop-down box next to "View" in the data viewer. This drop-down is only visible in Video scan mode when the [Multiple] option is selected in the [Exposure] section in the [Sensor] panel.

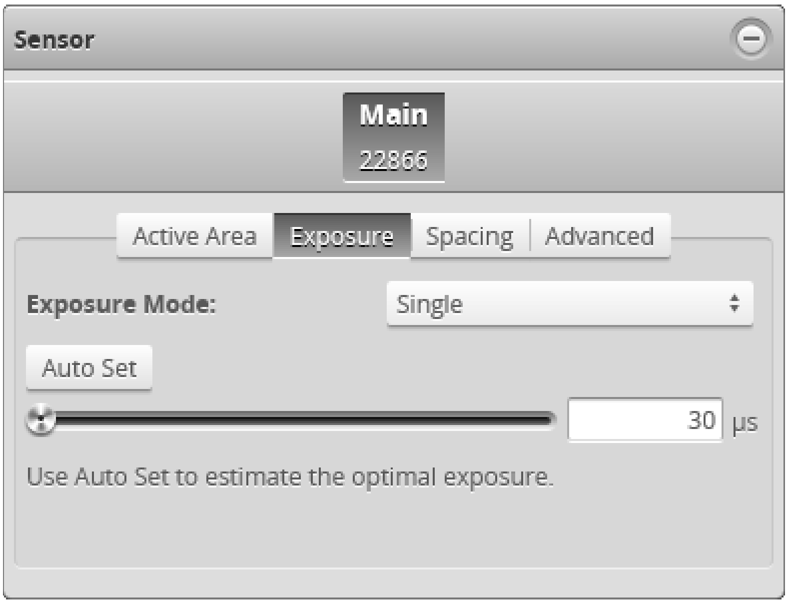


- Single Exposure

The sensor uses a fixed exposure in every scan. Single exposure is used when the target surface is uniform and is the same for all targets.

Tips

See the Tips in 📖 "■Exposure" on page 130 for important information on potential discrepancies between Max Frame Rate and the speed reported in the metrics area.



To enable single exposure:

1 **Place a representative target in view of the sensor.**

The target surface should be similar to the material that will normally be measured.

2 **Go to the [Scan] page.**

3 **Expand the [Sensor] panel by clicking on the panel header or the ⊕ button.**

4 **Click the button corresponding to the sensor you want to configure.**

The button is labeled [Top], [Bottom], [Top-Left], or [Top-Right], depending on the system. Exposure is configured separately for each sensor.

5 **Click the [Exposure] tab.**

6 **Select [Single] from the [Exposure Mode] drop-down.**

7 **Edit the exposure setting by using the slider or by manually entering a value.**

You can automatically tune the exposure by pressing the [Auto Set] button, which causes the sensor to turn on and tune the exposure time.

8 **Run the sensor and check that laser profiling is satisfactory.**

- Dynamic Exposure

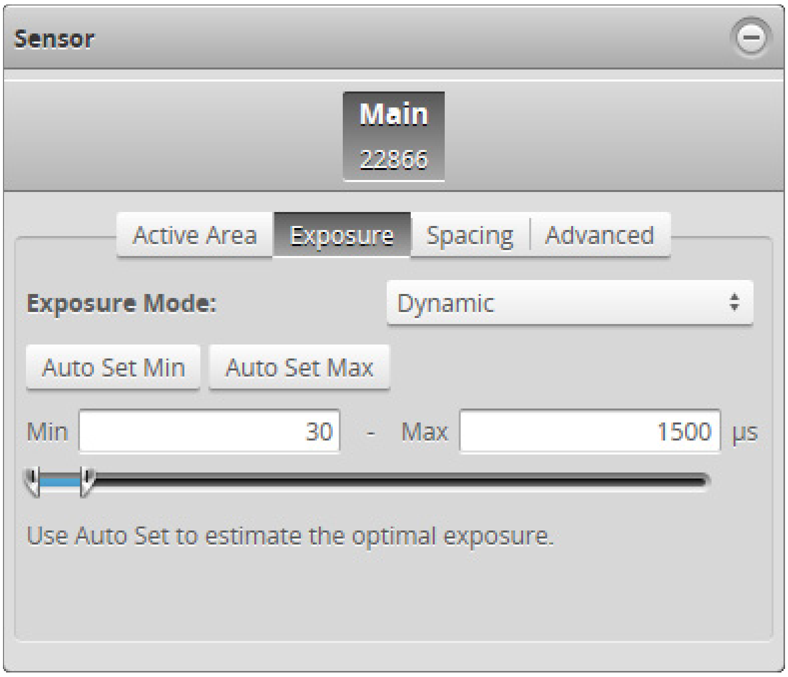
  The sensor automatically uses past profile information to adjust the exposure for subsequent exposures to yield the best profile. This is used when the target surface changes from exposure to exposure (that is, from scan to scan).

Tips

See the Tips in 📖 "■Exposure" on page 130 for important information on potential discrepancies between Max Frame Rate and the speed reported in the metrics area.

Tips

You can tune settings that control the exposure that is chosen by dynamic exposure in the Material tab.



To enable dynamic exposure:

1. **Go to the [Scan] page.**
2. **Expand the [Sensor] panel by clicking on the panel header or the ⊕ button.**
3. **Click the button corresponding to the sensor you want to configure.**

   The button is labeled [Top], [Bottom], [Top-Left], or [Top-Right], depending on the system. Exposure is configured separately for each sensor.
4. **Click the [Exposure] tab.**
5. **Select [Dynamic] from the [Exposure Mode] drop-down.**

6 Set the minimum and maximum exposure.

The auto-set function can be used to automatically set the exposure. First, place the brightest target in the field of view and press the [Auto Set Min] button to set the minimum exposure. Then, place the darkest target in the field of view and press the [Auto Set Max] button to set the maximum exposure.

7 Run the sensor and check that laser profiling is satisfactory.

If laser profiling is not satisfactory, adjust the exposure values manually. Switch to [Video] mode to use video to help tune the exposure; 📖 "■Exposure" on page 130 for details.

● Multiple Exposure

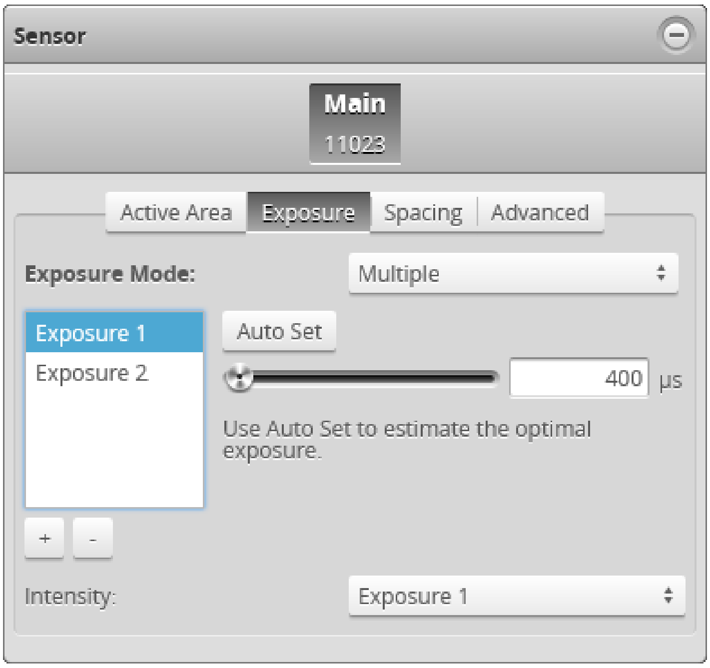
The sensor combines data from multiple exposures to create a single laser profile. Multiple exposures can be used to increase the ability to detect light and dark materials that are in the field of view simultaneously.

Tips

See the Tips in 📖 "■Exposure" on page 130 for important information on potential discrepancies between Max Frame Rate and the speed reported in the metrics area.

Up to five exposures can be defined with each set to a different exposure level. For each exposure, the sensor will perform a complete scan at the current frame rate making the effective frame rate slower. For example, if two exposures are selected, then the speed will be half of the single exposure frame rate. The sensor will perform a complete multi-exposure scan for each external input or encoder trigger.

The resulting profile is a composite created by combing data collected with different exposures. The sensor will choose profile data that is available from the lowest-numbered exposure step. It is recommended to use a larger exposure for higher-numbered steps.



If you have enabled intensity in the [Scan Mode] tab, you can use the [Intensity] setting to choose which of the exposures the sensor uses for acquiring intensity data. This lets you choose the exposure that produces the best image for intensity data.

To enable multiple exposure:

1 **Go to the [Scan] page.**

2 **Expand the [Sensor] panel by clicking on the panel header or the ⊕ button.**

3 **Click the button corresponding to the sensor you want to configure.**

The button is labeled [Top], [Bottom], [Top-Left], or [Top-Right], depending on the system. Exposure is configured separately for each sensor.

4 **Click the [Exposure] tab.**

5 **Select [Multiple] from the [Exposure Mode] drop-down.**

6 **Click the + button to add an exposure step.**

Up to a maximum of five exposure settings can be added.

To remove an exposure, select it in the exposure list and click the - button

7 **Set the exposure level for each exposure to make the sensor's camera less or more sensitive, as required.**

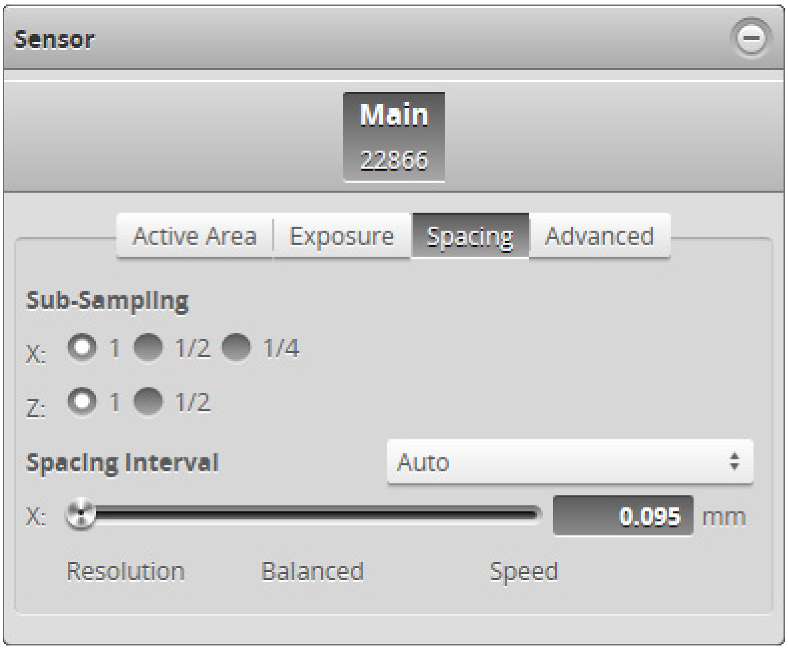
8 **If [Acquire Intensity] is enabled in [Scan Mode], select the exposure that is used to capture the intensity output.**

9 **Run the sensor and check that laser profiling is satisfactory.**

If laser profiling is not satisfactory, adjust the exposure values manually. Switch to [Video] mode to use video to help tune the exposure; 📖 "■Exposure" on page 130 for details.

■ Spacing

The [Spacing] tab lets you configure settings related to spacing (sub-sampling and spacing interval).



● [Sub-Sampling]

Sub-sampling reduces the number of camera columns or rows that are used for laser profiling, reducing the resolution. Reducing the resolution can increase speed or reduce CPU usage while maintaining the sensor's field of view. Sub-sampling can be set independently for the X axis and Z axis.

The [X] sub-sampling setting is used to decrease the profile's X resolution to decrease sensor CPU usage. The [X] setting works by reducing the number of image columns used for laser profiling.

The [Z] sub-sampling setting is used to decrease the profile's Z resolution to increase speed. The [Z] setting works by reducing the number of image rows used for laser profiling.

Sub-sampling values are expressed as fractions in the Web interface. For example, an X sub-sampling value of 1/2 indicates that every second camera column will be used for laser profiling.

Tips

The [CPU Load] bar at the top of the interface displays how much the CPU is being used.

Tips

Both the X and the Z sub-sampling settings must be decreased to increase speed.

To configure X or Z sub-sampling:

1 **Go to the [Scan] page.**

2 **Expand the [Sensor] panel by clicking on the panel header or the button.**

3 **Click the button corresponding to the sensor you want to configure.**

The button is labeled [Top, Bottom], [Top-Left], or [Top-Right], depending on the system.

X and Z sub-sampling is configured separately for each sensor.

4 **Click the [Spacing] tab.**

5 **Select an X or Z sub-sampling value.**

6 **Save the job in the [Toolbar] by clicking the [Save] button .**

7 **Check that laser profiling is satisfactory.**

- Spacing Interval

Spacing interval is the spacing between data points in resampled data. (In Profile mode, resampled data is only produced if the [Uniform Spacing] option in the [Scan Mode] panel is checked.) A larger interval creates profiles with lower X resolution, reduces CPU usage, and potentially increases the maximum frame rate. A larger interval also reduces the data output rate. For more information on resampled data, see "3.2.2 Uniform Data and Raw Data" on page 61.

Tips

The [Uniform Spacing] option must be checked in the [Scan Mode] panel for the [Spacing Interval] option to be displayed.

Tips

When combining different models in a single system that uses uniform data point spacing ([Uniform Spacing] is enabled in the [Scan Mode] panel), the minimum X resolution of the lowest resolution sensor limits the minimum X spacing of the entire system.

When combining non-matching models in a system that does not use uniform spacing, all sensors use their native X resolution. Typically, when using different models in a single system, you will want to use non-uniform spacing.

For more information on uniform spacing, "3.2.2 Uniform Data and Raw Data" on page 61.

You can set the spacing interval to one of three presets or set a custom value.

To configure the spacing interval:

1 **Go to the [Scan] page.**

2 **Choose Profile or Surface mode in the [Scan Mode] panel.**

If one of these modes is not selected, you will not be able to configure the spacing interval.

3 **Expand the [Sensor] panel by clicking on the panel header or the button.**

4 Click the button corresponding to the sensor you want to configure.

The button is labeled [Top, Bottom], [Top-Left], or [Top-Right], depending on the system.

Spacing is configured separately for each sensor.

5 Click the [Spacing] tab.

6 In the drop-down, choose [Auto] or [Custom], do following.

- Choose [Auto] and move the slider to one of the following values:

  [Speed]: Uses the lowest X resolution within the active area as the spacing interval. This setting minimizes CPU usage and data output rate, but the profile has the lowest X resolution (i.e., least detail).

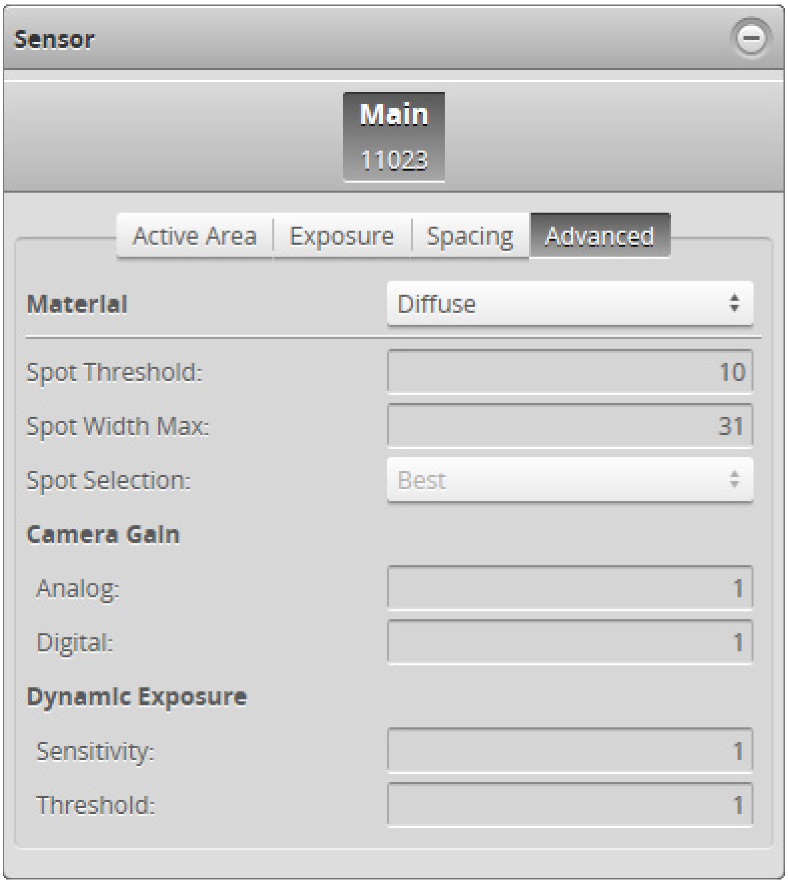
  [Balanced]: Uses the X resolution at the middle of the active area as the spacing interval. This setting balances CPU load, data output rate, and X resolution.

  [Resolution]: Uses the highest X resolution within the active area as the spacing interval. This setting maximizes resolution but has higher CPU load and has the highest data output rate (i.e., greatest detail).
- Choose [Custom] and move the slider to a precise value.

7 Save the job in the [Toolbar] by clicking the [Save] button .

■ Advanced

The [Advanced] tab contains settings to configure material characteristics, camera gain, and dynamic exposure.



To configure advanced settings:

1. **Go to the [Scan] page.**

2. **Switch to Video mode.**

   Using Video mode while configuring the settings lets you evaluate their impact.

3. **Expand the [Sensor] panel by clicking on the panel header or the ⊕ button.**

4. **If you are configuring a dual- or multi-sensor system, click the button corresponding to the sensor you want to configure.**

   The button is labeled [Top], [Bottom], [Top-Left], or [Top-Right], depending on the system.

   Settings can be configured separately for each sensor.

5. **Click on the [Advanced] tab.**

6. **Configure material characteristics, camera gain, or dynamic exposure.**

   For more information, see "●Material" on page 138 and "●Camera Gain and Dynamic Exposure" on page 141.

7. **Save the job in the [Toolbar] by clicking the [Save] button.**

8. **Check that scan data is satisfactory.**

● Material

Data acquisition can be configured to suit different types of target materials. This helps maximize the number of useful profile points produced. For many targets, changing the setting is not necessary, but it can make a great difference with others.

For 2380 sensors (revision B or later), use the [Sensitivity Compensation] setting (not shown above) to make the sensitivity of the sensor compatible with revision A sensors. This setting is enabled by default.

You can select preset material types in the [Materials] setting under the [Advanced] tab. The [Diffuse] material option is suitable for most materials.

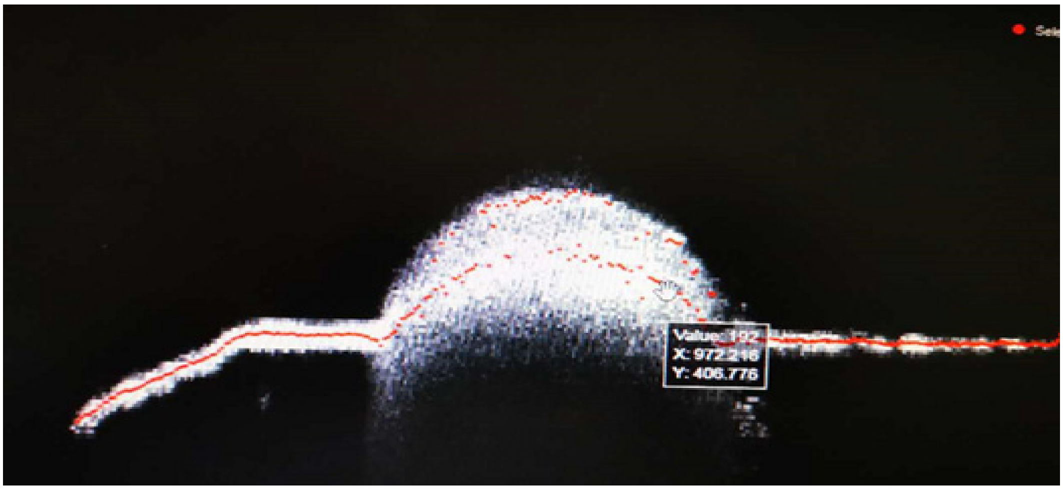
When [Materials] is set to [Custom], the following settings can be configured. In order to properly configure the spot-related settings, you should use Video mode (see "■Video Mode" on page 158) to observe the laser line and spots in the data viewer. For information on spots and displaying them in the data viewer, see "●Spots and Dropouts" on page 160.

Setting	Description
[Spot Threshold]	The minimum increase in intensity level between neighbouring pixels for a pixel to be considered the start of a potential spot. This setting is important for filtering false spots generated by sunlight reflection.
[Spot Width Max]	The maximum number of pixels a spot is allowed to span along Y in the data viewer. This setting can be used to filter out data caused by background light if the unwanted light is wider than the laser and does not merge into the laser itself. A lower [Spot Width Max] setting reduces the chance of false detection, but limits the ability to detect features/surfaces that elongate the spot.
[Spot Selection]	Determines the spot selection method. For details, see "Spot Selection Methods" on page 139.

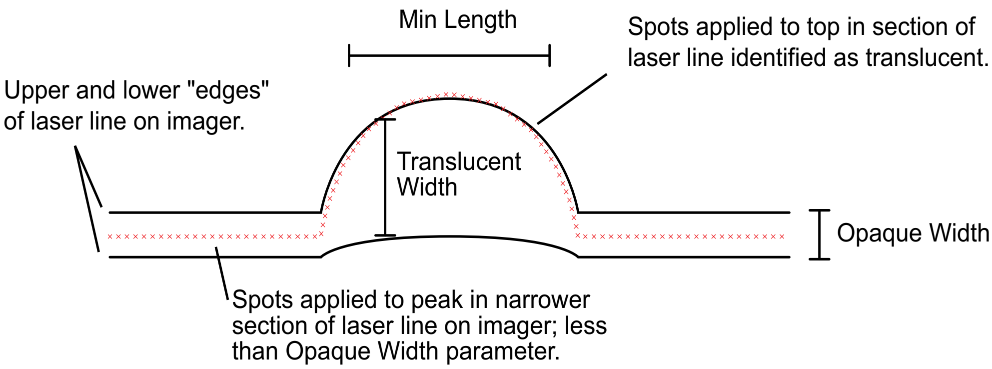
Spot Selection Methods

Setting	Description
[Best]	The [Best] spot selection method selects the strongest or peak spot in a given column on the imager.
[Top] or [Bottom]	[Top] selects the topmost spot or the one farthest to the left on the imager, and [Bottom] selects the bottommost spot or the one farthest to the right on the imager. These options can be useful in applications where there are reflections, flying sparks, or smoke that are always on one side of the laser.
[None]	The [None] selection mode performs no spot filtering. If multiple spots are detected in an imager column, they are left as is. This option is only available if [Uniform Spacing] is disabled in the [Scan Mode] panel on the [Scan] page; for more information on uniform spacing, see "3.2.2 Uniform Data and Raw Data" on page 61. Note that when [Uniform Spacing] is disabled and [Spot Selection] is set to None, both Profile Dimension and Profile Position are unavailable; for more information on enabling and disabling uniform spacing, see "4.4.2 Scan Modes" on page 116.
[Continu-ity]	The [Continuity] selection mode considers adjacent horizontal data points on the imager to place spots on pixels, giving preference to more complete profile segments. The setting can improve scans in the presence of reflections and noise.

<table>
<tr><th>Setting</th><th>Description</th></tr>
<tr><td>[Translucent]</td><td>
The [Translucent] spot selection mode helps the sensor better identify the surface of a translucent target, such as a glue bead. In the data viewer, in Video mode, a translucent target appears wider (along the Y axis) than an opaque surface. For example, in the following, the glue bead in the center is "wider" due to light dispersion in the translucent material) than the opaque surface to the left and right of the bead. Also, the peak or center of gravity of the translucent section (roughly, the center of intensity) is not obvious, and is often shifted down in relation to the actual surface.



With the [Translucent] spot selection mode, spots are placed at the top of translucent sections, but at the peak for opaque sections.
This selection method enables additional parameters, which are described below. The following image illustrates some of them, using a glue bead surrounded by opaque material as an example.



[Opaque Width]:
The spot width threshold below which spots are considered to be in an opaque section of the profile. The value represents the number of pixels in the data viewer along the Y axis.
[Translucent Width]:
The spot width in pixels along the Y axis in the data viewer required to activate a translucent section in the profile. A translucent section starts when the laser line on the imager reaches the Translucent Width value, and spans left and right as long as the laser line’s width doesn’t fall below the Opaque Width value.
[Min Length]:
The minimum length of a translucent section in pixels in the data viewer along the X axis.
[Threading Mode]:
The mode used to handle profiles. [Single Thread] or [Batching]. [Batching] is faster, but the first {n} profiles are delayed by the number (n) of threads the system is using.
</td></tr>
</table>

● Camera Gain and Dynamic Exposure

You can set camera gain and dynamic exposure to improve data acquisition.

Setting	Description
[Camera Gain]	[Analog] camera gain can be used when the application is severely exposure limited, yet dynamic range is not a critical factor. [Digital] camera gain can be used when the application is severely exposure limited, yet dynamic range is not a critical factor.
[Dynamic Exposure]	[Sensitivity] controls the exposure that dynamic exposure converges to. The lower the value, the lower the exposure the sensor will settle on. The trade-off is between the number of underexposed spots and the possibility of over-exposing. [Threshold] is the minimum number of spots for dynamic exposure to consider the profile point that make up the spot valid. If the number of spots is below this threshold, the algorithm will walk over the allowed exposure range slowly to find the correct exposure. Because this is slow, the Threshold value typically should be kept as low as possible, so this slow search is not used. These settings let you set tune how dynamic exposure settles on an exposure for a scan. For more information on Dynamic Exposure, see "●Dynamic Exposure" on page 132.

4.4.5 Filters

The filters in the [Filters] panel are used to post-process scan data along the X or Y axis to remove noise or clean it up before it is used by measurement tools or is output. Using the filters can help you get more repeatable measurements.

Tool-based filtering is also available on the [Measure] page. Using tool-based filtering provides various advantages:

- Additional filters not available in the [Filters] panel. (This mostly applies to Surface filters.)
- Choosing between millimeters and data points for the kernel units. (This mostly applies to Surface filters.)
- Filtering based on intensity and not just 3D height data.
- Choosing which tools used in a job take filtered data as input. That is, you can decide to have some tools running on unfiltered data and other tools on filtered data.

For more information on tool-based filters, see "6.17 Filter" on page 511 (Surface-based) and "5.10 Filter" on page 377 (Profile-based).

In some situations, such as when Uniform Spacing is disabled or when a sensor does not support filters, the filters panel is not displayed.

The following filters are available (and are applied in this order):

- Gap filling
- Median
- Smoothing
- Decimation

The filter window sizes in the [Filters] panel are specified in millimeters. To calculate the number of data points that a window covers, use the following calculation:

- User-specified window size divided by the X spacing interval (that is, the number of millimeters per point) on the [Spacing] tab in the [Sensor] panel. (For more information on spacing intervals, see 📖 "●Spacing Interval" on page 136.)
- With the exception of the gap filling filter, round the result of the division to the nearest integer value. With the gap filling filter, filling is performed within the provided window size.

For example, if you set the size of the filter's window to a value between 1.5 mm and 2.49 mm (inclusively), and the X spacing interval is set to 1 mm, the filter covers 2 data points. A filter window size from 2.5 mm to 3.49 mm results in a filter covering 3 data points.

To configure X or Y filtering:

1 **Go to the [Scan] page.**

2 **At the top of the Scan page, choose a mode other than Video in the [Scan Mode] panel.**

Otherwise, you will not be able to configure filtering.

3 **Expand the [Filters] panel by clicking on the panel header or the button.**

4 **Click the tab for the filter you want to configure.**

5 **Enable the [X] or [Y] setting and select the maximum width value.**

6 **Check that the filtered scan data is satisfactory.**

7 **Save the job in the [Toolbar] by clicking the [Save] button 💾.**

For details on each filter, see the descriptions below.

■ Gap Filling

Gap filling fills in missing data caused by occlusions using information from the nearest neighbors. Gap filling also fills gaps where no data is detected, which can be due to the surface reflectivity, for example dark or specular surface areas, or to actual gaps in the surface. The value represents the maximum gap width that the sensor will fill. Gaps wider than the maximum width will not be filled.

Gap filling works by filling in missing data points using either the lowest values from the nearest neighbors or linear interpolation between neighboring values (depending on the Z difference between neighboring values), in the specified X or Y window.

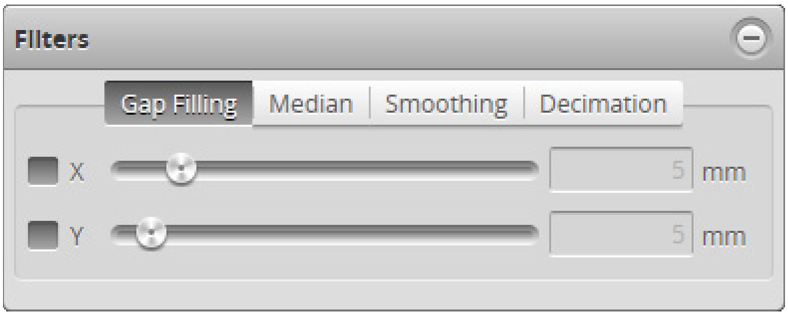
The sensor can fill gaps along both the X axis and the Y axis.

- X gap filling works by filling in the gaps within the same profile.
- Y gap filling works by filling in gaps in the direction of travel at each X location.
- If both X and Y gap filling are enabled, missing data is filled along the X and Y axes at the same time, using the available neighboring data.

Tips

In Profile mode, gap filling is limited to the X axis. In Range mode, the filter is limited to the Y axis (direction of travel).

X Gap Filling is enabled by default.



■ Median

The Median filter substitutes the value of a data point with the median calculated within a specified window around the data point.

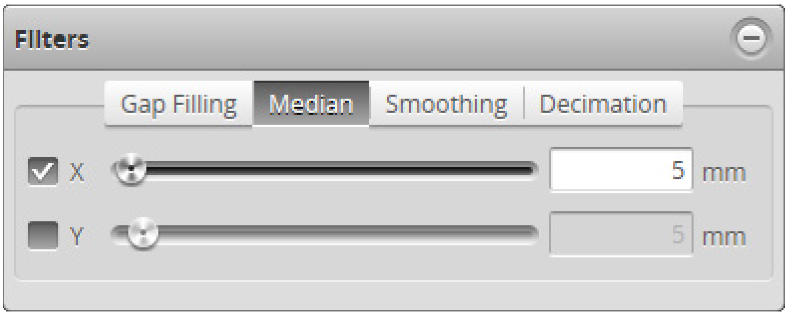
The number of valid (non null) data points in the window is even, the median value is simply the value in the center of the sorted list of values.

The number of valid points is odd, the average of the two values in the center is used instead.

Tips
Missing data points will not be filled with the mean value calculated from data points in the neighbourhood.

With an odd window size, the output is at the center of the window.

With an even window size, the output is 0.5 pixels to the right of the center (that is, using window / 2-1 values from the left, and window / 2 from the right.



■ Smoothing

Smoothing works by substituting a data point value with the mean value of that data point and its nearest neighbors within the specified window.

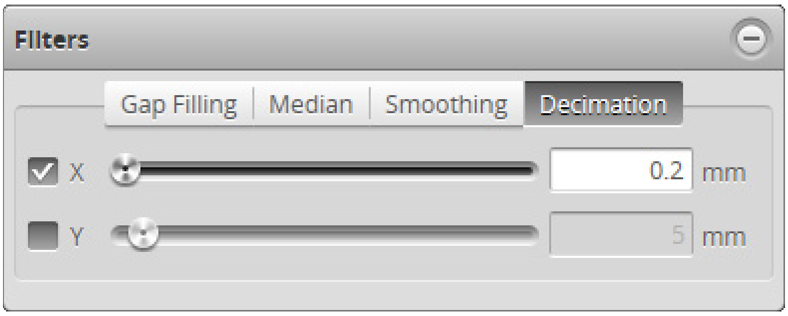
Smoothing can be applied along the X axis or the Y axis. X smoothing works by calculating a moving average across samples within the same profile. Y smoothing works by calculating a moving average in the direction of travel at each X location.

If both X and Y smoothing are enabled, the data is smoothed along X axis first, then along the Y axis.

Tips
Missing data points will not be filled with the mean value calculated from data points in the neighbourhood.

■ Decimation

Decimation reduces the number of data points along the X or Y axis by choosing data points at the end of a specified window around the data point. For example, by setting X to 0.2, only points every 0.2 millimeters will be used. The filter generates points starting from the leftmost edge of the scan data, stepping in equal steps away from that side.



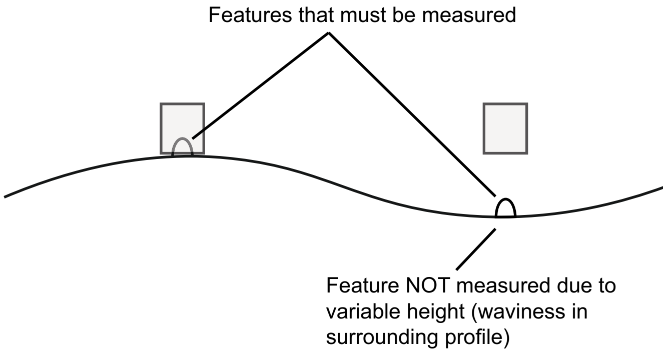
■ Slope

Slope modifies profile data in way that emphasizes high-frequency height changes when they are surrounded by lower frequency changes on the surface.

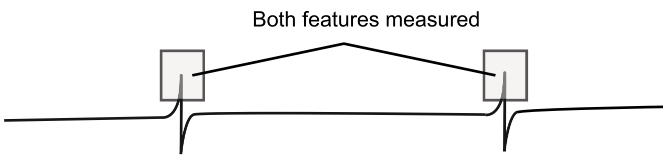
You can use the filter, for example, to easily measure the position of edges on a wavy surface.

An example is a that looks like this:

Without Slope filter



With Slope filter



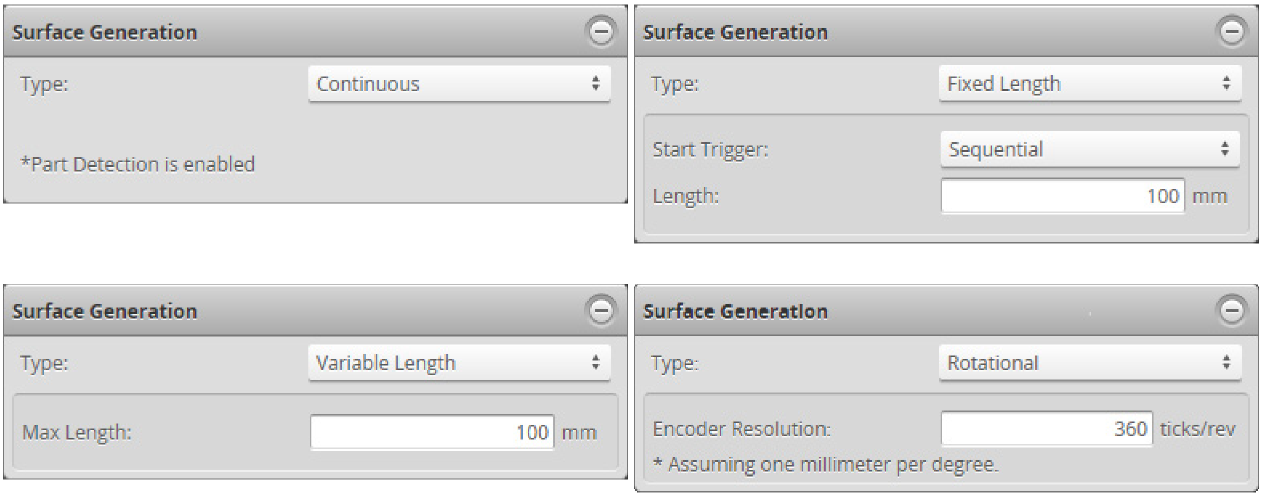
In the top profile (no filter applied), the second feature would be missed by a Position Z measurement, because the feature has moved beyond the region of interest defined for the measurement. When the filter is applied, the profile around the features is "evened out"—even though the overall height is greater than the features that must be detected—and the more abrupt changes of the features are emphasized. As a result, the position of the features can easily be measured.

The filter can be used in both Range and Profile mode.

4.4.6 Surface Generation

The sensor can generate a surface by combining a series of profiles gathered along the direction of travel.

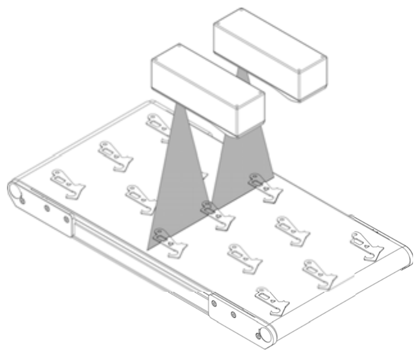
The sensor uses different methods to generate the data, depending on the needs of the application. Data generation is configured in the [Surface Generation] panel on the [Scan] page.

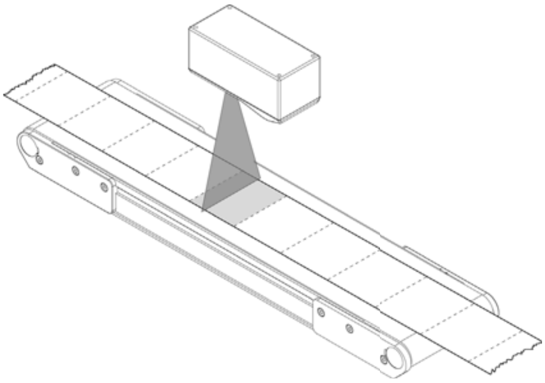


The types in the table below correspond to the [Type] setting in the panel.

> **Tips**
>
> When [Type] is set to [Continuous], part detection is automatically enabled. When [Type] is set to any of the other settings, [part detection] can be enabled and disabled in the [Part Detection] panel. For descriptions of the settings that control part detection logic, "4.4.7 Part Detection" on page 149.

[Continuous]: The sensor continuously generates surfaces of parts that are detected under the sensor. This type is typically used when the transport system continuously feeds material or parts under a sensor. The materials have a distinguishable start and stop edge.





[Fixed Length]: The sensor generates surfaces of a fixed length (in mm) using the value in the Length setting.

Like [Continuous] mode, Fixed [Length] mode is used when material or parts continuously pass under the sensor.

Unlike [Continuous] mode, parts/material do not have distinguishable start and stop edge.

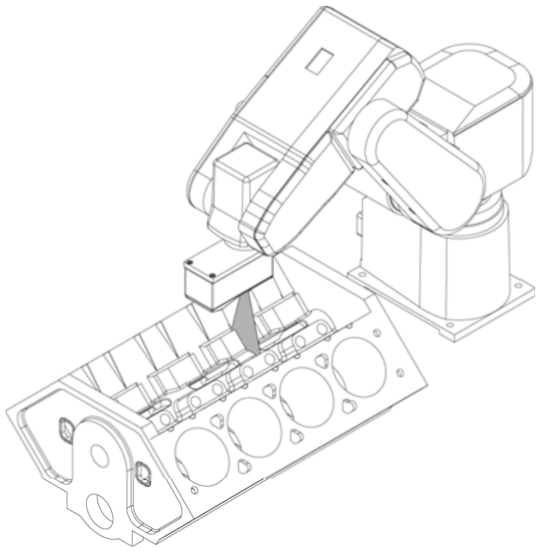
For correct length measurement, you should ensure that motion is calibrated (that is, encoder resolution for encoder triggers or travel speed time triggers).

The following types of start triggers are available under [Start Trigger]:

- [Sequential]: Continuously generates back-to-back fixed length surfaces.
- [External Input]: A pulse on the digital input triggers the generation of a single surface of fixed length.
- [Software]: Allows starting fixed length surfaces on command from PLC or PC.

For more information on connecting external input to a sensor, see 📖 "■Digital Input" on page 1010

You can optionally enable part detection to process the surface after it has been generated, but the generation itself does not depend on the detection logic. To do this, check [Enabled] in the [Part Detection] panel.



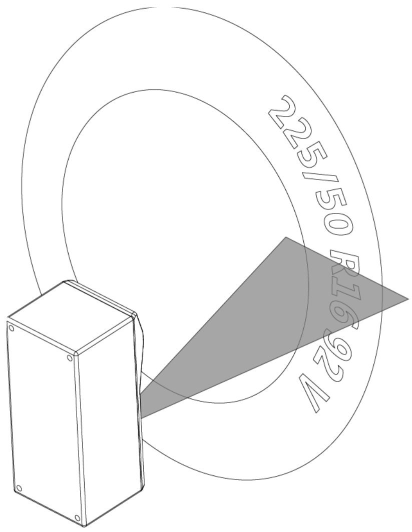
[Variable Length]: The sensor generates surfaces of variable length. Profiles collected while the external digital input is held high are combined to form a surface. If the value of the [Max Length] setting is reached while external input is still high, the next surface starts immediately with the next profile. This mode is typically used in robot-mounted applications, for example, measuring different parts on an engine block.

For correct length measurement, you should ensure that motion is calibrated (i.e., encoder resolution for encoder triggers or travel speed for time triggers).

For more information on connecting external input to a sensor, see 📖 "■Digital Input" on page 1010.

You can optionally enable part detection to process the surface after it has been generated, but the generation itself does not depend on the detection logic. To do this, check [Enabled] in the [Part Detection] panel.

[Rotational]: The sensor reorders profiles within a surface to be aligned with the encoder’s index pulse. That is, regardless of the radial position the sensor is started at, the generated surface always starts at the position of the index pulse. If the index pulse is not detected and the rotation circumference is met, the surface is dropped and the Encoder Index Drop indicator will be incremented. This mode is typically used in applications where measurements of circular objects or shafts need to be taken, such as tire tread inspection, or label positioning on bottles.



Tips

To scan exactly one revolution of a circular target without knowing the circumference, manually set the encoder resolution to 1, the encoder trigger spacing to (number of encoder ticks per revolution) / (number of desired profiles per revolution), and [Encoder Resolution] in the [Surface Generation] panel to the number of encoder ticks per revolution.

You can optionally enable part detection to process the surface after it has been generated, but the generation itself does not depend on the detection logic. To do this, check [Enabled] in the [Part Detection] panel.

To configure surface generation:

1. **Go to the [Scan] page and choose [Surface] in the [Scan Mode] panel.**

   If this mode is not selected, you will not be able to configure surface generation.

2. **Expand the [Surface Generation] panel by clicking on the panel header or the ⊕ button.**

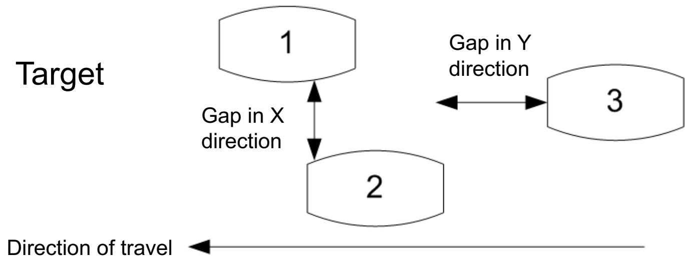
3. **Choose an option from the [Type] drop-down and any additional settings.**

   See the types and their settings described above.

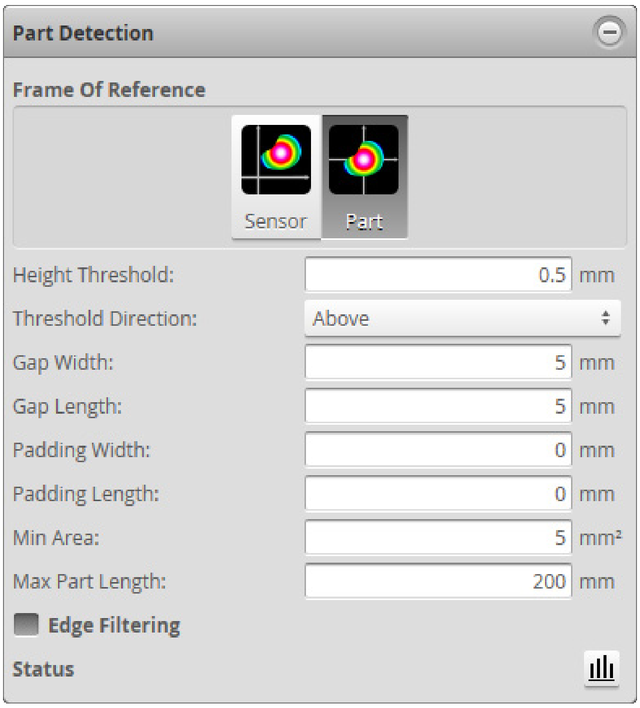
4.4.7 Part Detection

In Surface mode, a sensor can analyze scan data to identify discrete objects. Surface measurements can then be performed on each object. Part detection is configured using the [Part Detection] panel on the [Scan] page.
Part detection must be manually enabled when [Type] is set to [Fixed Length], [Variable Length], or [Rotational] in the [Surface Generation] panel. When [Type] is set to [Continuous], part detection is always enabled.
Part detection can be performed when [Source] in the [Trigger] panel is set to [Time] or [Encoder]. To use the [Time] trigger source, the travel speed must be calibrated. To use the [Encoder] trigger source, the encoder resolution must be calibrated. See "4.5 Aligning Sensors" on page 171 for more information.

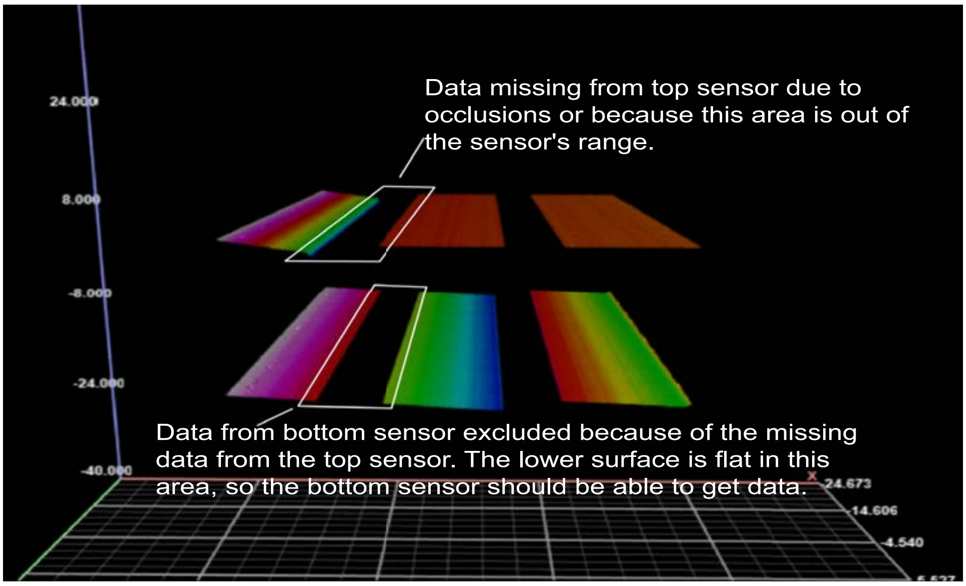
Multiple parts can pass through the laser at the same time and will be individually tracked. Parts can be separated along the laser line (X axis), in the direction of travel (Y axis), or by gated external input.

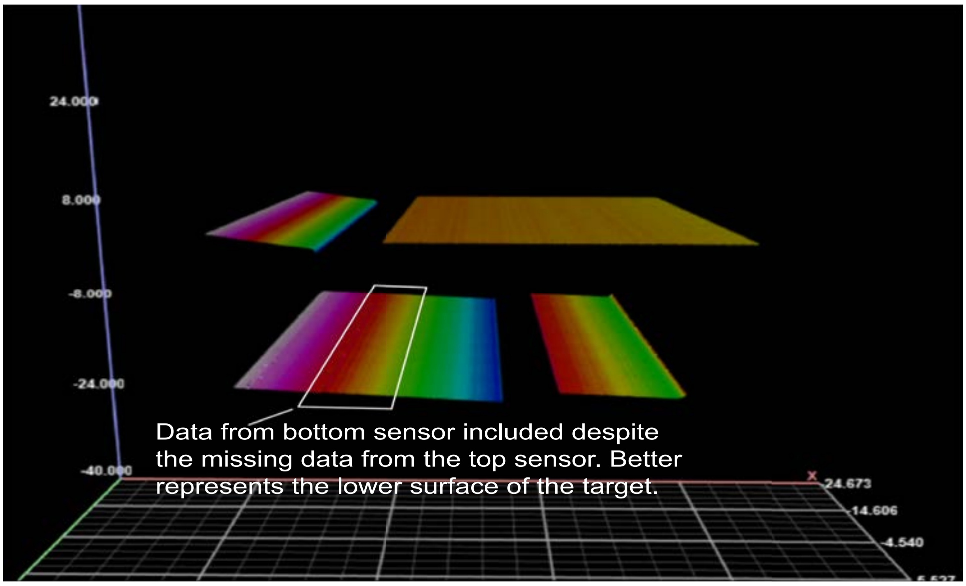


Tips
SurfaceMeasure1008S also lets you isolate and then measure using one of two Surface measurement tools (for more information on these tools, see "6.5 Blob" on page 431 and "6.29 Segmentation" on page 573). For a comparison of part detection and these tools, see "6.1 Isolating Parts from Surface Data" on page 421.



The following settings can be tuned to improve the accuracy and reliability of part detection.

Setting	Description
[Height Threshold]	Determines the profile height threshold for part detection. The setting for [Threshold Direction] determines if parts should be detected above or below the threshold. Above is typically used to prevent the belt surface from being detected as a part when scanning objects on a conveyor. In an Opposite layout, the threshold is applied to the difference between the top and the bottom profile. A target thinner than the threshold value is ignored, including places where only one of either top or bottom is detected. To separate parts by gated external input, set the [Height Threshold] to the active area Z offset (i.e., minimum Z position of the current active area), set [Source] to [Time] or [Encoder] and check the [Gate on External Input] checkbox in the [Trigger] panel.
[Include one-sided data]	The option is only displayed with dual-sensor systems in Opposite layout, or multi-sensor systems in Grid layout with at least one sensor in the Bottom row. When the option is disabled, data points from a sensor are excluded if the points directly opposite from the other sensor are missing (due to occlusions, drop-outs, and so on). When the option is enabled, data points are included even if data points from the other sensor are missing. The following image shows surface data from a dual-sensor system in which the sensors are mounted facing each other. In this case, [Include one-sided data] is disabled.  The data on the upper left is missing, due to the shape of the target: getting data from this area is difficult or impossible, due to occlusions or simply because this part of the upper surface is beyond the top sensor's measurement range. Data is missing on the left of the lower surface, even though the target is flat in this area. In the following image, [Include one-sided data] is enabled. The result is that data from the lower left is included in the scan data, better representing the actual target. (The same situation is occurring on the right side of the surfaces.)

Setting	Description
	 In general, you should leave this setting enabled.
[Threshold Direction]	Determines if parts should be detected above or below the height threshold.
[Gap Width]	Determines the minimum separation between objects on the X axis. If parts are closer than the gap interval, they will be merged into a single part.
[Gap Length]	Determines the minimum separation between objects on the Y axis. If parts are closer than the gap interval, they will be merged into a single part.
[Padding Width] [Padding Length]	The amount of padding data added in the X and Y directions, respectively. The padding can contain data points that were outside the height threshold and excluded from the initial part detection. This is mostly useful when processing part data with third-party software such as HexSight, Halcon, etc.
[Min Area]	Determines the minimum area for a detected part. Set this value to a reasonable minimum in order to filter out small objects or noise.
[Max Part Length]	Determines the maximum length of the part object. When the object exceeds the maximum length, it is automatically separated into two parts. This is useful to break a long object into multiple sections and perform measurements on each section.
[Frame of Reference]	Determines the coordinate reference for surface measurements. **[Sensor]** When [Frame of Reference] is set to [Sensor], the sensor's frame of reference is used. The way the sensor's frame of reference is defined changes depending on the surface generation [Type] setting (and 📖 "4.4.6 Surface Generation" on page 146for more information): • When parts are segmented from a continuous surface (the surface generation [Type] setting is set to [Continuous]), measurement values are relative to a Y origin at the center of the part (the same as for Part frame of reference; see below). • When parts are segmented from other types of surfaces (the surface generation [Type] setting is set to [Fixed Length], [Variable Length], or [Rotational]), measurement values are relative to a Y origin at the center of the surface from which the part is segmented.

Setting	Description
	The Surface Bounding Box GlobalX and GlobalY measurements (see 📖 "6.6 Bounding Box" on page 440) are exceptions: regardless of the [Frame of Reference] setting, these measurements produce the Sensor frame of reference values of the Part frame of reference origin (which is the bounding box center), except for GlobalY when parts are segmented from continuous surfaces. In this case the GlobalY value is the Y value relative to the encoder zero position. These values can be used to locate Part frame of reference measurements in a world space. **[Part]** When [Frame of Reference] is set to [Part], all measurements except Bounding Box X and Y are relative to the center of the bounding box of the part. For Bounding Box X and Y, the measurement values are always relative to the sensor frame of reference (see 📖 "6.6 Bounding Box" on page 440).
[Status]	Provides details on the status of the part detection engine. For more information, see 📖 "■Part Detection Status" on page 153.
[Edge Filtering]	See 📖 "■Edge Filtering" on page 154.

To set up part detection:

1. **Go to the Scan page and choose [Surface] in the [Scan Mode] panel.**

   If this mode is not selected, you will not be able to configure part detection.

2. **Expand the [Part Detection] panel by clicking on the panel header or the ⊕ button.**

3. **If necessary, check the [Enabled] option.**

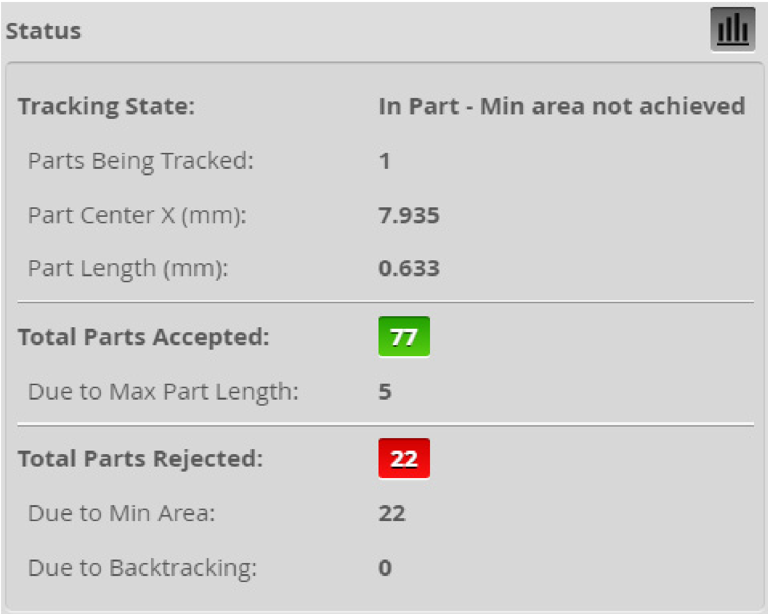
   When [Surface Generation] is set to [Continuous], part detection is always enabled.

4. **Adjust the settings.**

   See the part detection parameters above for more information.

■ Part Detection Status

One of the most common issues when setting up part detection is that surface data is not generated after the target is scanned. The [Status] section on the Part Detection panel allows you to see details on the status of the part detection engine. This can be used to diagnose why parts are not being detected during setup, reducing setup time.



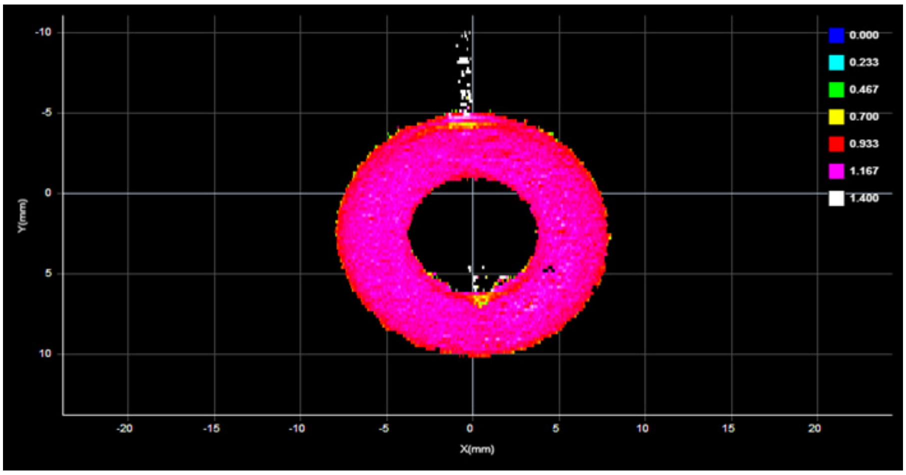
The following part detection status information is available:

Part Detection Diagnostics

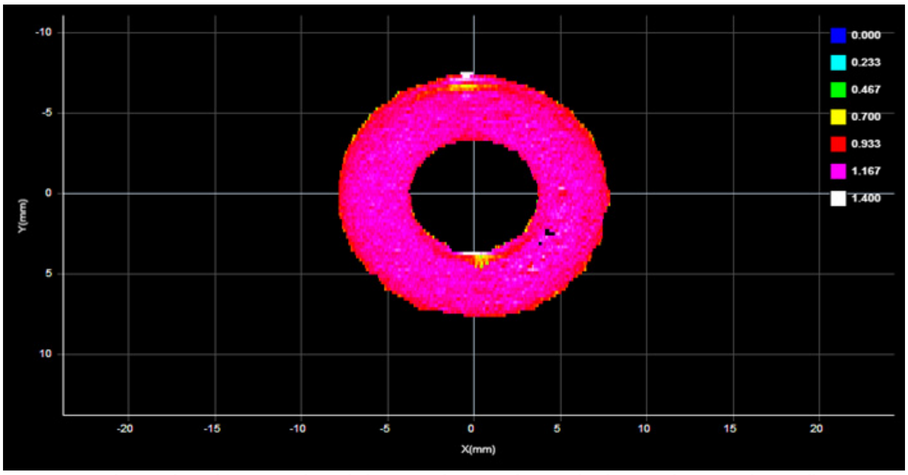
Status Indicator	Description
[Tracking State]	Part detection state for largest currently tracking part. One of the following: • [Not In Part] • [In Part, Min area not achieved] • [In Part, Min area achieved] • [In Gap, Min area not achieved] • [In Gap, Min area achieved]
[Parts Being Tracked]	The number of parts the engine is currently tracking.
[Part Center X]	The center of the partial part, midway between the minimum X and maximum X detected for the part.
[Part Length]	The length of the part. In cases of backtracking, the number decreases.
[Total Parts Accepted]	The number of parts that meet the part detection criteria.
[Due to Max Part Length]	The number of parts accepted because they have reached Max Part Length. If too many parts are being accepted, increase [Max Part Length].
[Total Parts Rejected]	The number of parts that fail to meet the part detection criteria.
[Due to Min Area]	The number of parts rejected because they are below Min Area. If too many parts are being rejected, reduce [Min Area].
[Due to Backtracking]	The number of parts rejected due to backtracking, for example, when the user reverses the direction of the transport mechanism while the sensor is actively scanning a part. Only applicable when the encoder trigger behavior has been set to Bi-Directional.

■ Edge Filtering

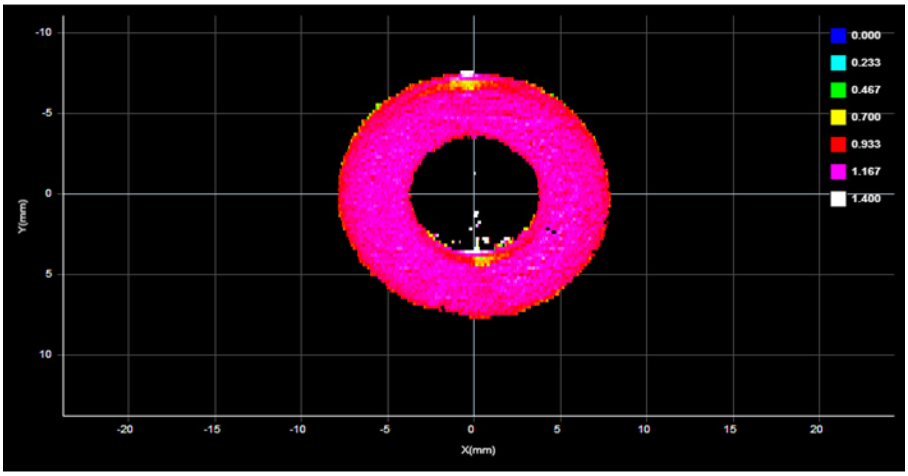
Part scans sometimes contain noise around the edges of the target. This noise is usually caused by the sensor's light being reflected off almost vertical sides, rounded corners, etc. Edge filtering helps reduce edge noise in order to produce more accurate and repeatable volume and area measurements, as well as to improve positioning of relative measurement regions. Optionally, the [Preserve Interior Feature] setting can be used to limit filtering to the outside edges of the target.



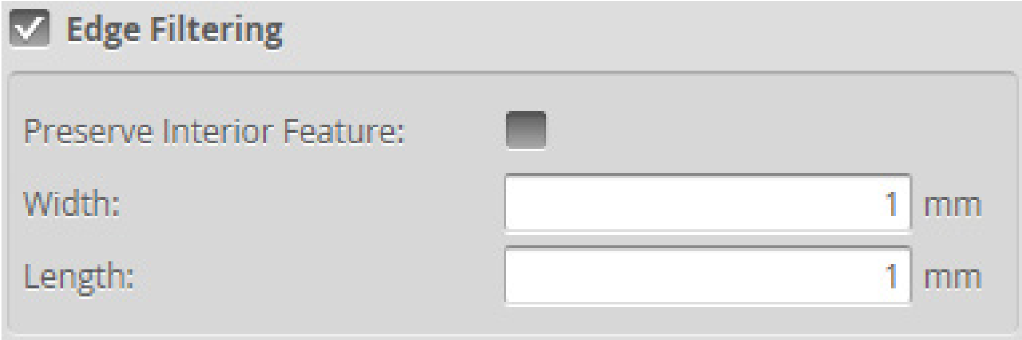
Edge Filtering disabled (scan shows reflection noise)



Edge Filtering enabled (reflection noise eliminated or reduced)



Edge Filtering enabled, Preserve Interior Feature enabled



To configure edge filtering:

1 **Go to the [Scan] page and choose [Surface] in the [Scan Mode] panel.**

If this mode is not selected, you will not be able to configure part detection.

2 **Expand the [Part Detection] panel by clicking on the panel header or the button and enable part detection if necessary.**

Part detection can be enabled and disabled when [Type] in the [Surface Generation] panel is set to [Fixed Length], [Variable Length], or [Rotational]. Part detection is automatically enabled when [Type] is set to [Continuous].

3 **Check the [Edge Filtering] checkbox to enable edge filtering.**

4 **Configure the [Width] and [Length] settings.**

The [Width] and [Length] settings represent the size of the filter on the X axis and the Y axis, respectively.

5 **Set the [Preserve Interior Feature] setting if necessary.**

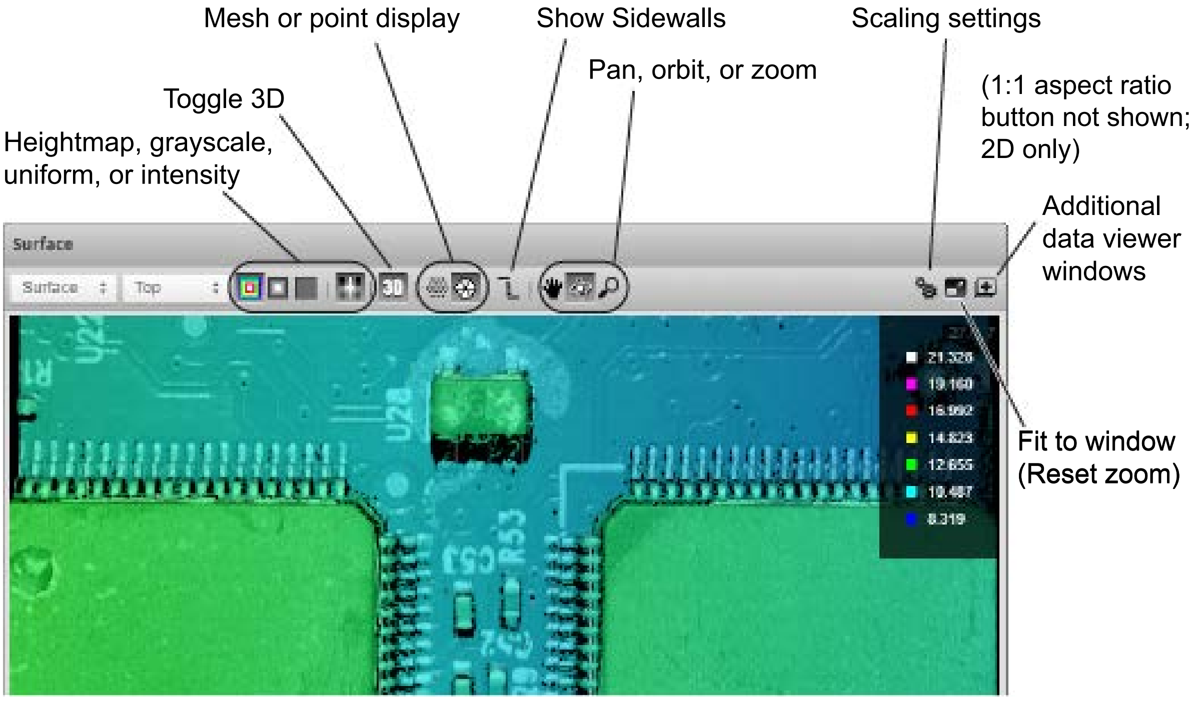
The [Preserve Interior Feature] setting limits filtering to the outside edges of the target.

4.4.8 Data Viewer

The data viewer can display video images, profiles, sections, surfaces, height maps, and intensity images. It is also used to configure the active area (📖 "■Active Area" on page 124) and measurement tools (see 📖 "4.7 Measurement and Processing" on page 230). The data viewer changes depending on the current operation mode and the panel that has been selected.
The data viewer lets you "pin" multiple outpus (measurements and geometric features) to the data viewer; for more information, see 📖 "4.7.5 Pinning Measurements and Features" on page 281.

■ Data Viewer Controls

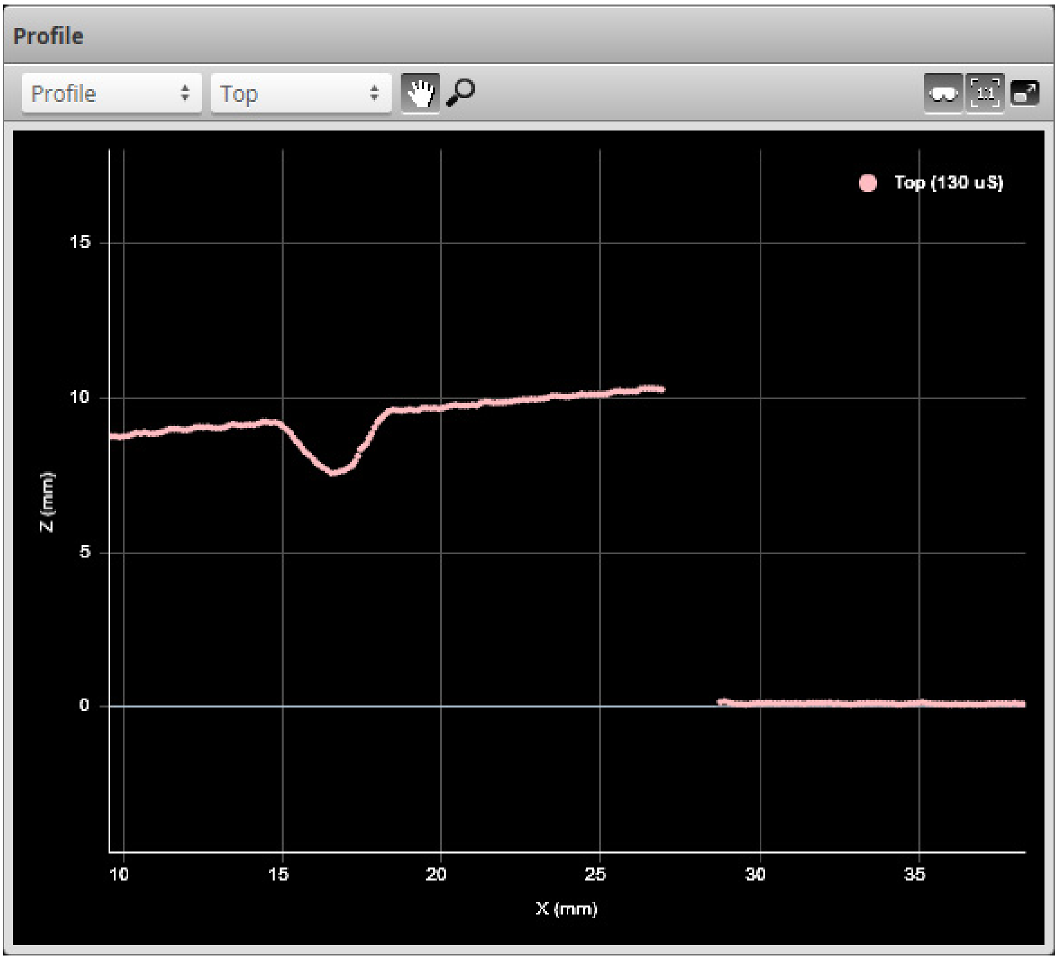
The data viewer is controlled by mouse clicks and by the buttons on the display toolbar. The mouse wheel can also be used for zooming in and out.



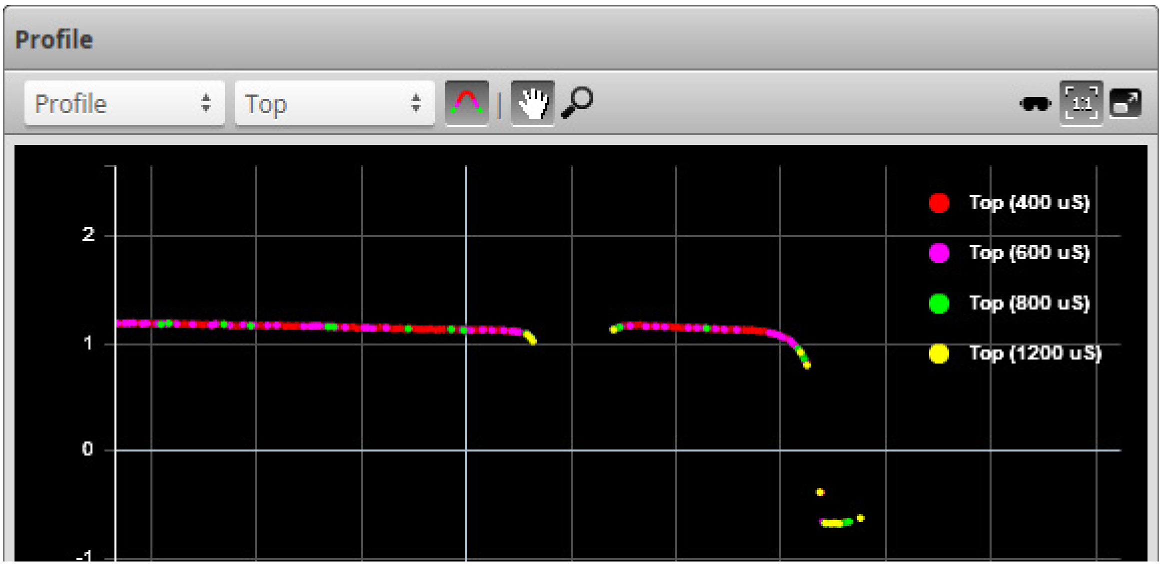
For more information on the kinds of data displayed in Surface mode and how scan data is displayed, see 📖 "■Surface Mode" on page 162.
For more information on the kinds of data displayed in Profile mode and how scan data is displayed, see 📖 "■Profile Mode" on page 161.

For information on how to open and use additional data viewer windows, see 📖 "4.7.2 Using Multiple Data Viewer Windows" on page 232.

When the sensor displays profiles, a safety goggle mode button ( ) is available above the data viewer. Enabling this mode changes some colors to ensure that profiles are visible in the data viewer when wearing laser safety goggles. The option is also available in Surface mode when a section is displayed.



When multiple exposures have been defined, you can use the Multiple Exposures button ( ) to toggle between showing a single-color profile made up of data from all exposures, and a profile in which the source exposure of the data points is identified by a different color.



■ Video Mode

In Video mode, the data viewer displays images directly from the sensor's camera or cameras. In a dual- or multi-sensor system, camera images from any camera can be displayed.

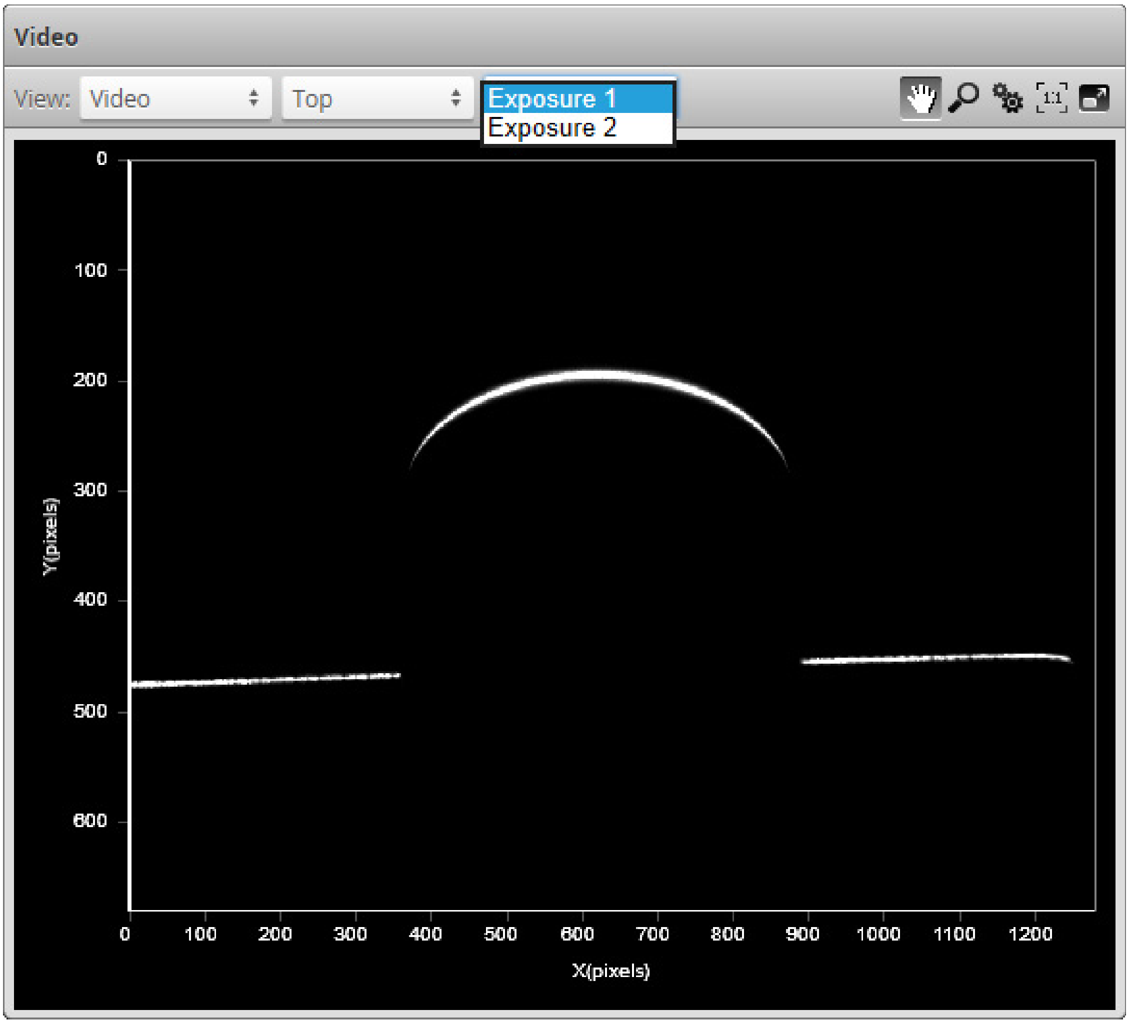
In this mode, you can configure the data viewer to display exposure information (see 📖 "●Exposure Information" on page 158). You can also configure spot and dropout information that can be useful in properly setting up the system for scanning (see 📖 "●Spots and Dropouts" on page 160).

● Exposure Information

In Video mode, you can display exposure-related information. This information can help you correctly adjust the exposure settings.

Exposures

If you have set [Exposure Mode] to [Multiple], and have set more than one exposure, a drop-down at the top of the data viewer lists the available exposures. Choosing an exposure changes the view of the data viewer to that exposure.



For details on setting exposure in the [Exposure] tab in the [Sensor] panel, see 📖 "■Exposure" on page 130.

To select the exposure view of the display:

1 Go to the [Scan] page and choose [Video] mode in the [Scan Mode] panel.

2 Select the camera view in the data viewer.

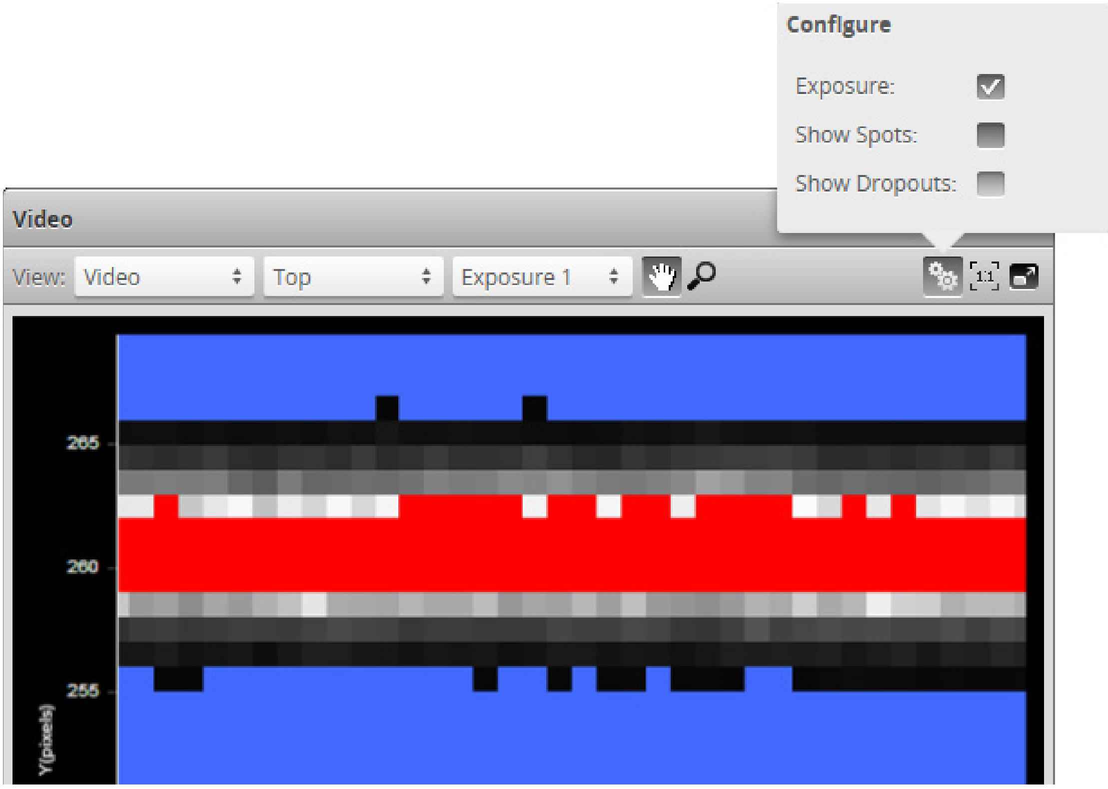
Use the first drop-down list next to [View] at the top of the data viewer to select [Main] or [Buddy].

3 Select the exposure.

Use the second drop-down list next to [View] at the top of the data viewer to select the exposure.

Overexposure and Underexposure

You can display a color exposure overlay on the video image to help set the correct exposure.



The [Exposure] setting uses the following colors:

- Blue: Indicates background pixels ignored by the sensor.
- Red: Indicates saturated pixels.

Correct tuning of exposure depends on the reflective properties of the target material and on the requirements of the application. Settings should be carefully evaluated for each application, but often a good starting point is to set the exposure so that there are 2 to 3 red pixels in the center of the laser line.

To display an overlay:

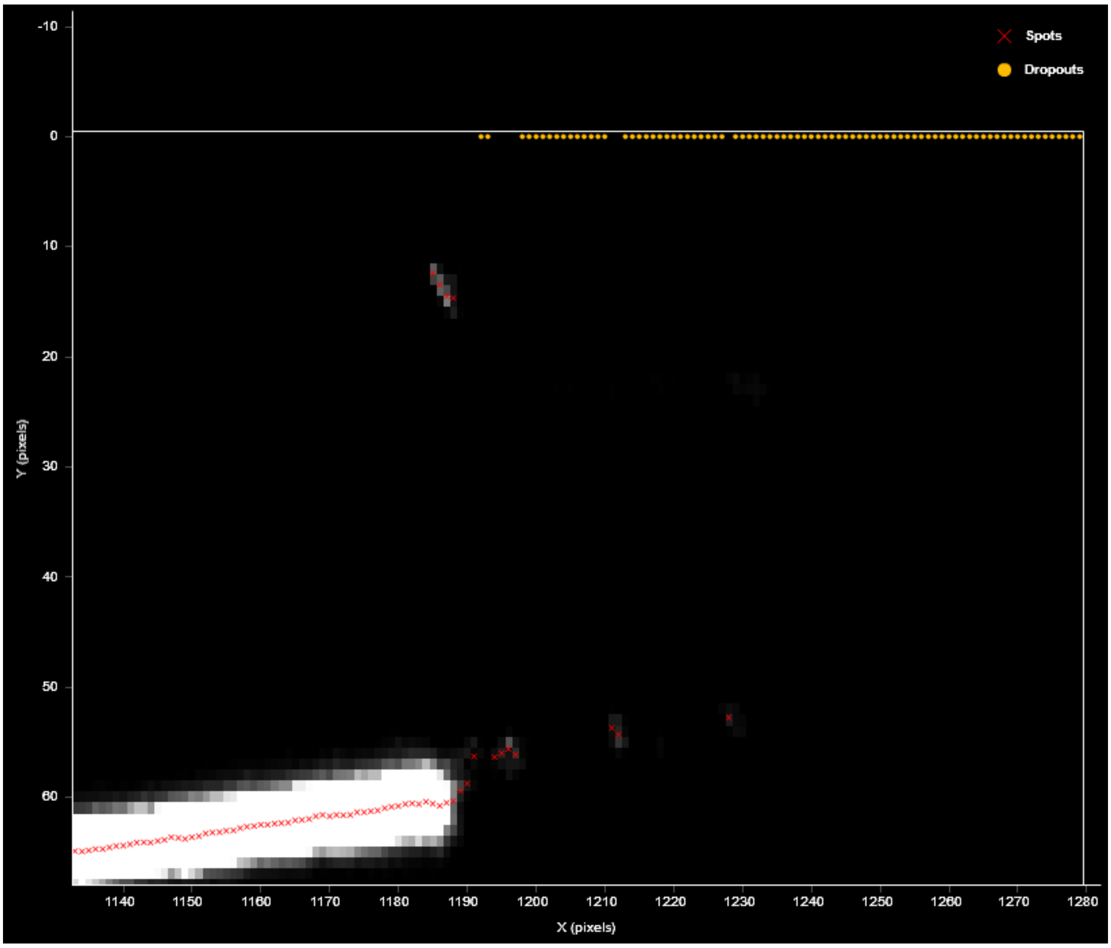
1 Go to the [Scan] page and choose [Video] mode in the [Scan Mode] panel.

2 Check [Exposure] at the top of the data viewer.

- Spots and Dropouts

Various material sub-settings can affect how the [Material] settings behave. In Video mode, you can examine how the [Material] settings are affected. To do this, in Video mode, check the [Show Spots] option at the top of the data viewer to overlay a representation of the spots in the data viewer.

In the image below, the white and gray squares represent the light as it appears on the camera sensor. Spots (which represent the center of the laser line on the camera sensor for each column) are displayed as red "x" symbols. Dropouts (where no spot is detected on the camera sensor in a given column) are depicted at the upper edge of the data viewer as yellow dots.



To show data dropouts:

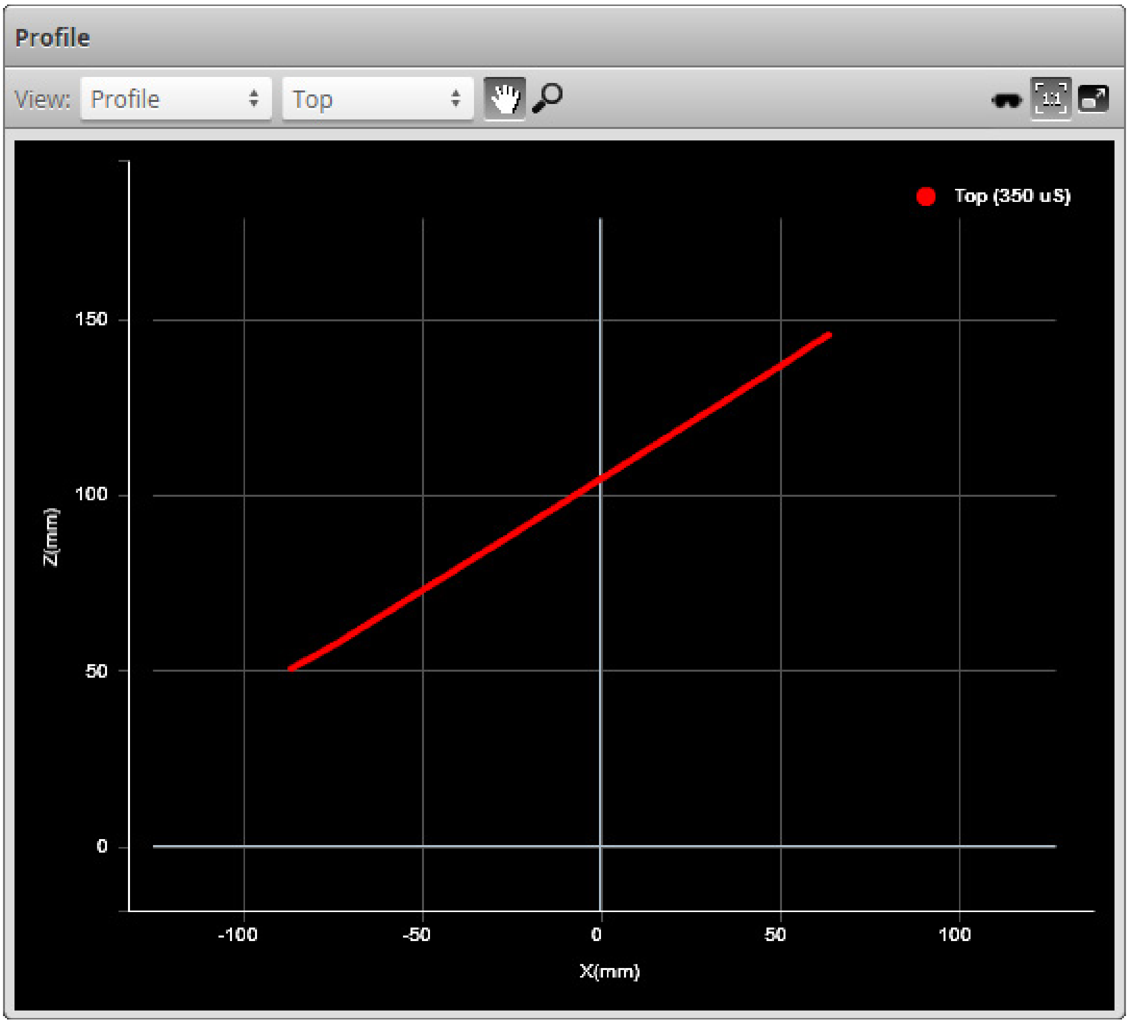
1 Go to the [Scan] page and choose [Video] mode in the [Scan Mode] panel.

2 check the [Show Dropouts] option at the top of the data viewer.

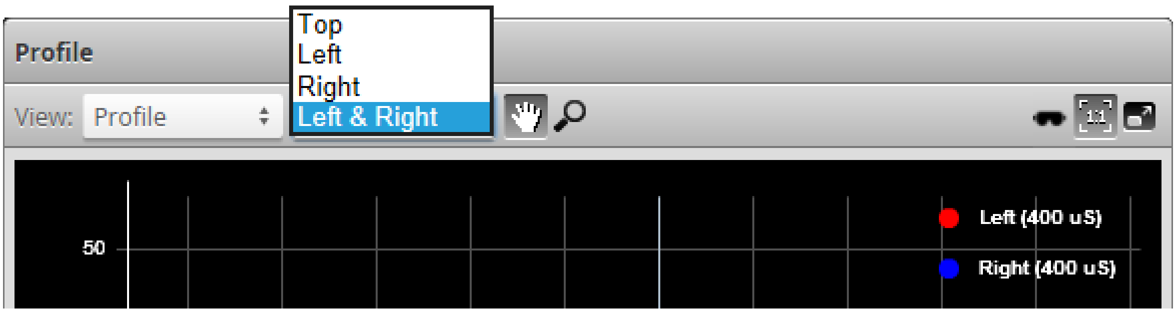
For more information on the material settings, see "■Advanced" on page 137.

■ Profile Mode

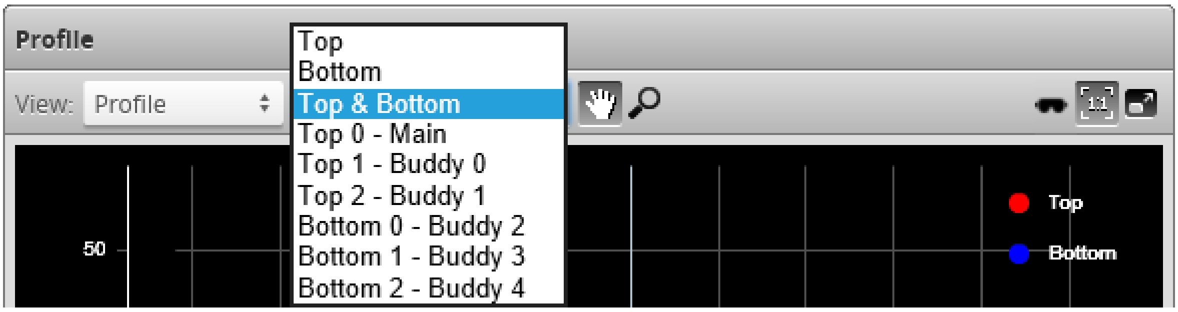
When the sensor is in Profile scan mode, the data viewer displays profile plots.



In a dual-sensor system, profiles from individual sensors or from a combined view can be displayed.



Similarly, in a multi-sensor system, profiles from individual sensors or from combined views can be displayed.



When in the [Scan] page, selecting a panel (e.g., [Sensor] or [Alignment] panel) automatically sets the display to the most appropriate display view.

To manually select the display view in the Scan page:

1 Go to the [Scan] page.

2 Choose [Profile] mode in the [Scan Mode] panel.

3 Select the view.

[Top]: View from a single sensor, from the top sensor in an opposite-layout dual-sensor system, or the combined view of sensors in the top position.

[Bottom]: View from the bottom sensor in an opposite-layout dual-sensor system, or all sensors in the bottom row of a multi-sensor system.

[Top & Bottom]: Combined view from all sensors in a multi-sensor system set up with sensors on the top and bottom rows in the layout grid.

[Left]: View from the left sensor in a dual-sensor system.

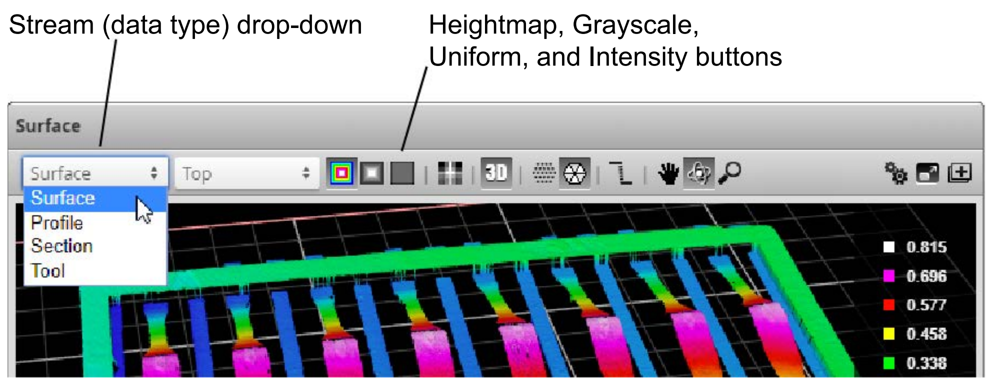
[Right]: View from the right sensor in a dual-sensor system.

[Left & Right]: In a dual-sensor system, views from both sensors, displayed at the same time in the data viewer, using the coordinate systems of each sensor.

In the [Measure] page, the view of the display is set to the profile source of the selected measurement tool.

■ Surface Mode

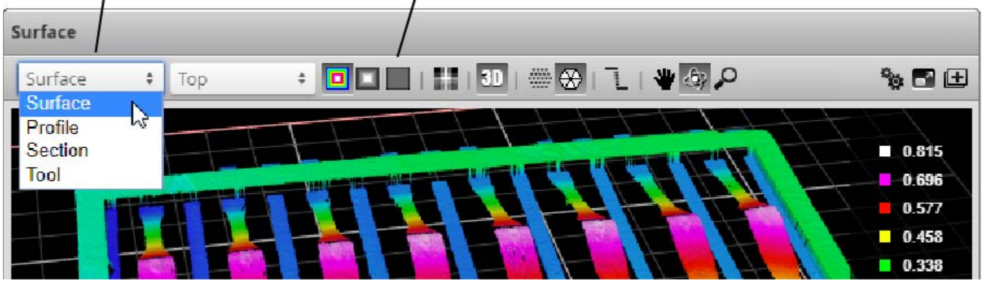
When the sensor is in Surface scan mode, the data viewer can display height maps, sections, and intensity images. You can select the data to display from the first drop-down.



<table>
<tr><th>Data Type Option or Button</th><th>Description</th></tr>
<tr><td>[Surface]</td><td>Displays surface data received from the sensor's scan engine.

If intensity data is available in the scan data, you can choose to display heightmap and intensity data at the same time to produce a more realistic part. For more information, see Heightmap button below.</td></tr>
<tr><td>[Profile]</td><td>Displays the last collected profile. (Only available in 2D view. Only displays data on physical sensors: in the emulator, no data is displayed.)</td></tr>
<tr><td>[Section]</td><td>If any sections have been defined, displays the section selected in the Sections drop-down. (Only available in 2D view.)</td></tr>
<tr><td>[Tool]</td><td>Displays data from tools capable of producing "tool data" output (such as Surface Stitch or Surface Track). When you select [Tool], a second drop-down is displayed next to the first, which lets you choose among the available data.

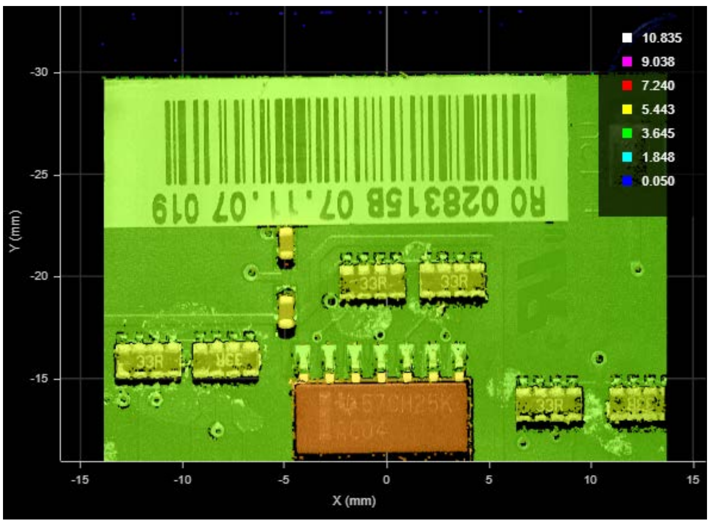
Stream (data type) drop-down
Heightmap, Grayscale, Uniform, and Intensity buttons



For more information on tool data output, see "3.6.3 Tool Data" on page 71.</td></tr>
<tr><td>[Heightmap] button</td><td>Displays a pseudo-color height map over the scan data.

If intensity data is available, you can use the Intensity button (see below) to display the combined heightmap and intensity data. This results in a more realistic-looking part in the data viewer and lets you use contrast-based information to help position tool regions. For more information on intensity data, see "■Intensity Output" on page 170. By default, intensity is not enabled in the data viewer.

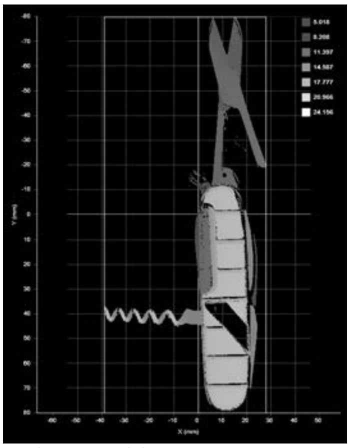
For example, if you needed to measure the flatness of a CPU, this could help you avoid placing measurement regions on top of labels that are slightly raised compared to the surrounding area, which, if included in the flatness measurement, would result in inaccurate measurements:

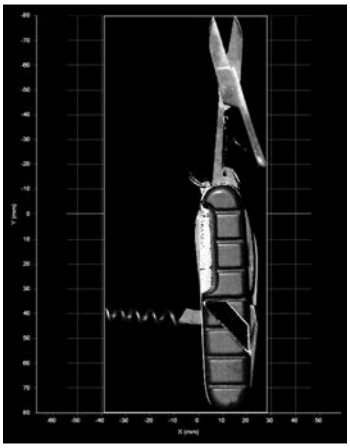


</td></tr>
</table>

Data Type Option or Button	Description
[Grayscale] button	If intensity data is available, when the Intensity button is toggled off (see below), this displays a grayscale height map. This is useful to better differentiate between scan data and the various elements of measurement tools that are displayed over the scan data. When the Intensity button is toggled on, displays intensity data only.
[Uniform] button	Displays a uniformly shaded surface on the 3D model. (Only available in 3D view.) Mostly useful when you want to focus on shape or geometry. When this mode is selected, the Intensity button is hidden.
[Intensity] button	Displays intensity data. See the descriptions of the Heightmap, Grayscale, and Uniform buttons above for an explanation of how this button interacts with those display modes. (The button is hidden if no intensity data is available in the scan data.) ([Acquire Intensity] must be checked in the [Scan Mode] panel for this button to be visible. For more information, see 📖 "■Intensity Output" on page 170 and 📖 "4.4.2 Scan Modes" on page 116.)

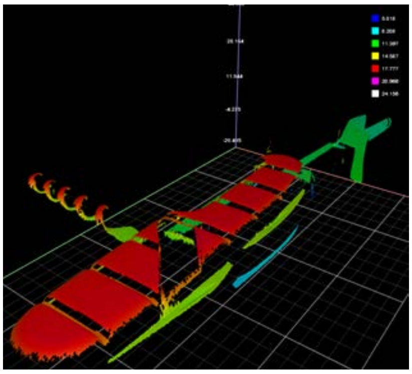

2D viewer with height map overlay

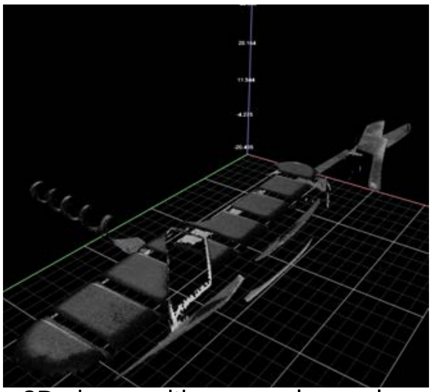

2D viewer with grayscale overlay

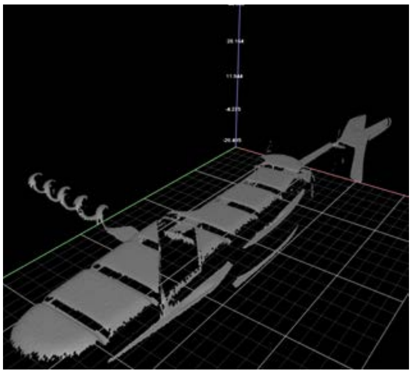

2D viewer with intensity overlay

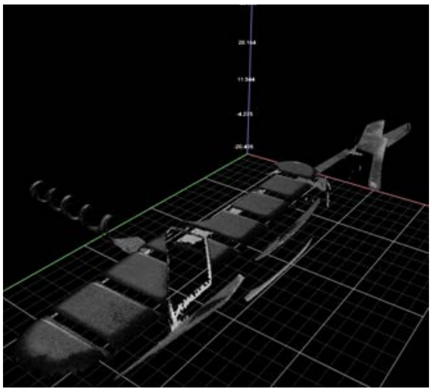
Choosing the [Profile] view option will switch the data viewer out of the [3D] viewer and display a profile.

Clicking the [3D] button toggles between the 2D and 3D viewer. The 3D model is overlaid with the information that corresponds to the selected [View] option.


3D viewer with height map overlay

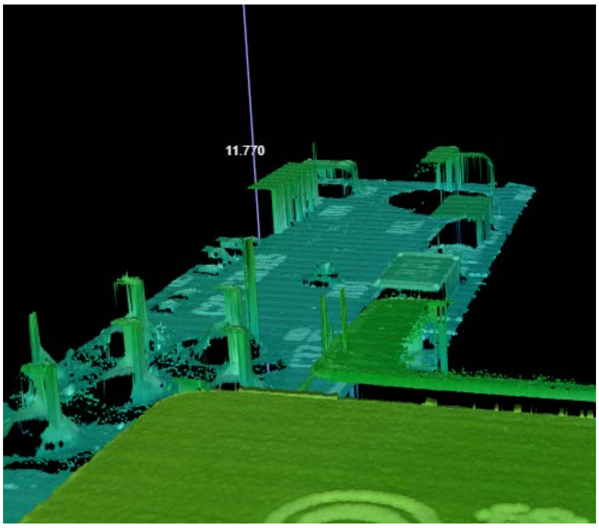
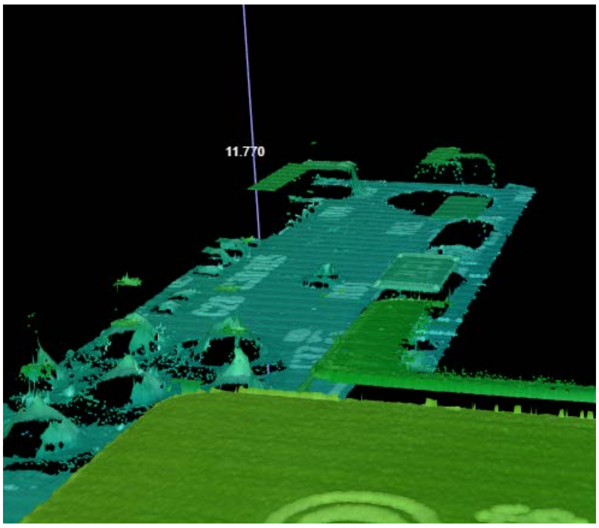

3D viewer with grayscale overlay


3D viewer with uniform overlay (Mesh)


3D viewer with uniform overlay (Points)

You can choose among the following options to change how the data viewer renders the scan data.

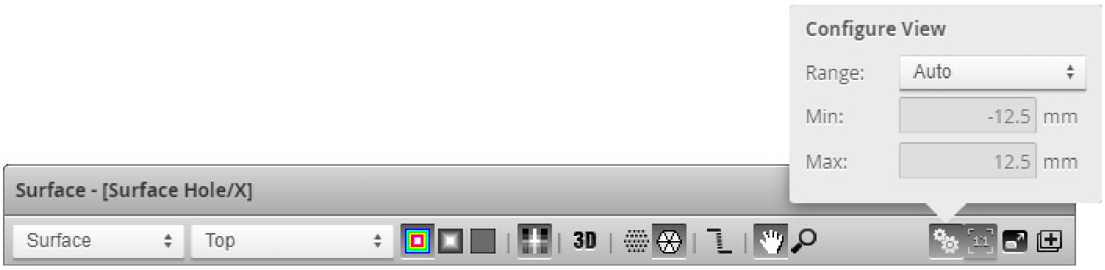
Rendering Mode	Description
Points 	Renders scan data using point. Useful in scan data that contains noise around edges, and can show hidden structure.
Mesh 	Renders scan by connecting points with polygons.

Rendering Mode	Description
Show Sidewalls 	Toggles between hiding and showing polygons involving geometrically distant points. For example, in the following, the sidewalls are enabled: the long lines of scan data shown at the edges of the PCB components may be visually distracting.  These artifacts are hidden when "sidewalls" are disabled.  Note that this setting only affects the appearance of scan data in the data viewer. It does not change the scan data and therefore does not affect measurements. In some situations, displaying long triangles may provide useful information. Try both modes in your application to determine the best choice.

In a dual- or multi--sensor system, data from individual sensors or from a combined view can be selected. While in the [Scan] page, selecting a panel (e.g., [Sensor] or [Part Detection panel]) will automatically set the display to the most appropriate display type and display view.

- Height Map Color Scale

Height maps are displayed in pseudo-color. The height axis (Z) is color-coded. The scaling of the height map can be adjusted.



To change the scaling of the height map:

1 Select [Heightmap] from the [View] drop-down in the data viewer.

2 Click the [Scaling] button.

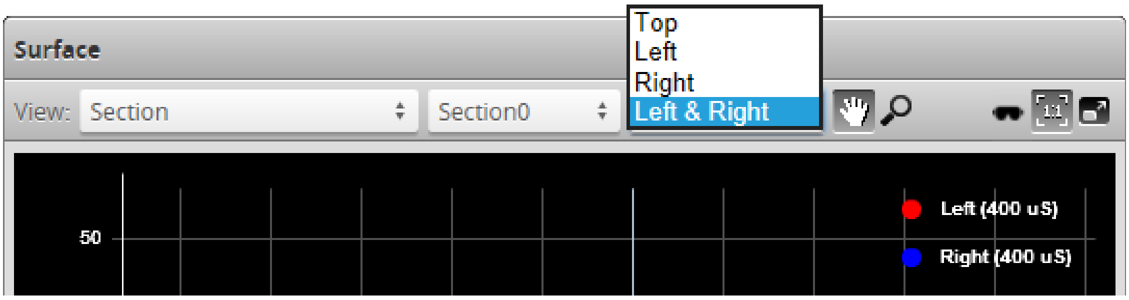
- To automatically set the scale, choose [Auto] in the [Range] drop-down.
- To automatically set the scale based on a user-selected sub-region of the heightmap, choose [Auto - Region] in the [Range] drop-down and adjust the yellow region box in the data viewer to the desired location and size.
- To manually set the scale, choose the [Manual] in the [Range] drop-down and enter the minimum and maximum height to which the colors will be mapped.

- Sections

When the sensor is in Surface scan mode, the data viewer can display sections (profiles extracted from surfaces).

In a multi-sensor system, profiles from individual sensors or from a combined view can be displayed.

When in the [Scan] page, selecting a panel (e.g., [Sensor] or [Alignment] panel) automatically sets the display to the most appropriate display view.



To manually select the display view in the Scan page:

1 Go to the [Scan] page.

2 Choose [Surface] mode in the [Scan Mode] panel.

3 Just above the data viewer, choose [Section] in the [View] drop-down.

The view from an individual sensor or the combined view of two sensors can be selected from the drop-down list at the top of the data viewer.

[Top]: View from a single sensor, from the top sensor in an opposite-layout dual-sensor system, or the combined view of sensors that have been aligned to use a common coordinate system.

[Bottom]: View from the bottom sensor in an opposite-layout dual-sensor system.

[Left]: View from the left sensor in a dual-sensor system.

[Right]: View from the right sensor in a dual-sensor system.

[Left & Right]: Views from both sensors, displayed at the same time in the data viewer, using the coordinate systems of each sensor.

1 Go to the [Scan] page.

2 Choose [Surface] mode in the [Scan Mode] panel.

3 Just above the data viewer, choose [Section] in the [View] drop-down.

The view from an individual sensor or the combined view of two sensors can be selected from the drop-down list at the top of the data viewer.

[Top]: View from a single sensor, from the top sensor in an opposite-layout dual-sensor system, or the combined view of sensors that have been aligned to use a common coordinate system.

[Bottom]: View from the bottom sensor in an opposite-layout dual-sensor system.

[Left]: View from the left sensor in a dual-sensor system.

[Right]: View from the right sensor in a dual-sensor system.

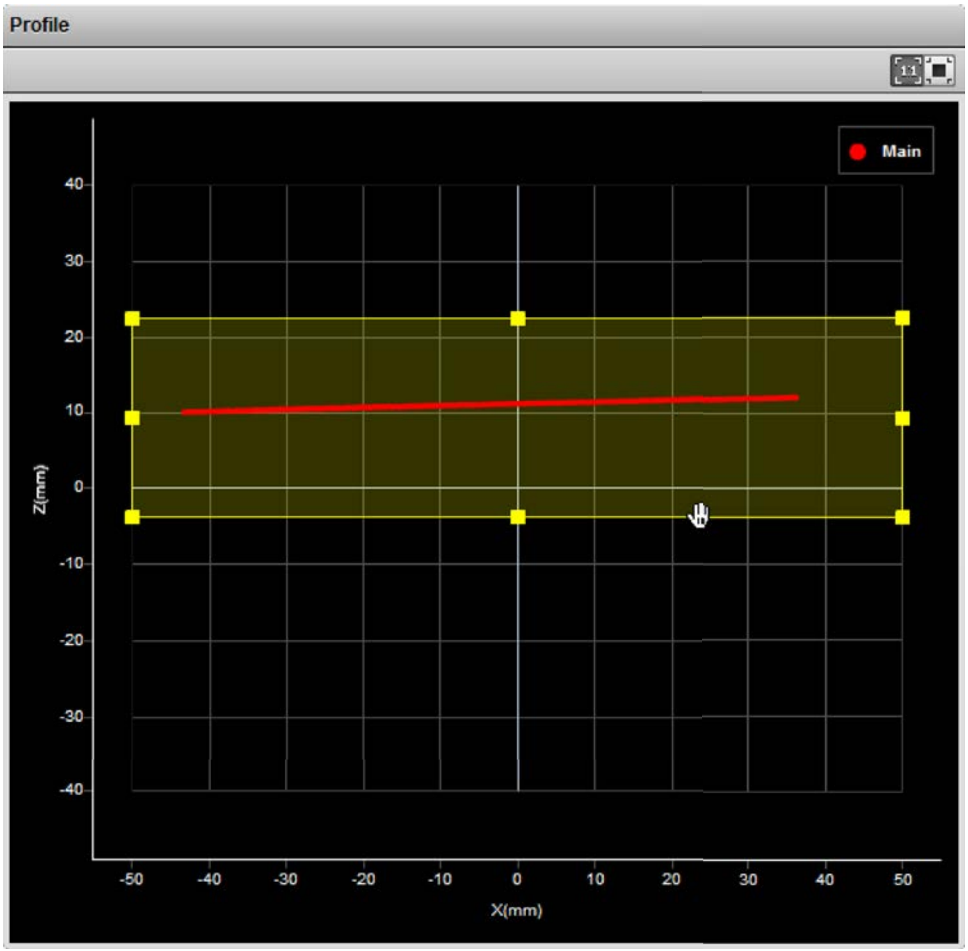
[Left & Right]: Views from both sensors, displayed at the same time in the data viewer, using the coordinate systems of each sensor.

In the [Measure] page, the view of the display is set to the profile source of the selected measurement tool.

■ Region Definition

Regions, such as an active area or a measurement region, can be graphically set up using the data viewer.

When the [Scan] page is active, the data viewer can be used to graphically configure the active area. The [Active Area] setting can also be configured manually by entering values into its fields and is found in the [Sensor] panel (see "4.4.4 Sensor" on page 123).



To set up a region of interest:

1 Move the mouse cursor to the rectangle.

The rectangle is automatically displayed when a setup or measurement requires an area to be specified.

2 Drag the rectangle to move it, and use the handles on the rectangle's border to resize it.

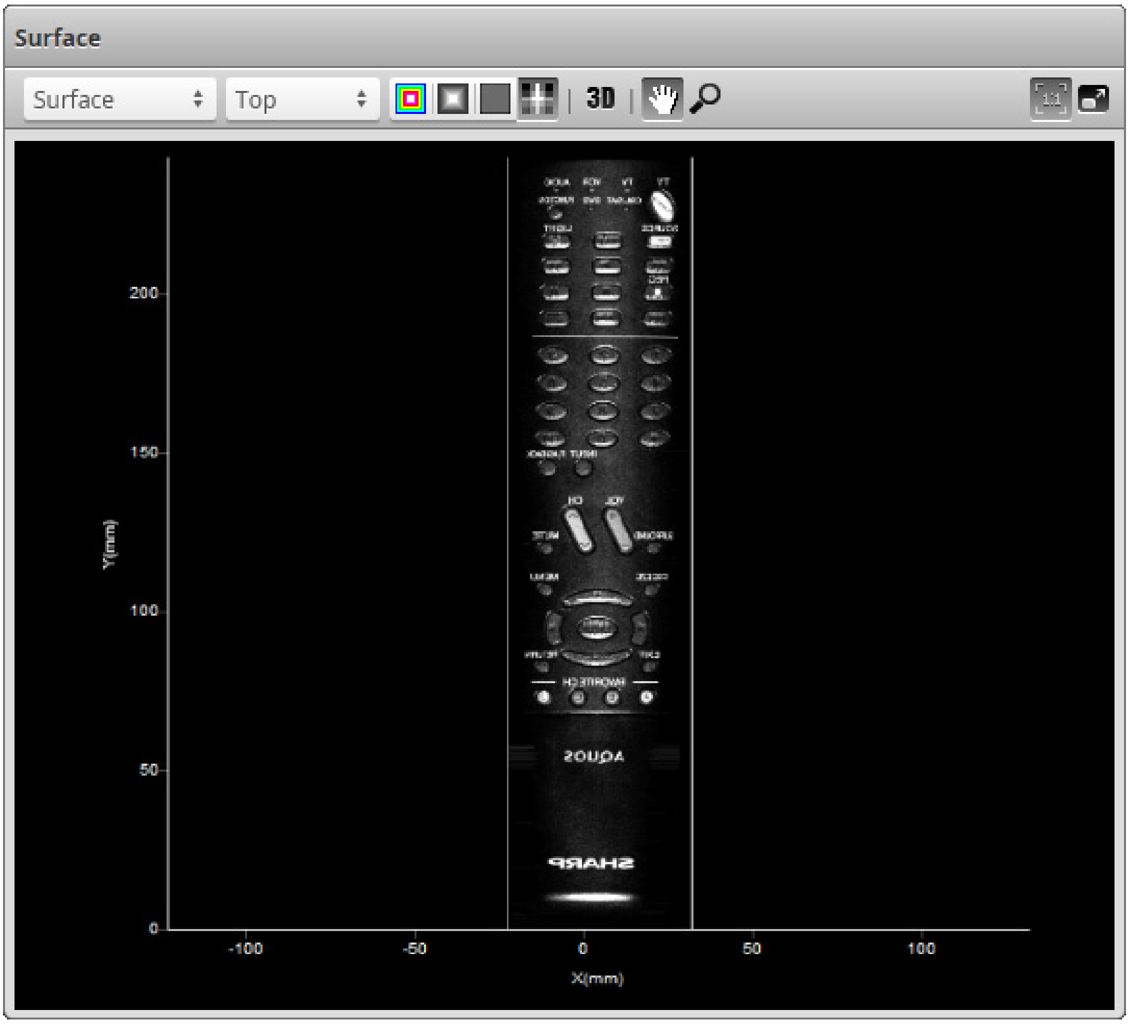
■ Intensity Output

Sensors can produce intensity images that measure the amount of light reflected by an object. An 8-bit intensity value is output for each range value along the laser line. A sensor applies the same coordinate system and resampling logic as the ranges to the intensity values.

To display intensity data, click the Intensity button ( ).

Tips

To be able to display intensity data, you must enabled [Acquire Intensity] in the [Scan Mode] panel.



4.5 Aligning Sensors

Alignment is the process Gocator uses to automatically calculate transformations (rotations and transformations / offsets) that are applied to a sensor's scan data while it is scanning targets. If you do not correct for these rotations, scan data may be too distorted for your application, and your measurements may therefore be inaccurate. Alignment is often required for various reasons:

- To compensate for sensor mounting inaccuracies relative to the intended scanning surface, and to other sensors in dual- or multi-sensor systems.
- To set a Z (height) reference plane, using a flat surface or an alignment target.
- To accommodate intentional rotation of sensors, or intentional offsets of sensors in multi-sensor systems.
- To merge profiles in dual- and multi-sensor systems so that the combined profiles can be measured (setting a common coordinate system).
- Optionally, to determine the encoder resolution (if present) and the speed of the transport system. (In many systems, the reference surface is a conveyor belt.) This is only possible using the first of the two methods described below.

As of Gocator firmware version 6.1, two methods of aligning sensors are available:

- A lower-accuracy method that provides up to 5 degrees of freedom (X angle rotations are not compensated for). You perform this type of alignment using the [Alignment] panel on the [Scan] page. Although resulting scans are of a lower accuracy compared to the higher accuracy described below, it is often sufficient in applications and is more commonly used. This is the only method available in firmware version 6.0 and earlier. (This method lets you optionally determine encoder resolution or transport speed.)
- A high-accuracy method that provides 6 degrees of freedom. Typically used for ring layouts and wide (side-by-side) layouts where high accuracy is required, you perform this type of alignment using specialized tools on the [Measure] page and special alignment targets. After alignment, scans from individual sensors are transformed and stitched together using measurement tools corresponding to the type of layout (ring vs. wide). The resulting scan data can be measured using built-in or custom GDK tools. An advantage to this method is that due to differences in the algorithm used to combine scans from multiple sensors, performance is improved compared to the other method.

In some situations, however, the inaccuracies introduced in scan data by not aligning may be acceptable to your application. For more information, see 📖 "4.5.1 Planning Alignment" on page 172.

Tips
Sensors are pre-calibrated and ready to deliver data in engineering units (mm) out of the box. Alignment procedures do not affect sensor calibration.

4.5.1 Planning Alignment

Sensors are aligned to compensate for mounting rotations and offsets of sensors: unaligned sensors, when scanning, produce inaccurate scan data and measurement results. However, depending on your measurement and accuracy requirements, you may not need to perform the built-in alignment procedure. In addition to the time and effort required to prepare alignment targets and perform the procedure, the transformations applied to scan data (the corrections) that result from the alignment procedure can reduce the maximum available frame rate, which in turn determines how fast you can scan and measure parts, or the maximum available precision in measurements.

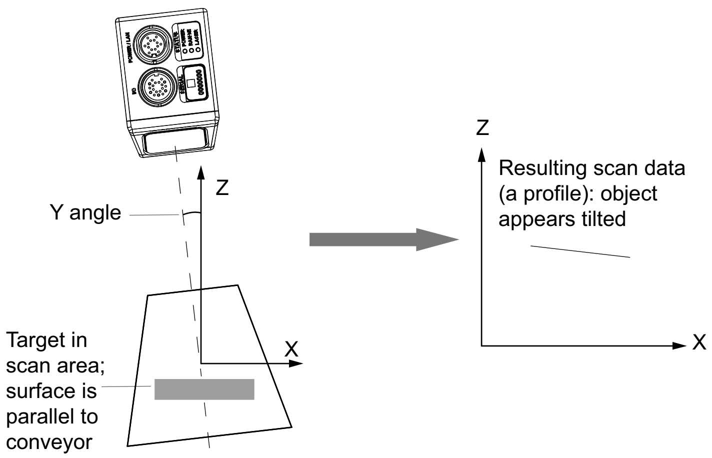
In general, if the inaccuracies are below your required tolerances, or inaccuracies are on an axis that doesn't affect your measurements, you can simply manually set a Z reference within the sensor's scan area (for example, to set the Z = 0 origin to be at the level of the conveyor).

The following sections refer to rotations and offsets on the X, Y, and Z axes. If you are not familiar with the coordinate systems used by Surfacemeasure1008S sensors, see "3.2.1 Coordinate Systems" on page 56. Furthermore, when viewing the diagrams below, consult the coordinate system information of your sensor provided in "14.1 Sensors" on page 1001 to get the correct orientation of the X, Y, and Z axes relative to an unaligned sensor. Note that as a rule of thumb, Y increases moving from the camera to the laser emitter.

The following sections describe the three main effects of not aligning certain degrees of freedom of a sensor; use this information to decide which alignment method to use. Remember that after mounting a sensor, it's unlikely that there will only be a mounting inaccuracy on or around a single axis. To clarify the impact of the rotations and offsets we describe below, we touch on them independently.

■ Y Angle

An unaligned sensor scanning with a Y angle rotation produces data rotated on the XZ plane. It does not distort geometry, unlike Z angle rotation (see below). So for example, with a flat object, data from one side would appear higher than data from the other side:



An exaggerated Y angle of roughly 6 degrees, producing a profile rotated around Y

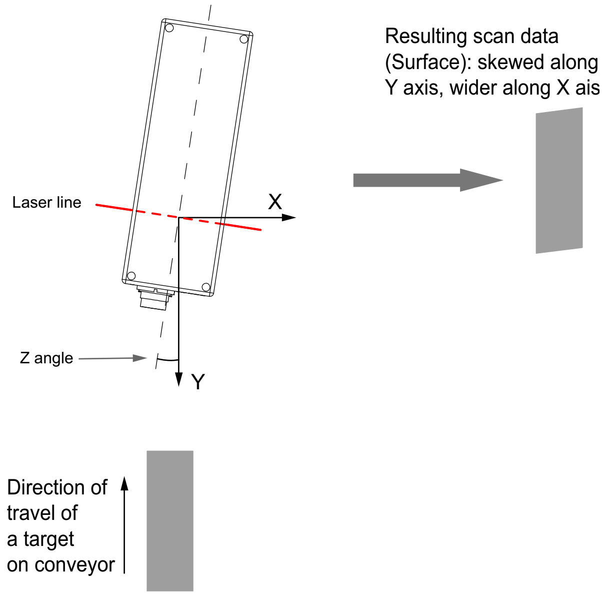
Although transformations to compensate for a Y angle mounting inaccuracy don't affect frame rates, if the resulting Z offset is acceptable in your application, you may be able to save the time and effort of performing the alignment procedure.

Y Offset

Y offset occurs in dual- or multi-sensor systems when sensors are shifted differently along the Y axis, the parts of a combined profile coming from different sensors to be offset along Y. In some situations, sensors are intentionally shifted along the Y axis, for example, with high resolution sensors, whose FOV is too small to get complete coverage when placed side by side.

Z Angle

An unaligned sensor scanning with a Z angle rotation produces data skewed on the XY plane: it creates a Y offset dependent on X position (the Z angle introduces a cosine error). So for example, a rectangular object would appear skewed along the direction of travel, and wider than it actually is.



An exaggerated Z angle of roughly 8 degrees, producing a skewed scan.
Scan data is slightly wider along X because the laser line produces a longer profile.

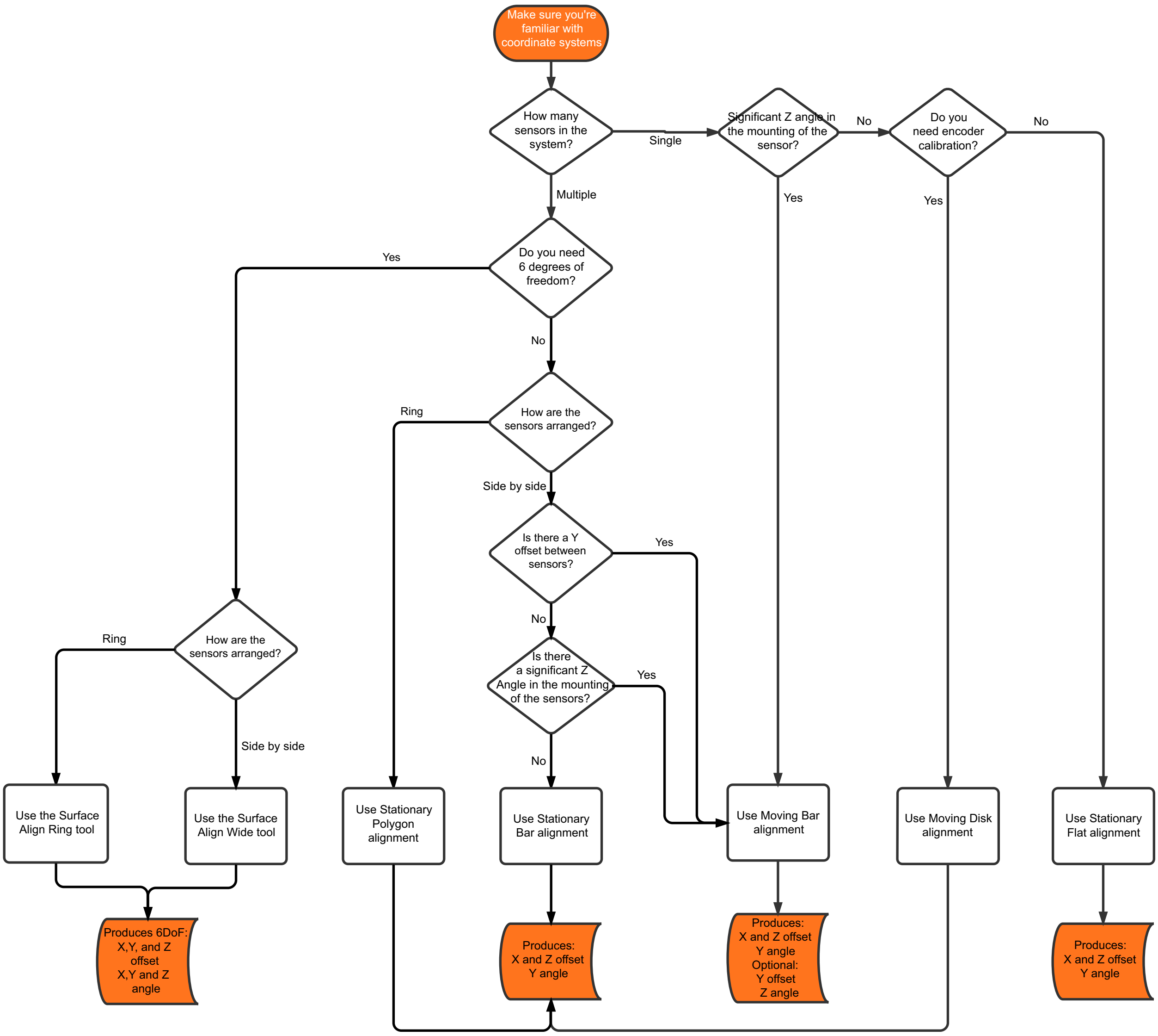
However, if your application only involves measuring the height of a feature on the scanned target (so position along the Z axis), although the scan data will be inaccurate, the distortion that Z angle introduces may have no effect on your measurement results.

You can use the sensor itself to determine the mounting angle and the impact on resulting scan data. For example, you can scan a rectangular or square target whose corners are exactly 90 degrees, and then use two Surface Edge tools (for details, see 📖 "6.14 Edge" on page 488) on adjacent sides to fit an edge line to those edges, and then use the Feature Intersect tool to determine the angle between those lines (for details, see 📖 "5.12 Intersect" on page 383).

Note that although a Z angle mounting inaccuracy also reduces the effective FOV of a sensor, with Z angles less than 5 degrees, the impact on the FOV is minimal. (To calculate this impact, multiply the FOV by the cosine of the Z angle.)

4.5.2 Choosing an Alignment Method

Most alignment methods use a special target that you must fabricate, either a bar with one or more holes, a polygon bar, or a target containing two or more truncated pyramids. Use the following flowchart to help you decide which alignment method (alignment type and alignment target) to use, and then consult the appropriate sections for the target specifications and procedures relating to the chosen alignment type. Before you begin, you should be familiar with the basics of coordinate systems and be able to understand concepts such as X / Y / Z offsets and X / Y / Z angles. To understand the transformations resulting from alignment that are then applied to scan data while a sensor is scanning objects in production, see "3.2.1 Coordinate Systems" on page 56.



Tips

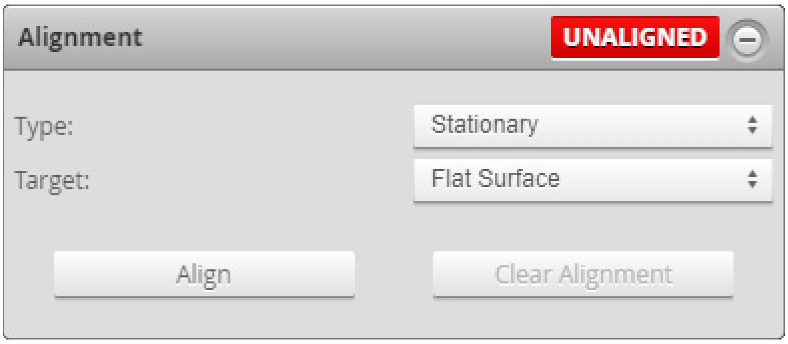
Whether or not a given rotation or offset should be considered "significant" depends on factors such as your required tolerances. For more information, see "4.5.1 Planning Alignment" on page 172.

For alignment methods involving Surface Align Ring or Surface Align Wide, see "4.5.4 Aligning Sensors to 6 Degrees of Freedom" on page 195. For all other alignment methods, see the appropriate subsection in "4.5.3 Aligning Sensors with up to 5 Degrees of Freedom" on page 175.

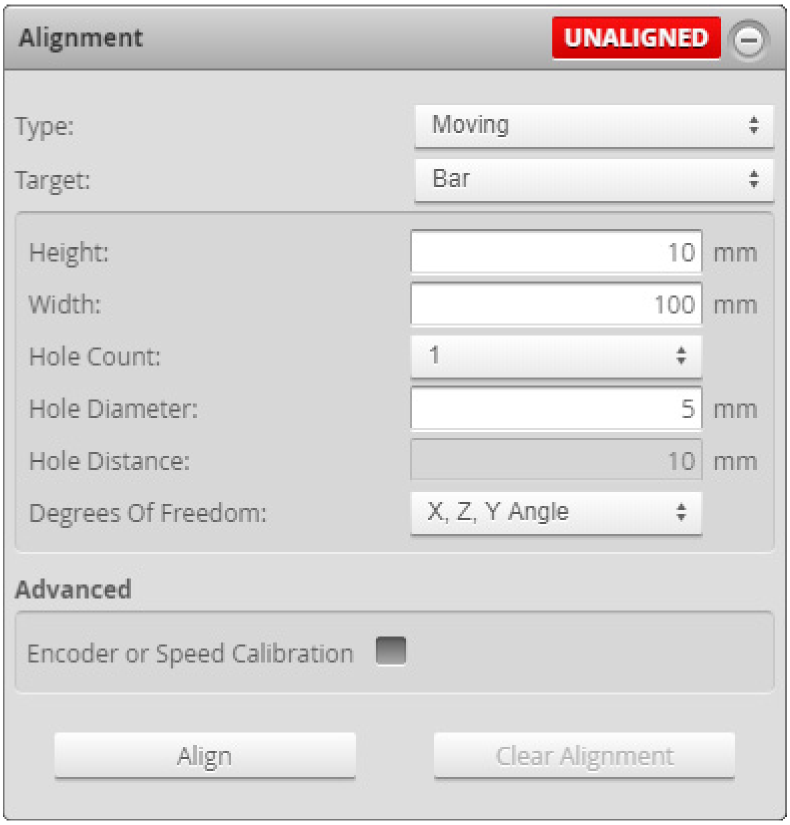
4.5.3 Aligning Sensors with up to 5 Degrees of Freedom

The alignment of single or multi-sensor systems with up to 5 degrees of freedom is configured and performed using the [Alignment] panel. Before proceeding, make sure that you have determined the alignment type (stationary or moving) and alignment target that you need for your system; for more information, see 📖 "4.5.2 Choosing an Alignment Method" on page 174.

For information on coordinate systems, see 📖 "3.2.1 Coordinate Systems" on page 56.



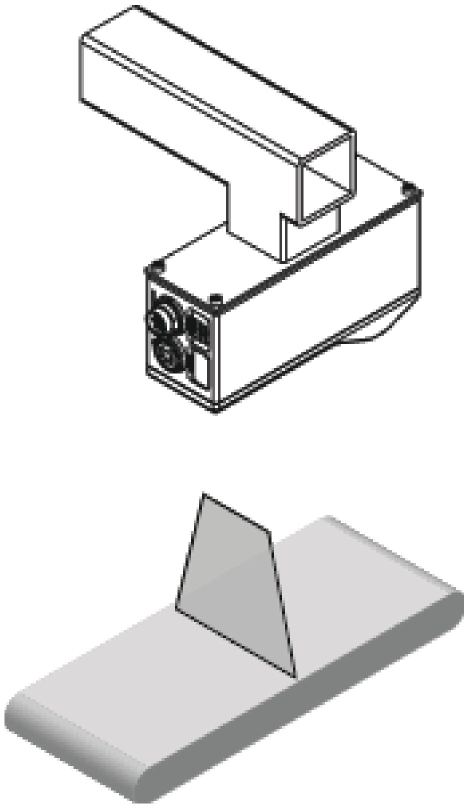
Alignment panel when Stationary Flat Surface is selected

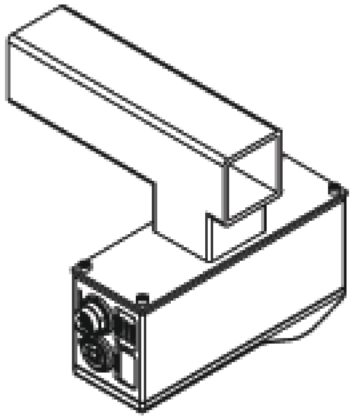
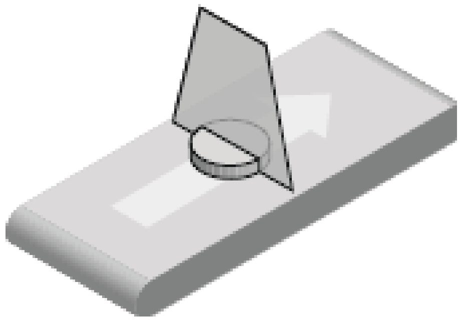
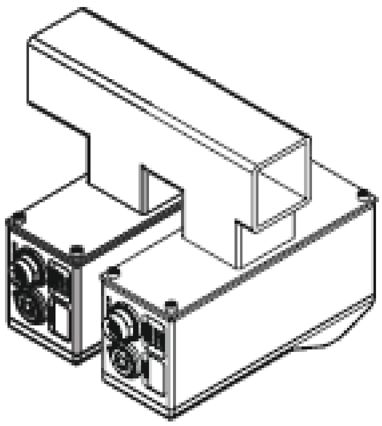
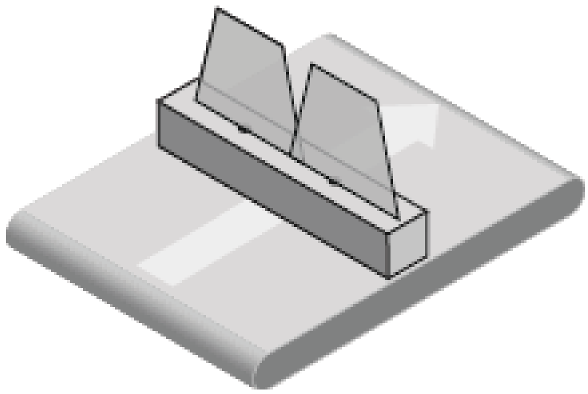


Alignment panel when Moving Bar type is selected

When using the alignment procedure on the [Alignment] panel, you choose an alignment type (whether the target moves relative to the sensor) and an alignment target. You choose the combination of type and target based on the types of mounting inaccuracies (mostly minor rotations of the sensor around the X, Y, or Z axis relative to the scanning surface, but also intentional rotations in some situations (such as Y rotation, which is very common), and offsets of sensors in dual- or multi-sensor systems) you need to compensate for, or the reference plane you wish to set. Surfacemeasure1008S will calculate different transformations depending on your choice.

Sensors support two types of alignment: stationary or moving.

Type	Description
[Stationary]	[Stationary] is used when the alignment target does not move during the alignment procedure. This type of alignment can only compensate for mounting position and orientation in the laser plane (Y angle and X and Z offsets). 

Type	Description
[Moving]	[Moving] is used when the alignment target moves beneath the sensor. This type allows for Y offset and Z angle alignment, in addition to X and Z offset and Y angle alignment.    

A sensor can be in one of two alignment states: Unaligned and Aligned. An indicator on the [Alignment] panel displays UNALIGNED or ALIGNED, depending on the sensor's state. A sensor's alignment state determines its coordinate system; for more information on coordinate systems, see "3.2.1 Coordinate Systems" on page 56.

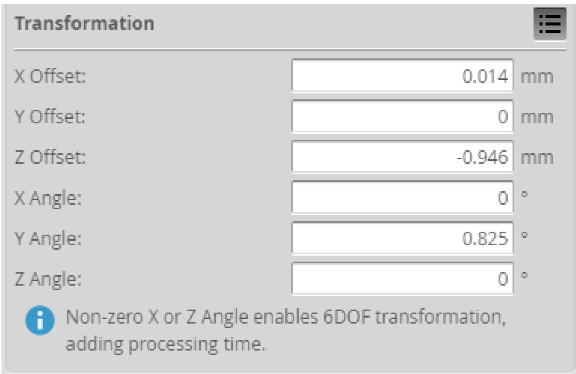
> **Tips**
> If you perform a high-accuracy tool-based sensor alignment, the [Alignment] panel will still display UNALIGNED. This is normal.

Alignment State

State	Explanation
Unaligned	The sensor or sensor system is not aligned. Data points are reported in sensor coordinates.
Aligned	The sensor is aligned using the alignment procedure (described below) or by manually modifying the values under [Transformation] in the [Sensor] tab on the [Scan] page (for more information, see "●Transformations" on page 128). Data points are reported in system coordinates.

Once you have performed the alignment procedure on the [Alignment] panel, the calculated transformation values are displayed under [Transformations] in the [Sensor] panel on the [Scan] page.

> **Tips**
> If you perform a tool-based sensor alignment, the derived transformation values are not displayed under [Transformations] in the [Sensor] panel. This is normal.

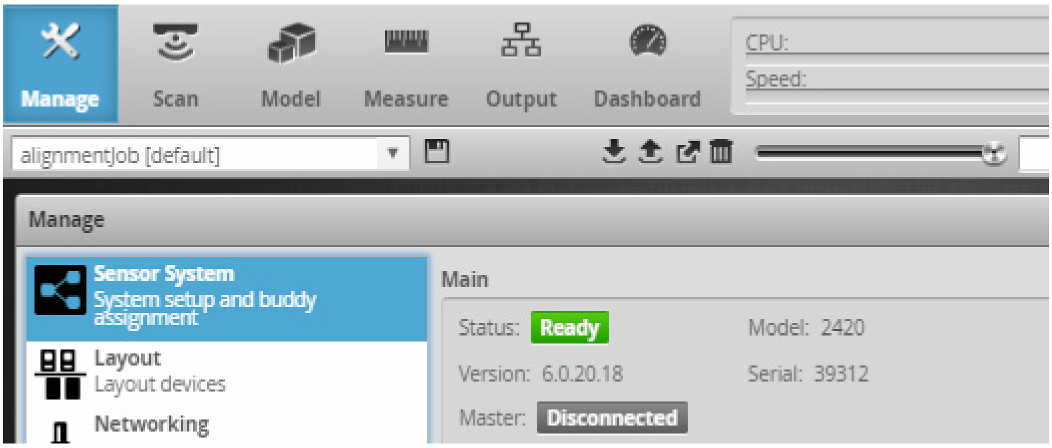


With certain types of alignment, a [Degrees of Freedom] setting lets you choose the axes on which offsets and rotations are calculated. If the setting is not available, only X and Z offsets, and Y angle rotation, are calculated. That is, alignment is only performed within the profile plane. When the [Degrees of Freedom] setting is available, it generally provides options that let you perform alignment outside the profile plane.

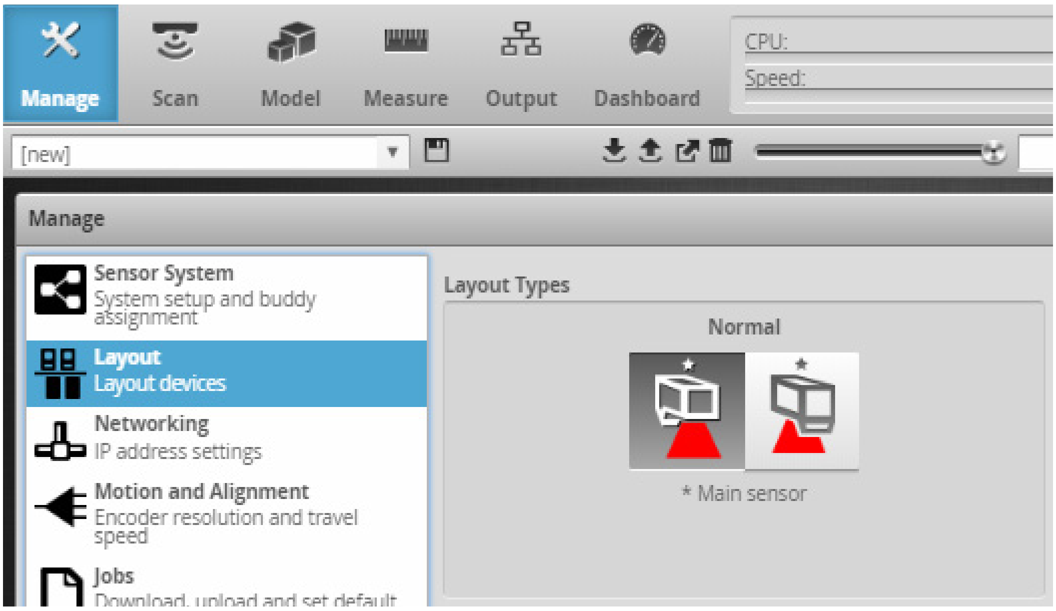
To prepare for alignment

1 For dual- or multi-sensor systems, make sure you have done the following:

On the [Manage] page, add sensors to the system using the Sensor System category (for details, see 📖 "■Dual- and Multi-sensor Systems" on page 92).

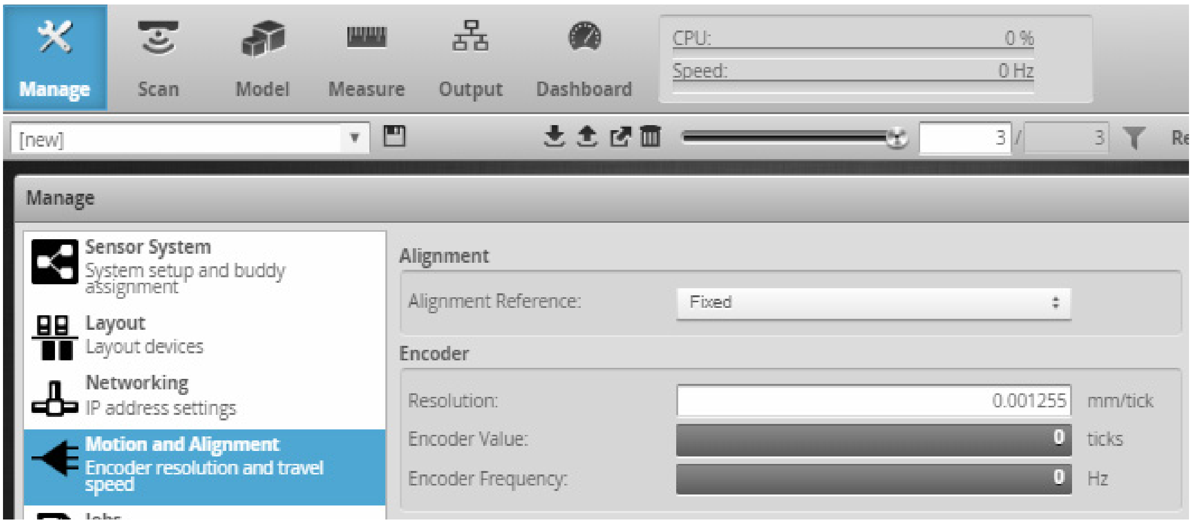


Configure the system's layout using the Layout category (for details, see 📖 "4.3.3 Layout" on page 96).



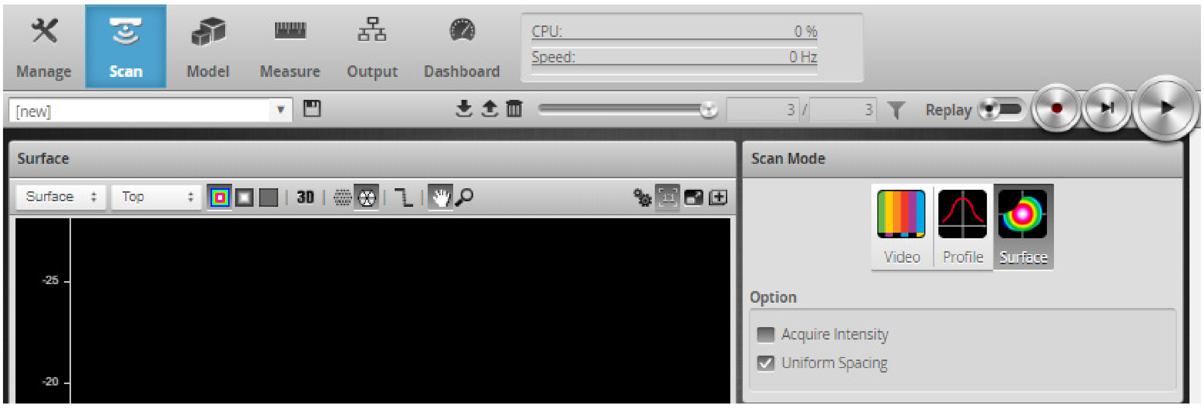
If the laser lines of the sensors overlap, make sure to check the [Device Exposure Multiplexing] option (only displayed after additional sensors have been added). Otherwise, the laser line from one sensor will be detected by other sensors and cause the alignment procedure to fail or be inaccurate; for more information, see 📖 "■Device Exposure Multiplexing" on page 103.

2 **If you have not already done so, choose an alignment reference in the Motion and Alignment category on the [Manage] page.**



For more information, see 📖 "■Alignment Reference" on page 105.

3 **Go to the [Scan] page.**



4 **In the [Scan Mode] panel (see above), choose a mode other than Video mode in the [Scan Mode] panel.**

The [Alignment] panel is hidden in Video mode. (For the alignment procedure, it doesn't matter which mode you use.)

5 **Leave the settings in the [Trigger] panel as is.**

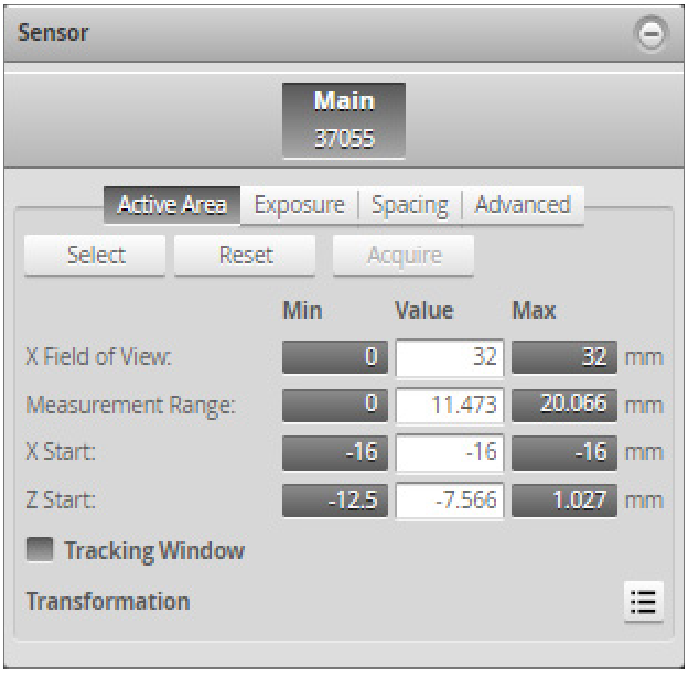
The alignment procedure automatically uses Time triggering, regardless of the settings in the [Trigger] panel. (For information on triggering, see 📖 "4.4.3 Triggers" on page 117.)

6 **Ensure that all sensors will have a clear view of the target surface.**

7 **Perform a preliminary scan of the alignment target to evaluate the quality of the scan data.**

Doing this will help ensure that the alignment process succeeds. In the next step, adjust the settings based on the scan data of the alignment target.

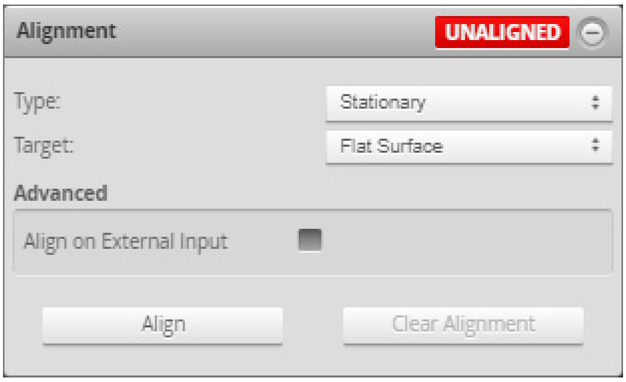
8 **If necessary, in the [Sensor] panel, adjust the sensor settings to get the best data possible from the scans of the alignment target.**



Some examples of the settings you may need to adjust are:

- Active area. (For example, to exclude the ends of a bar alignment target). For more information, see 📖 "■Active Area" on page 124.
- Exposure duration (to make sure the target is clearly represented in the scan data). Typically, only a single exposure is needed. For more information, see 📖 "●Single Exposure" on page 131.
- Spacing: Make sure to use the sensor's full X resolution (sub-sampling is set to 1 and spacing interval is set to full resolution). For more information, see 📖 "■Spacing" on page 135.

9 **Expand the [Alignment] panel by clicking on the panel header or the button.**



10 **Based on the decisions made in 📖 "4.5.2 Choosing an Alignment Method" on page 174, do one of the following:**

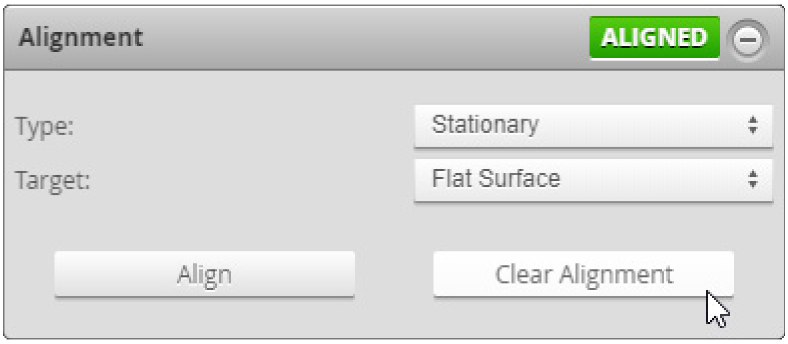
- If you need to perform a stationary alignment, see 📖 "■Performing Stationary Alignment" on page 182
- If you need to perform a moving alignment, see 📖 "■Performing Moving Alignment" on page 184.

■ Performing Stationary Alignment

To perform stationary alignment

1 In the [Alignment] panel, select [Stationary] as the [Type].

2 (Optional) If a previous alignment is present (indicated by "Aligned" at the top right of the panel), click [Clear Alignment].



3 Make sure that the alignment surface (whether it's the surface of a conveyor or of an alignment target) is within the sensor's measurement range.

To determine this, in the sensor's web interface, click [Start] and observe whether the Range LED on the sensor is illuminated. Be sure to stop the sensor after this step by clicking the [Stop] button.

Alternatively, you can determine the correct distance to the scan surface by consulting the sensor's measurement range specifications (see "14.1 Sensors" on page 1001), and measuring the physical distance between the scan surface and the sensor.

4 **Based on the decisions made in "4.5.2 Choosing an Alignment Method" on page 174, choose an alignment [Target].**

- [Flat Surface]: Use this to align to a surface such as a conveyor. For more information, see "■Stationary Flat Surface" on page 185.
- [Bar]: Use this to align to a bar alignment target. For information on alignment target requirements, bar-specific settings, and general setup tips, see "■Stationary and Moving Bar" on page 186.
- [Polygon]: Use this to align a ring layout setup using a polygon shaped alignment target. For information on alignment target requirements, polygon-specific settings, see "■Stationary Polygon" on page 192.

5 **Click the [Align] button.**

» The alignment process starts.

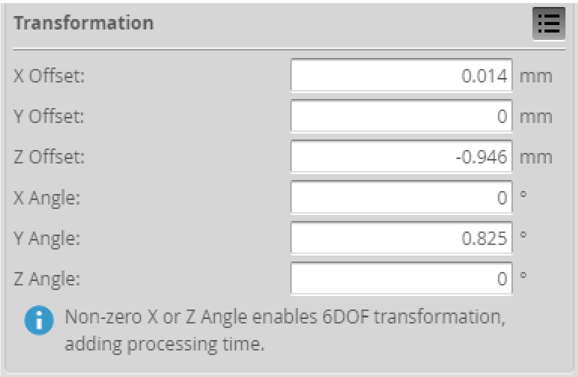
Alignment is performed simultaneously for all sensors.

If the alignment fails, check the settings described in "To prepare for alignment" on page 179 and repeat the steps described here.

6 **Inspect alignment results.**

» Data points from all sensors should now be aligned to the alignment target surface.

Check the alignment results under [Transformation] in the [Active Area] tab in the [Sensor] panel.



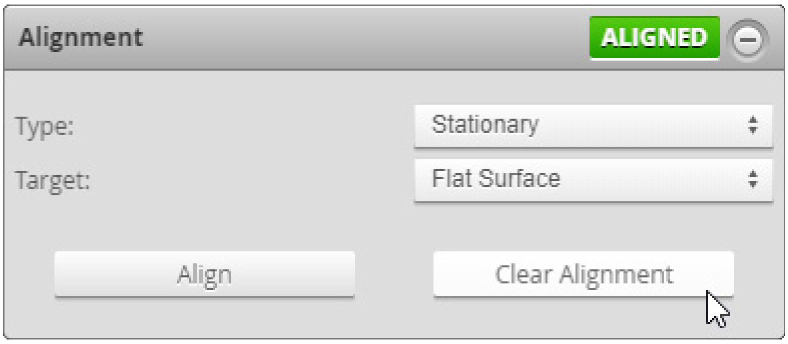
For information on how alignment affects the coordinate system used by sensors, see "3.2.1 Coordinate Systems" on page 56.

■ Performing Moving Alignment

To perform moving alignment

1 **In the [Alignment] panel, select [Moving] as the [Type].**

2 **If a previous alignment is present (indicated by "Aligned" at the top right of the panel), click [Clear Alignment].**



3 **Place the target under the sensor.**

4 **Make sure that the surface of the alignment target is within the sensor's measurement range.**

To determine this, in the sensor's web interface, click [Start] and observe whether the Range LED on the sensor is illuminated. Be sure to stop the sensor after this step by click the [Stop] button.

Alternatively, you can determine the correct distance to the scan surface by consulting the sensor's measurement range specifications (see "14.1 Sensors" on page 1001), and measuring the physical distance between the scan surface and the sensor.

5 **Choose an alignment in the [Target] drop-down (Based on the decisions made in "4.5.2 Choosing an Alignment Method" on page 174).**

- [Disk]: Use this to align to a disk alignment target. For information on disk-specific settings, alignment target requirements, and general setup tips, see "■Moving Disk" on page 186.
- [Bar]: Use this to align to a bar alignment target. For information on bar-specific settings, alignment target requirements, and general setup tips, see "■Stationary and Moving Bar" on page 186.

6 (Optional) If you need to calibrate the transport system, check the [Encoder or Speed Calibration] checkbox.

The automatic encoder and speed calibration functionality is less accurate than manually specifying the transport system's encoder resolution or travel speed. You should only use this option if you have no other way of getting these values.

If you do not use the built-in encoder or speed calibration functionality, make sure you have done one of the following:

- If the transport system includes an encoder, make sure you have configured the encoder resolution. For more information, see "■Encoder Resolution" on page 106.
- If the transport system does not use an encoder (it is a time-based system), make sure you have configured travel speed. For more information, see "■Travel Speed" on page 107.

7 Click the [Align] button.

» The alignment starts.

If the alignment fails, check the settings described in "To prepare for alignment" on page 179 and repeat the steps described here.

8 Start the transport system.

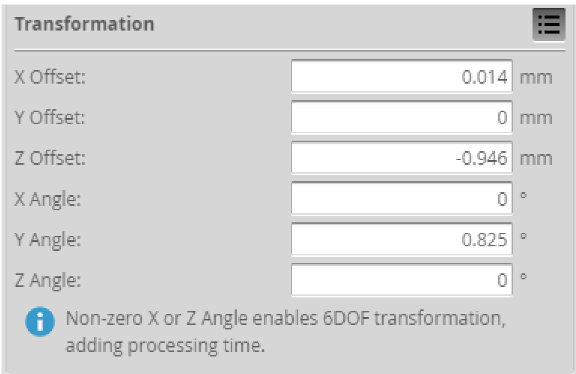
» The sensors will start and then wait for the alignment target to pass through the laser plane.

Alignment is performed simultaneously for all sensors. Alignment may take a minute or more.

9 Inspect alignment results.

» Data points from all sensors should now be aligned to the alignment target surface.

Check the alignment results under [Transformation] in the [Active Area] tab in the [Sensor] panel.



For information on how alignment affects the coordinate system used by sensors, see "3.2.1 Coordinate Systems" on page 56.

■ Stationary Flat Surface

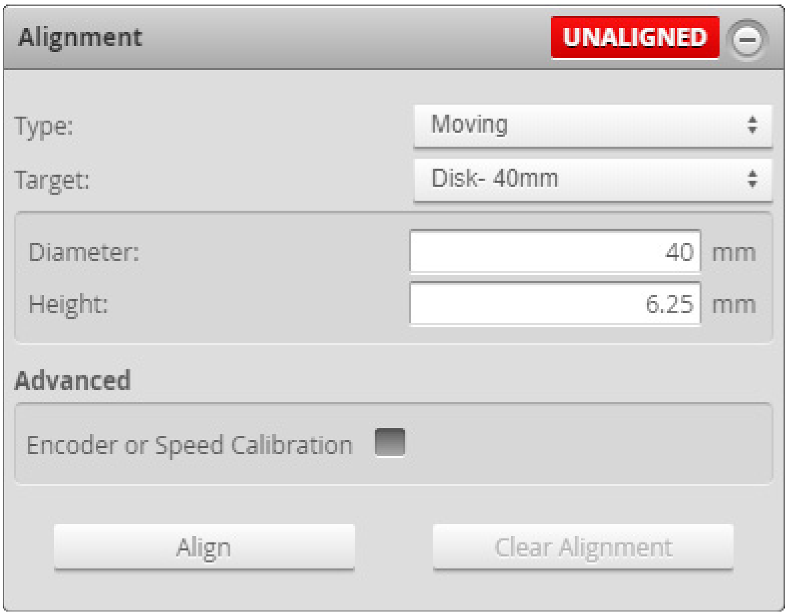
No settings are required for this alignment method. Note however that this type of alignment expects to receive flat scan data. Therefore, if the surface is curved, the alignment will be inaccurate. The surface should also be clear of debris and damage. The alignment results in 3 degrees of freedom (X and Z offset, and Y angle).

■ Moving Disk

Configure the characteristics of the target. Select [Disc - 40mm] in the [Target] drop-down list and enter the diameter and height of the included 40mm disc. For each value, enter the calibration value shown on the back of the disc. Otherwise, select [Disk - Custom] and provide the dimensions manually.

[Diameter] defines the expected diameter of the disk.

[Height] defines the thickness of the disk in the Z direction. The alignment is performed to determine the average Z height of the disk's top surface. This height value is used to offset the coordinate system so that the bottom of the alignment disk becomes the Z origin.



■ Stationary and Moving Bar

For information on bar specifications and procedural requirements, see "●Bar Specifications and Procedural Requirements" on page 187.

For information on configuring Surfacemeasure1008S for bar alignment, see "●Configuring Surfacemeasure1008S for Bar Alignment" on page 190.

> **Tips**
> The Y offset, X angle, and Z angle transformations cannot be non-zero when Uniform Spacing is unchecked. Therefore, when aligning a sensor using a bar alignment target with [Uniform Spacing] unchecked, set the [Degrees of Freedom] setting to [X, Z, Y Angle], which prevents these transformations from being non-zero.

> **Tips**
> On sensors aligned using Z angle (or sensors with a manually set X angle), and to a lesser extent Y offset, CPU usage increases when scanning, which reduces the maximum scan speed.

Tips

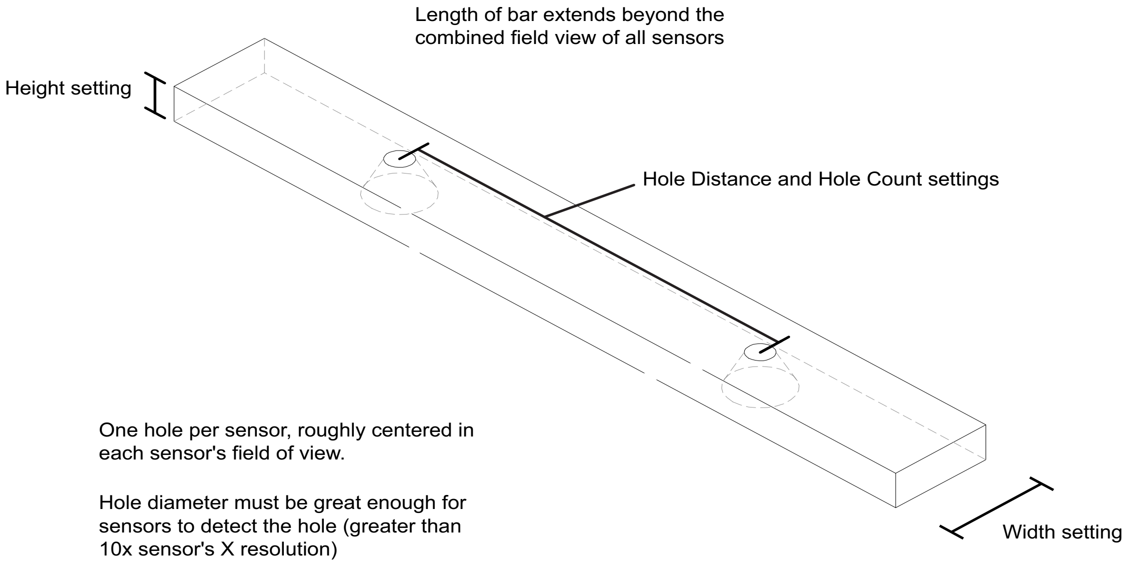
Artifacts may appear in scan data on sensors aligned using Z angle or X angle if encoder trigger spacing is set too high (resulting in a low sampling rate).

● Bar Specifications and Procedural Requirements

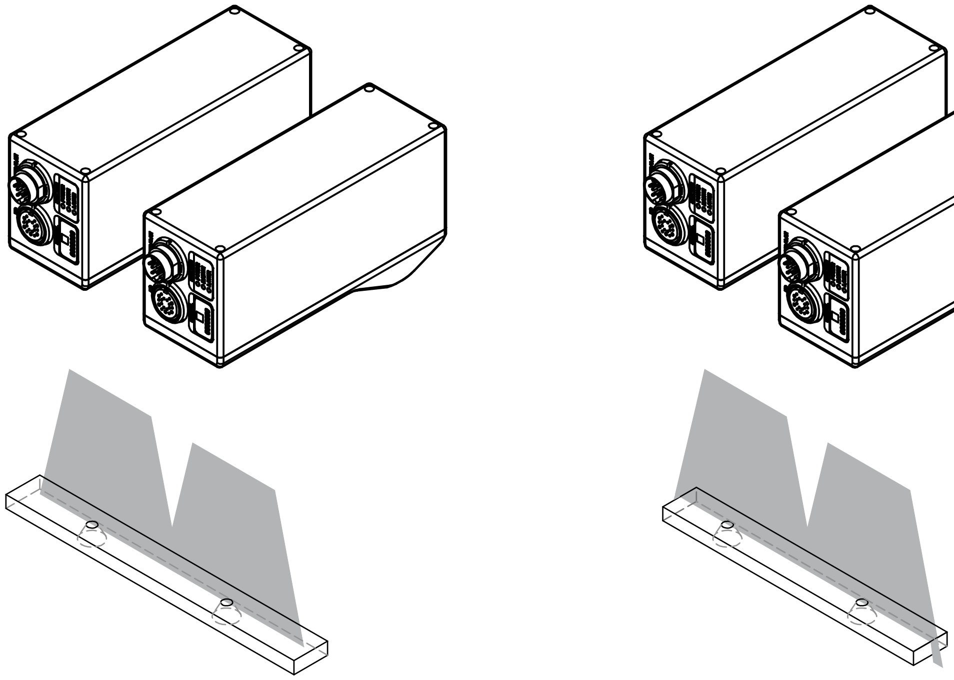
See the following sections for bar specifications and procedural requirements (stationary or moving alignment).

Bar Specifications

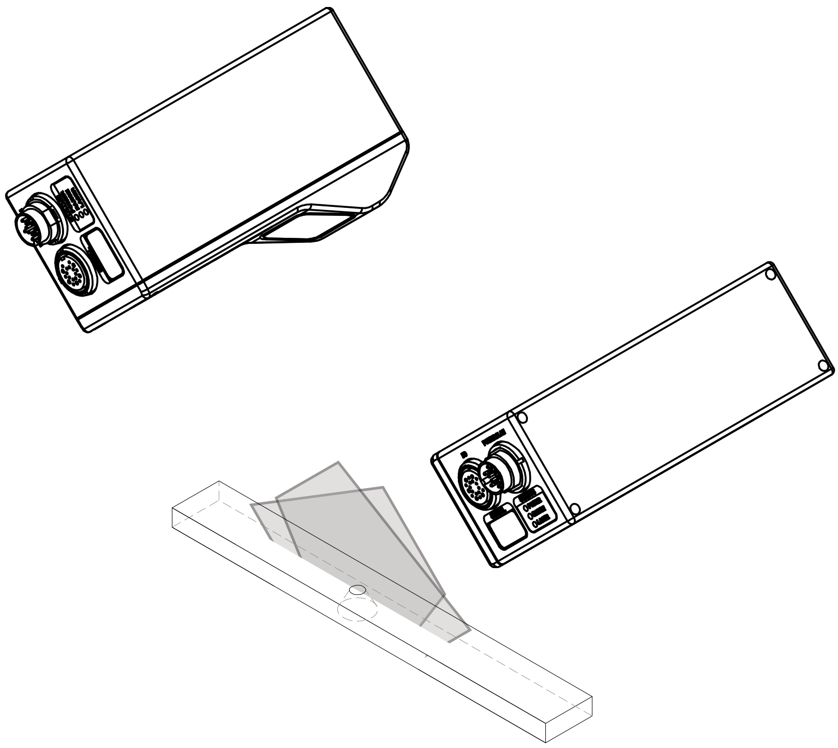
Ensure the following:



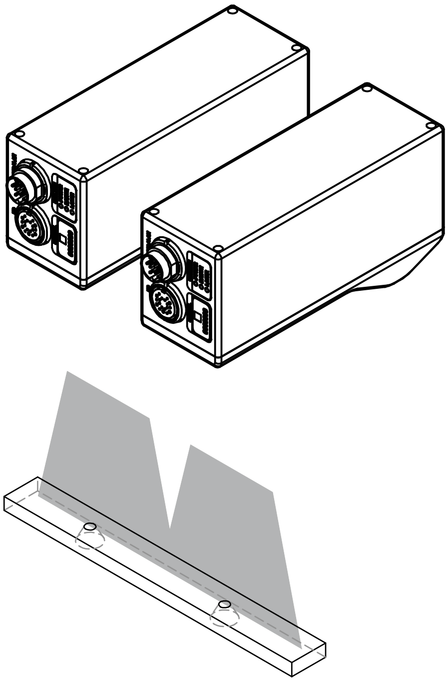
- The bar must extend beyond the outer ends of any laser line: sensors must not "see" the left or right end of the bar (relative to the direction of travel of the transport system). Alternatively, you can set the active area of sensors that can "see" the ends of the bar to exclude the ends from the scan data; for more information, see 📖 "■Active Area" on page 124. Otherwise, although the alignment should succeed, it will not be accurate: it may result in unwanted offsets or angles in the transformations.



- If the sensor system contains two or more sensors side by side that are not intentionally angled toward each other around the Y axis (for example, to reduce occlusions), the bar should have one hole per sensor. Hole spacing should roughly correspond to the distance between the center of the FOVs of the mounted sensors, and holes should be equidistant. Although alignment can be performed if a sensor sees more than one hole (for example, if the laser lines overlap enough), but only the hole nearest to the center of a sensor's FOV is used for that sensor's alignment.
- If the sensor system contains two or more sensors side by side that are angled toward each other around the Y axis, a single hole should be used.



- Holes and bar edges must be as sharp as possible: avoid bevels.
- The size of the holes should be more than 10 times the X resolution of the sensor; for the X resolution of your sensor, see specifications of the sensor in "14.1 Sensors" on page 1001.



- Sensors must capture as little data from the inside of a hole as possible. Either countersink holes from the opposite side of the bar (if no sensors are positioned on the opposite side of the hole in a "Bottom" position), or paint the insides of the holes with a flat black paint. Otherwise, although the alignment should succeed, it will not be as accurate: it may result in unwanted offsets or angles in the transformations.
- The recommended flatness of bar targets for accurate Y angle is roughly the Z resolution rating of the sensor. If the bar target is curved, it will introduce an apparent Y angle in the sensor alignment. For sensor Z resolution, see the specifications for your sensor in "14.1 Sensors" on page 1001.
- It is not necessary to machine the bar height to a high tolerance. Bar height can instead be controlled during measuring rather than at manufacture. Only flatness and parallelism are important. If the zero level is not critical for the measurement, then standard machining tolerances can be used. Alternatively you can machine to a low tolerance and measure the value to a high precision to save cost.
- Bar width (the dimension along Y, that is, the direction of travel) is used to calibrate the encoder or travel speed, and is unrelated to Y offset in dual- or multi-sensor systems.
- Bars should be painted with flat light grey or white paint to improve data capture (by reducing the possibility of reflections and improving profile data of the bar surface). Doing this also allows you to reduce the exposure to further reduce the possibility of sensors seeing the interior of a hole. Note that when performing alignment, typically, sensors only need a Single exposure, regardless of whether sensors are going to be configured to use Dynamic or Multiple exposure when scanning in production. For more information on exposure, see "■Exposure" on page 130.

Stationary Bar: Visibility of holes and bar

The hole closest to the center of each sensor's field of view is used for the alignment procedure.

Each laser line must cross the center of a hole.

To do this:

1. **Advance or back up the transport system until the sensor laser line falls on the center of the hole.**

2. **Continue with step 3 in "To perform stationary alignment" on page 182.**

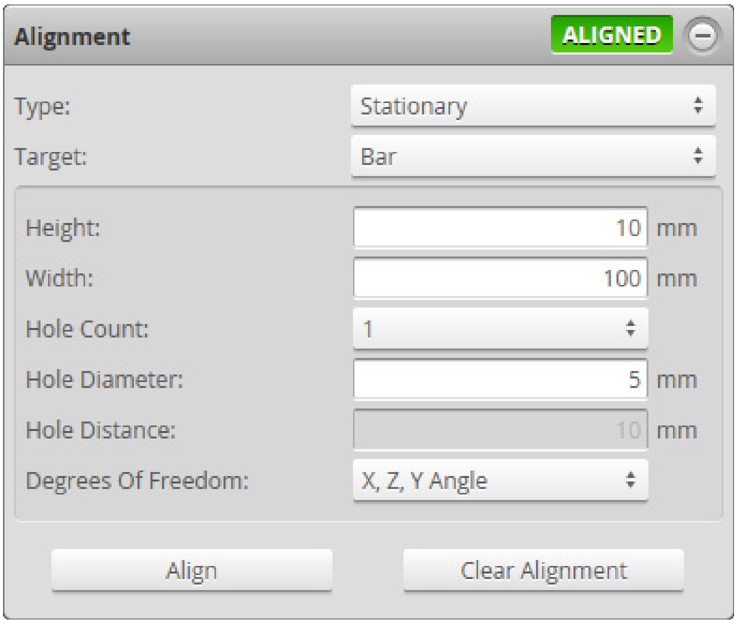
Moving Bar: Visibility of holes and bar

No other edges than the long edges of the bar should be visible during the alignment procedure: if sensors capture data from a conveyor or other structural component, or even debris, edges from these items may be misinterpreted as bar edges, and alignment will result in a false Y offset. Adjust the active area of sensors that see any of these items to prevent them from affecting the alignment; for more information, see 📖 "■Active Area" on page 124.

Sensors may either see both the bar surface and the surface the bar is on, or only the bar surface (that is, if the supporting surface is beyond the sensor's measurement range): this has no impact on the alignment procedure.

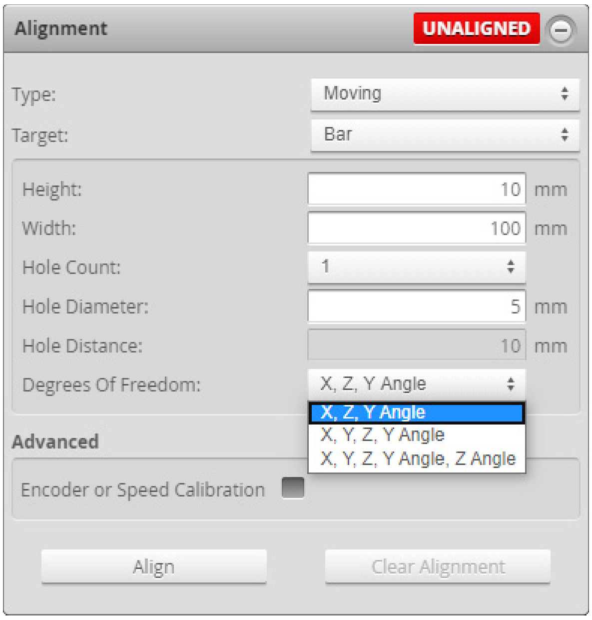
● Configuring Surfacemeasure1008S for Bar Alignment

Configure the characteristics of the target (bar dimensions and reference hole layout); for more information on these settings, see below.



For an illustration of the various settings, see above.

- [Height]: The alignment procedure determines the average Z height of the alignment target's top surface and uses the value specified in [Height] to offset the coordinate system from that average Z height; in effect, the bottom of the alignment target becomes the Z origin (the zero reference level).
- [Width] sets the width of the bar in the Y direction. This value is only used to calibrate encoder resolution and travel speed in conjunction with the [Encoder or Speed Calibration] setting; for more information, see "■Encoder Calibration" on page 193. A width of 100 mm is typical; the width is unrelated to any Y offset between sensors in dual- or multi-sensor systems.
- [Hole Count] is the number of holes in the bar. In a dual-sensor system, you set this manually in the [Alignment] panel to the number of holes in the bar. In a multi-sensor system, the number of holes in this panel is automatically set to the number of columns you enable when configuring a Grid system layout, in the [Layout] category on the [Manage] page; for more information, see "4.3.3 Layout" on page 96.
- [Hole Diameter] is the diameter of the holes.
- [Hole Distance] is the distance between the centers of the holes. This measurement is critical: you should measure this distance to within the sensor's X resolution. However, you can also machine the bar to a lower tolerance and measure the true spacing.
- In stationary bar alignment, under [Degrees of Freedom], only one option is provided, namely, [X, Z, Y Angle]. This alignment method produces a Y angle correction, and calculates X and Z offsets.
- In moving bar alignment, under [Degrees of Freedom], three options are available, which are combinations of different types of alignments. X, Y, and Z compensate for offsets on the X, Y, and Z axes, respectively. Y Angle and Z Angle compensate for rotation around the Y and Z axes, respectively. Compensating for X angle rotation is currently only possible by manually setting the rotation in the Transformations panel.



■ Stationary Polygon

Polygon target alignment is typically used when you need to scan 360 degrees around a target. A polygon target can also be used with an "arc" of sensors.

● Polygon Target Specifications

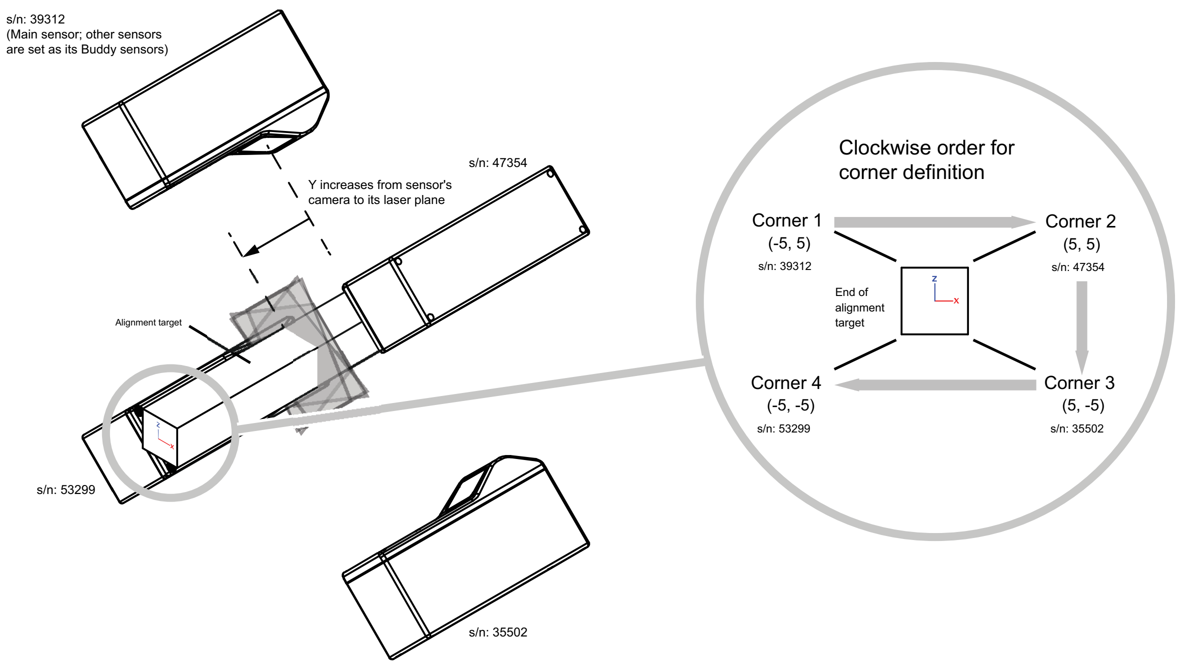
Ensure the following:

- The target must have one corner per sensor.
- Corners must have sharp edges and should be as close to 90 degrees as possible (unless the system layout prevents using 90-degree angles).
- The surface adjacent to the corners must be flat.
- Targets should be painted with flat light grey or white paint to improve data capture (by reducing the possibility of reflections and improving profile data of the bar surface).
- Each sensor must clearly see a corner of the polygon target.

● Configuring Surfacemeasure1008S for Polygon Alignment

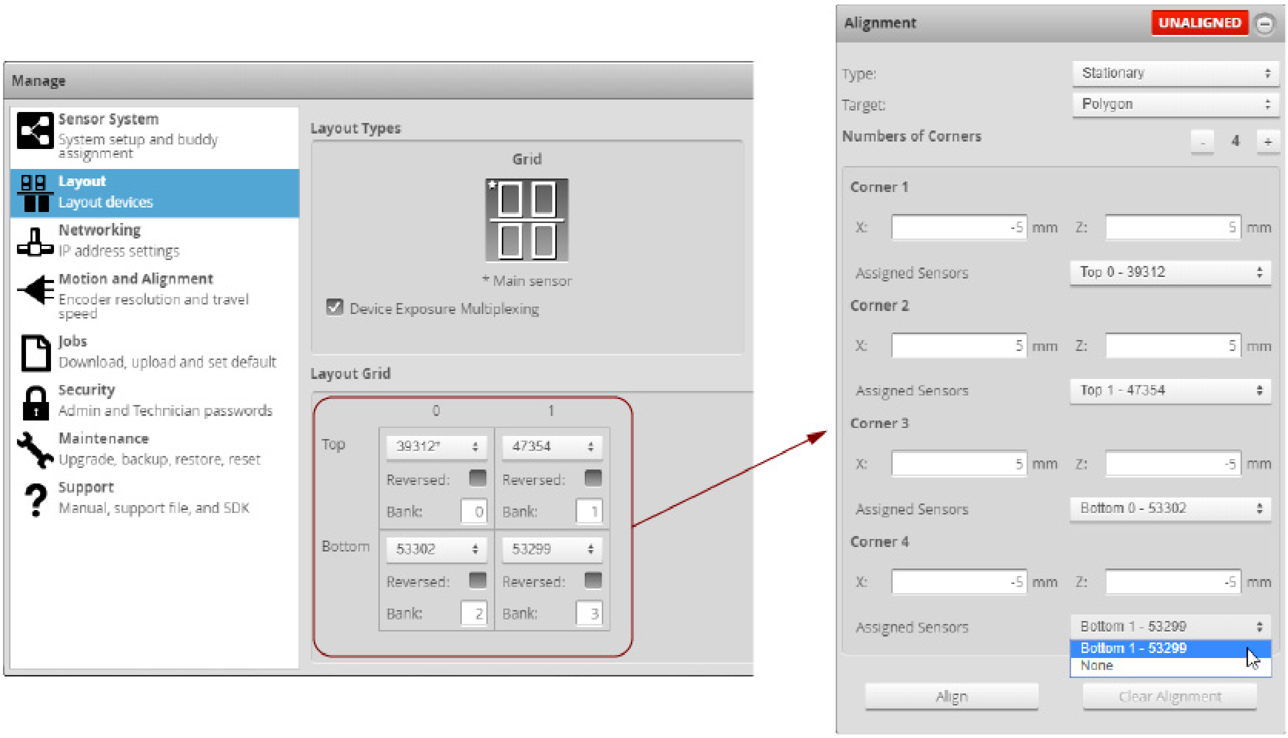
To perform polygon target alignment, you must set the X and Z coordinates of each corner of the alignment target. The coordinates are relative to the target itself, and you typically set them such that the X and Z origins are at the center of the target.

To properly configure the X and Z values of each corner of the alignment target (and assign sensors to the corners), you must view the sensors and alignment target so that Y increases toward you. To determine how to view the sensors and target, refer to the coordinate system orientation information for your sensor model in 📖 "14.1 Sensors" on page 1001, or remember that Y increases moving from the camera to the laser emitter. (If any sensors are defined as [Reversed] in the layout grid, use only the non-reversed sensors to determine how to view the sensors; for more information on layout grids, see 📖 "4.3.3 Layout" on page 96.) Starting with the sensor set as Main (the sensor to which all other Buddy sensor, for each corner, define the X and Z coordinates and assign the sensor that is viewing that corner, proceeding in a clockwise order. You can start with any corner.



Simplified representations of sensors. When looking at the end of the alignment target and non-reversed sensors, Y must increase toward you. In the illustration, an alignment target measuring 10 mm on each side is represented. Therefore, X and Z coordinates are + or - 5 mm.

You can use the serial numbers of the sensors in the [layout] grid in the [Layout] category on the [Manage] page (left in the following) to help populate the fields in the Alignment panel (right).



You are not required to assign a sensor to every corner.

Encoder Calibration

For systems that use an encoder, encoder calibration can be performed while aligning sensors. The table below summarizes the differences between performing alignment with and without encoder calibration.

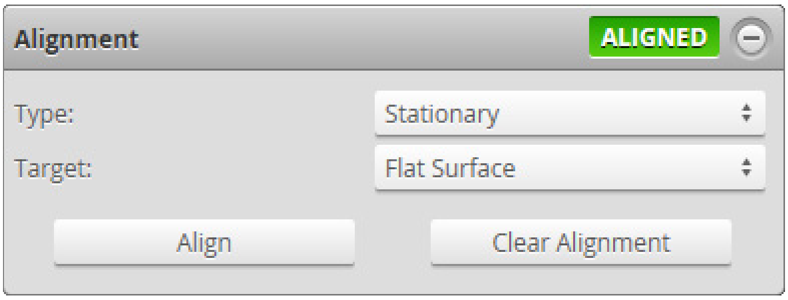
	With encoder calibration	Without encoder calibration
Target Type	Calibration disk or calibration bar	Flat surface or calibration bar
Target/Sensor Motion	Linear motion	Stationary
Calibrates Tilt	Yes	Yes
Calibrates Z axis Offset	Yes	Yes
Calibrates X axis Offset	Yes	Yes (Calibration bar required)
Calibrates Encoder	Yes	No
Calibrates Travel Speed	Yes	No

See 📖 "3.2.1 Coordinate Systems" on page 56 for definitions of coordinate axes. For descriptions of disks and bars, as well as alignment procedures, see the appropriate sections in 📖 "4.5.3 Aligning Sensors with up to 5 Degrees of Freedom" on page 175.

After alignment, the coordinate system for laser profiles will change from sensor coordinates to system coordinates.

■ Clearing Alignment

Alignment can be cleared to revert the sensor to sensor coordinates.



To clear alignment:

1. **Go to the [Scan] page.**
2. **Expand the [Alignment] panel by clicking on the panel header or the ⊕ button.**
3. **Click the [Clear Alignment] button.**

   The alignment will be erased and sensors will revert to using sensor coordinates.

4.5.4 Aligning Sensors to 6 Degrees of Freedom

The alignment of a system of sensors to 6 degrees of freedom involves the use of one of two Surface measurement tools (Surface Align Wide or Surface Align Ring), which results in a set of transformations stored in an XML file. The resulting alignment is more accurate compared to the other method available on the [Alignment] panel, and includes compensations for X angle rotations. Note that in order to apply the transformations to scan data, you must use a "stitching" tool that corresponds to the tool used to create the transformations. For more information, see the sections below.

- Surface Align Wide: Use this tool if the sensors in a multi-sensor system are in a wide (that is, side-by-side) layout where the sensors are slightly angled (no more than 15 degrees) on the Y axis, that is, in an arc above the target. Sensors are on the same side as the target: no data is supported on the other side. The tool is designed for up to four sensors. The tool aligns to a multi-column truncated pyramid plate alignment target (one column per sensor) to produce the transformations necessary to stitch scans of production targets into a single frame of Surface scan data. In a single-sensor system, you can also use the tool to compensate for X angle rotation. (Note that in a single-sensor system, Y offset is not calculated or used.) For more information, see 📖 "■Wide Layouts" on page 198. The workflow / information flow is as follows:

  Surface Align Wide (one-time creation of XML transformation file) > Surface Merge Wide > any Surface tool
- Surface Align Ring: Use this tool if the sensors in a multi-sensor system are in a ring or partial ring layout. The tool aligns to a double-sided truncated pyramid alignment target to produce the transformations necessary to stitch scans of production targets into a single frame of Mesh scan data. For more information on performing this type of alignment, see 📖 "■Ring Layouts" on page 203. The workflow / information flow is as follows:

  Surface Align Ring (one-time creation of XML transformation file) > Surface Mesh > any Mesh tool or (after extracting a Surface with one of the Mesh tools) any Surface measurement tool

Both tools produce XML initialization / calibration transformation files, and can optionally load previously saved "Start" files, which contain the transformations (position) of the sensors in the system. These files serve two purposes. First, they can be used to provide a rough, initial estimate of the sensor position; these are referred to as "Start" or "Starting" files. These files are created by first configuring the tool's parameters related to the alignment target and to the positions and orientations of the sensors in the system and then saving the those settings using the Save operation in the [Operation] drop-down. Second, the tool itself generates high-accuracy XML alignment files, using the initial parameter settings as a starting point. The latter is used by other tools to merge scan data together. These XML files are found in C:\GoTools\SurfaceAlign\.

For the alignment targets, keep the following in mind:

- The alignment target should scan well, so ensure the surface is not too shiny or too dark to be scanned.
- Maximize the size: The target should be fabricated with a size that fills your scan volume while not extending past the field of view of your sensors.
- Edges do not need to be perfectly sharp: The alignment tool performs a plane fit to points within the planar surfaces and excludes data close to the edges.

The following provides an overview of the steps involved in performing a high-accuracy alignment.

To perform high-accuracy alignment:

1 Set up and configure the multi-sensor system.

The following sections describe setting up and configuring a system:

"2.4 Installation" on page 27

"2.5 Network Setup" on page 42

"4.3 Management and Maintenance" on page 91

"4.4 Scan Setup" on page 114

2 Fabricate an alignment target appropriate for your system (wide or side-by-side layout versus ring layout).

For details on the specific alignment targets, see "■Wide Layouts" on page 198 or "■Ring Layouts" on page 203.

3 Enable recording by clicking the Record button.

> **Tips**
> Although you can scan the alignment target without acceleration, you must perform the alignment using PC-based acceleration (for more information, see "7.4 Software-Based Acceleration" on page 629). Because starting acceleration after having performed a scan clears scan data from a sensor, if you are going to perform alignment on-sensor, you should start acceleration before continuing. You can also optionally download the sensor state and scan data as an emulator scenario and perform the alignment on the scanned target using the emulator. For more information, see "8.3 Downloading a Support File" on page 637 and "8.4 Running the Emulator" on page 638.

4 Start the transport system and then perform a scan of the alignment target.

5 On the [Measure] page, add an alignment tool corresponding to your system.

For wide (side-by-side) layouts, add a Surface Align Wide tool.

For ring layouts (full or partial), add a Surface Align Ring tool.

6 Do one of the following:

- If you have a "Start" initialization file (see above), choose Load from the [Operation] drop-down, load that file, and go to step 10.
- If you don't have a "Start" initialization file, go to the next step.

7 Set [Sensor Count] to the number of sensors in the system.

8 **Under [Sensor Parameters], select the sensors, one by one and configure the parameters related to the sensor's position.**

For more information, see the Sensor Parameters table in 📖 "■Wide Layouts" on page 198 or 📖 "■Ring Layouts" on page 203, depending on the layout of the sensor system.

9 **Depending on your system layout, check one of the following checkboxes, and configure the parameters related to the alignment target:**

- If your system is in a wide layout, check [Configure Pyramid Plate].
  For more information, see the Alignment Target Parameters table in 📖 "■Wide Layouts" on page 198.
- If your system is in a ring layout, check [Configure Double-Sided Pyramid].
  For more information, see the Alignment Target Parameters table in 📖 "■Ring Layouts" on page 203.

10 **Configure the alignment tool's remaining parameters and enable the diagnostics data outputs (on the tool's [Data] tab) if needed.**

For more information, see 📖 "■Wide Layouts" on page 198 or 📖 "■Ring Layouts" on page 203.

11 **Check the [Enable Processing] checkbox.**

The tool processes the scan data, using the provided sensor transformations (in the "Start" XML file or directly from the tool's sensor parameters) and alignment target configuration, and saves an XML transformation file to C:/GoTools/SurfaceAlign. If the alignment process succeeds, the [Calibration Status] field displays the time and date of the alignment.

Make note of the location and the name of the file for later use.

The tool additionally produces various Surface data outputs.

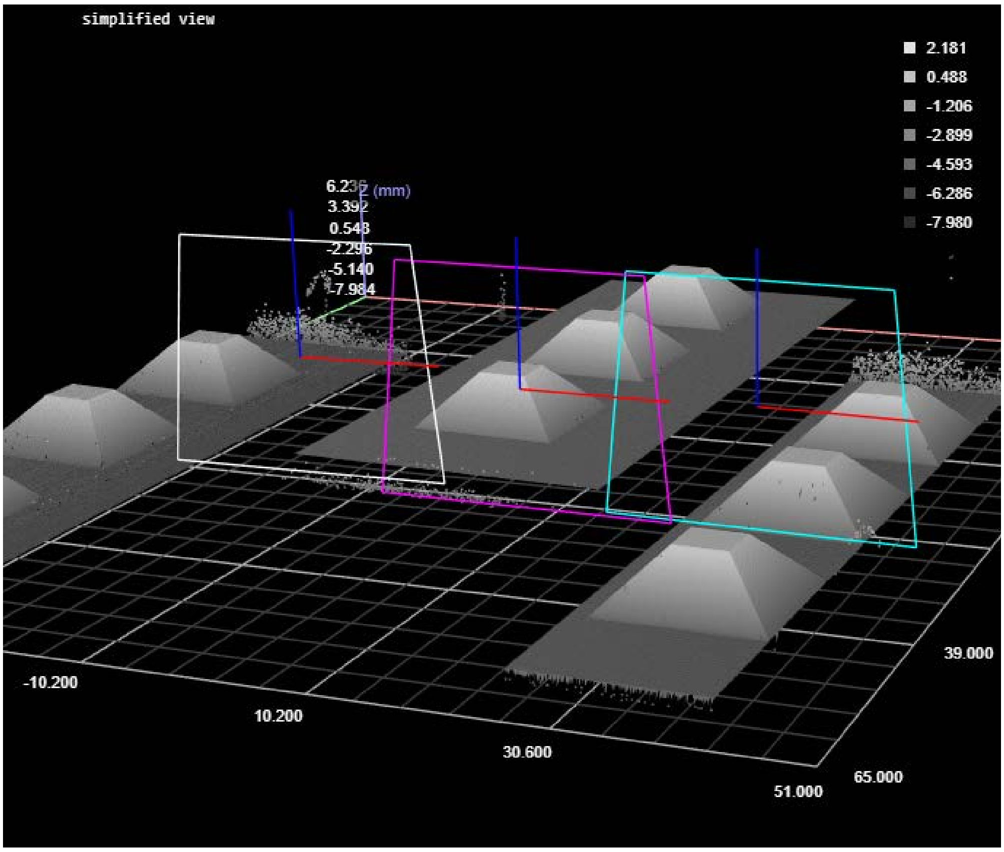
After a successful alignment, you use the XML in either Surface Merge Wide (for wide layouts) or Surface Mesh (for ring layouts) to produce frames of properly combined multi-sensor scan data, to which other measurement tools can then be applied for inline measurement. For more information on the merging tools, see 📖 "6.21 Merge Wide" on page 531 or 📖 "6.22 Mesh" on page 534.

■ Wide Layouts

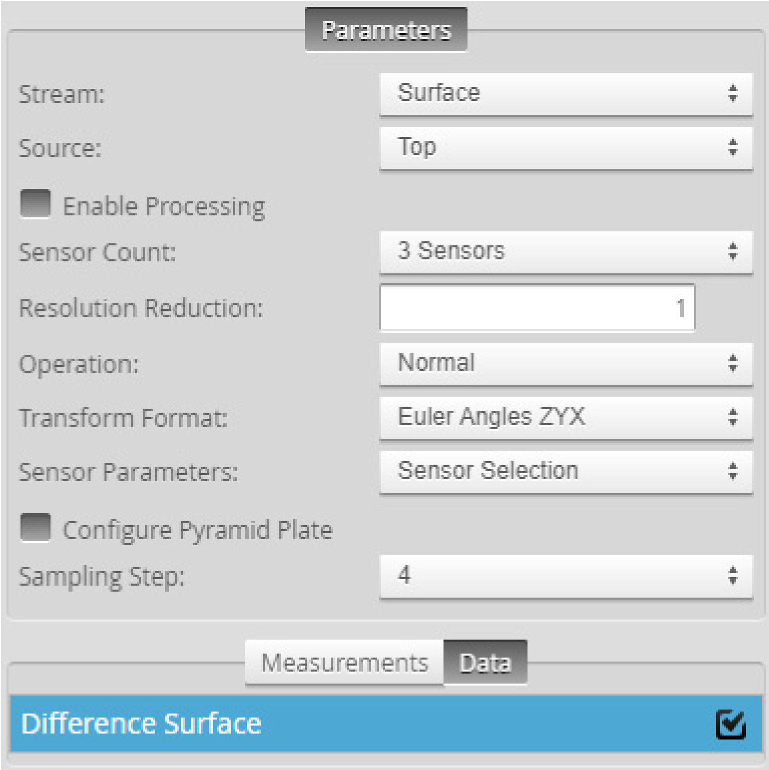
Tips
The tool is supported in emulator scenarios.

Tips
This tool requires acceleration (either by a PC-based application or by GoMax).

The Surface Align Wide tool aligns a multi-sensor system in a wide (side-by-side) layout and saves the transformations (with affinity correction) for each sensor in an XML file. Unlike alignment performed using the [Alignment] panel on the Scan page, the tool compensates for X angle rotation (for information on coordinate systems, see 📖 "3.2 Profile Output" on page 56), giving you a full six degrees of freedom. This method of alignment will produce higher accuracy scans, and allows for higher scan rates, due to the use of a different algorithm when the sensor combines data from multiple sensors.

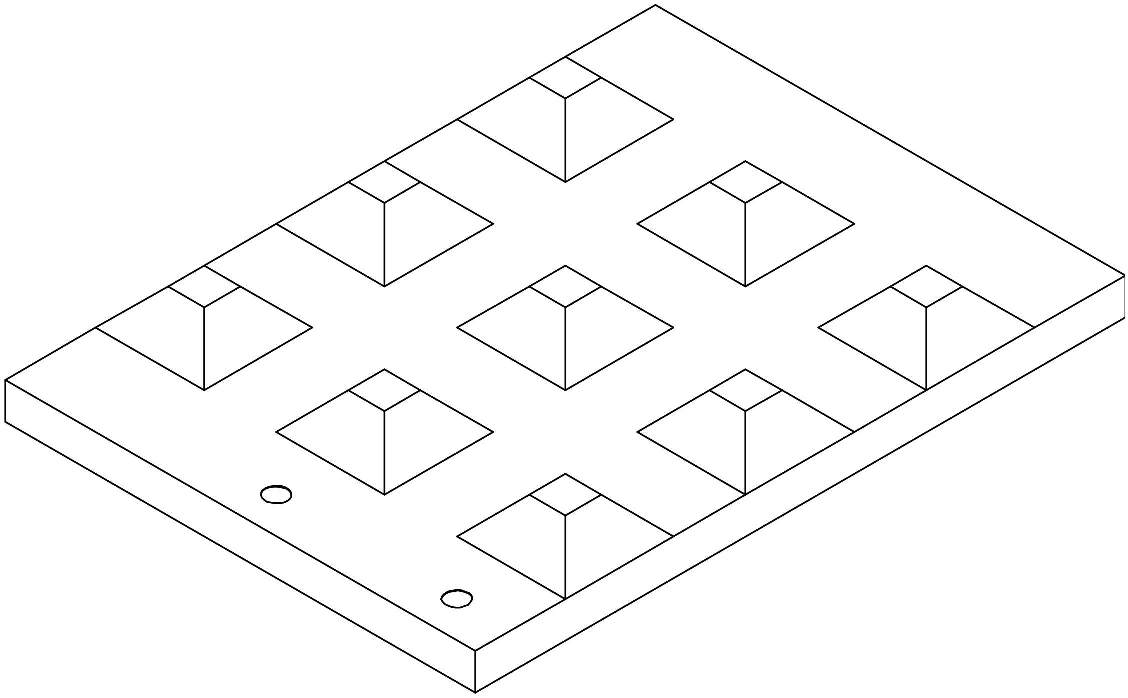


FOVs of individual sensors displayed over the scans of each sensor.



Note that in order to perform scans in production using a system aligned using this tool, you must use the Surface Merge Wide tool (see "6.21 Merge Wide" on page 531), loading the transform XML file created by this tool to stitch the scans from the individual sensors into single frames of Surface scan data. You can then apply any built-in or custom GDK-based Surface tools to the resulting processed data (see "6 Surface Measurement" on page 419).

This alignment tool requires the use of a pyramid plate alignment target, which consists of rows and columns (3x3) of truncated pyramid forms. You can find CAD files for this type of target under Tools\Alignment CAD\Pyramid Plate in the Utilities package (e.g., 14405-x.x.xx.x_SOFTWARE_Utilities_SM1008S.zip, available on Mitutoy's web site.). Note that you should adapt the size of the plate and the pyramids to the size of the sensors in your system: the plate should be scaled so that a truncated pyramid fills most of the field of view of a sensor.



A 3x3 pyramid plate. Exact dimensions of the plate
and the pyramids will depend on the sensors in your system.

Each sensor can view its own column (that is, sensors are not angled), or sensors can view the same column (that is, sensors are angled) if your application requires angled sensors.

After configuring the tool (see below), you must check the [Enable Processing] checkbox to start processing. After the tool has finished processing the data, it produces the XML file and the Difference Surface you can use to assess the quality of the alignment.

Note that after aligning using this tool, on the [Alignment] panel on the [Scan] page, Surfacemeasure1008S indicates that the sensor is unaligned.

[Measurements]

Measurement
[Standard Deviation] Alignment uncertainty (an indicator of alignment quality).
[X Offset {n}] [Y Offset {n}] [Z Offset {n}] The X, Y, and Z offset transformation calculated for sensor {n}.
[X Angle {n}] [Y Angle {n}] [Z Angle {n}] The X, Y, and Z angle transformation calculated for sensor {n}.
[Processing Time] The time the tool takes to run.

[Data]

Type	Description
[Difference Surface]	Use this for diagnostic purposes.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Enable Processing]	Causes the tool to perform the alignment. If the alignment is successful, the tool creates an XML alignment (calibration) file containing the transformations of the sensors that you must use with the Surface Merge Wide tool when scanning production targets to merge scan data. Make note of the XML file indicated in the log pane for use with Surface Merge Wide. Make sure to properly configure the tool before enabling this option. Disable it after performing the alignment; otherwise, the tool will continue performing the alignment on new frames of data, which will have an impact on performance.
[Operation]	Actions that apply to the tool's XML initialization files. One of the following: • [Normal]: The tool automatically chooses this operation after you have chosen another operation. • [Load]: Displays a list of initialization files you can load. After you select a file, the tool loads it and displays a message in the log. The settings in the file, such as the number of sensors and their X and Y origin, are updated in the tool's parameters. • [Save]: Saves the tool's settings to an XML initialization file (in C:\GoTools\SurfaceAlign\). Provide the name of the initialization file in the Configuration Name parameter (without an extension) and press Enter or Tab. Saving the initialization file saves you time if you need to adjust the positions of the sensors in the system and perform the alignment again as a rough starting point for the alignment procedure. • [Delete]: Deletes the initialization file you select.
[Sensor Count]	Indicates the number of sensors in the system.
[Sensor Parameters]	A drop-down that display the settings of the selected sensor. For descriptions of the individual sensor parameters used for the alignment, see 📖 "[Sensor Parameters]" on page 202.
[Configure Pyramid Plate]	If enabled, displays parameters that let you configure the pyramid plate's specifications. For descriptions of the pyramid plate parameters, see 📖 "[Pyramid Plate Configuration Parameters]" on page 202.
[Transform Format]	The transformation format the tool uses. One of the following: • [Standard Angles ABC] • [Euler Angles ZYX] • [Euler Angles XYZ] • [Euler Angles ZYZ] • [Euler Angles ZXZ] • [Affine Angles YZX]

Parameter	Description
[Sampling Step]	The step in data points in both directions with which the surface is processed. Choosing a higher sampling step reduces the processing time the tool requires, but reduces fit accuracy. Useful if the surface being processed has a large number of data points. Typically, you will want to use as high a sampling step as possible.
[Resolution Reduction]	Reduces the lateral resolution of the heightmap to reduce processing time.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253. Not typically used with this tool.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251. Not typically used with this tool.

[Sensor Parameters]

Parameter	Description
[Sensor Model]	Sets the sensor's model.
[X Reversed {n}]	Enable this setting if the sensor is in a reverse orientation (that is, the sensor's positive Y is the same as the direction of travel of the transport system).
[Origin X {n}] / [Origin Y {n}]	The X and Y origin of the sensor. In order for the alignment to succeed, you must enter the rough spatial relationship between the sensors.
[X Offset {n}]	The physical X offset of sensor {n} in relation to the Main sensor. (For Main sensor, typically set to 0.)
[X Field of View {n}]	The field of view along the X axis of sensor {n}; this value is model-dependent. Filled by choosing the sensor model in [Sensor Model].
[X Start {n}]	Sets the X start of sensor {n}. Typically half of the entire FOV (and a negative value).

[Pyramid Plate Configuration Parameters]

Parameter	Description
[X Count] [Y Count]	The count of the truncated pyramids on the pyramid plate, along the X and Y axis, respectively, that are used in the alignment. For example, if you are using only two sensors in a system, and they are each scanning a different column in a 3x3 pyramid plate, [X Count] would be set to 2. In a system where the sensors are angled so that they scan the same column, [X Count] would be set to 1.
[Plate Width] [Plate Length] [Plate Height]	The width, length, and height of the pyramid plate.
[Top Width] [Bottom Width]	The width of the top of the truncated pyramids and the base of the pyramids, respectively.
[Pyramid Height]	The height of the truncated pyramids.
[X Field of View {n}]	The field of view along the X axis of sensor {n}.
[X Distance]]Y Distance]	The distance between the centers of the truncated pyramids along the X and Y axis, respectively.

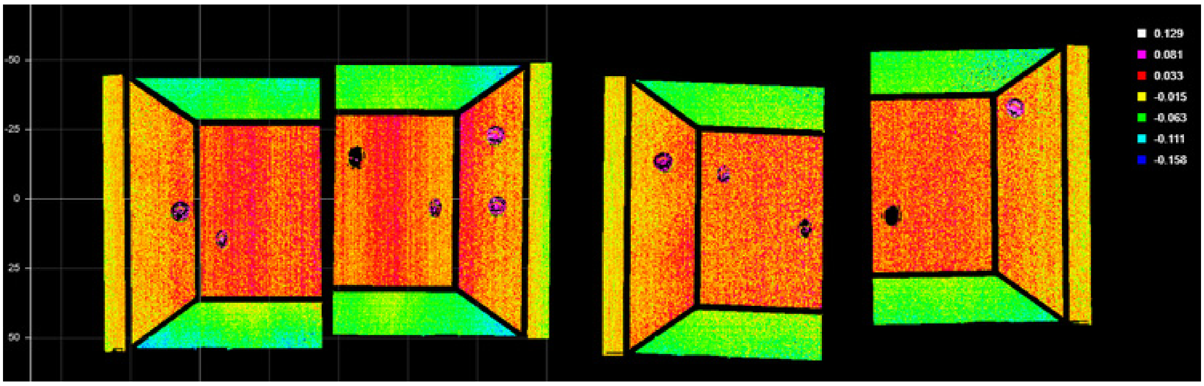
■ Ring Layouts

> **Tips**
> This tool is not supported on A and B revision Gocator 2100 and 2300 sensors that are not accelerated (either by a PC-based application or by GoMax). The tool is supported in emulator scenarios.

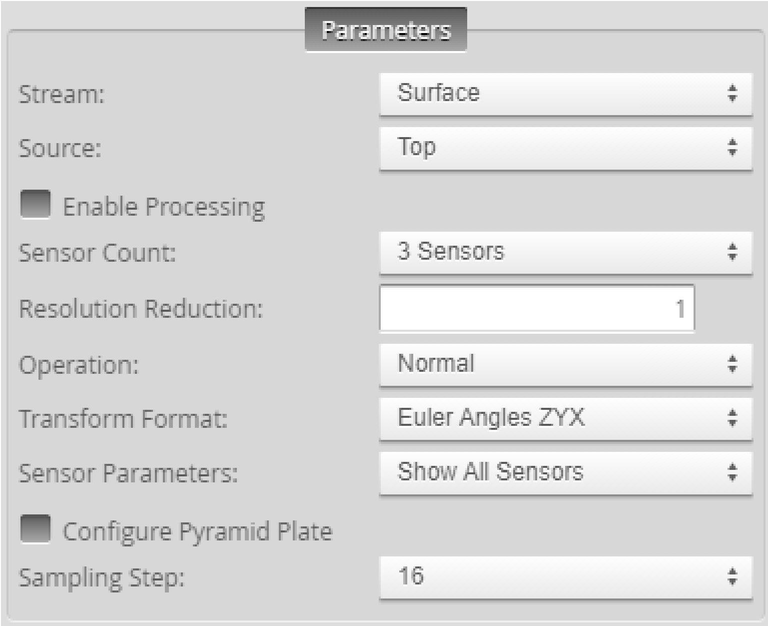
> **Tips**
> This tool requires acceleration (either by a PC-based application or by GoMax).

You can use the Surface Align Ring tool to align a multi-sensor system in a ring layout or a dual- or multi-sensor partial ring layout with 6 degrees of freedom. The alignment procedure saves the transformations required for the sensors in an XML file. Unlike alignment performed using the [Alignment] panel, the tool also compensates for X angle rotation (giving you a full six degrees of freedom).

Note that in order to perform scans in production, you must use the Surface Mesh tool (loading the transform XML file created by this tool) to stitch the scans from the individual sensors into Mesh data; for more information on the Surface Mesh tool, see 📖 "6.22 Mesh" on page 534. You can then either perform measurements directly on the Mesh data using the Mesh measurement tools (see 📖 "4.7.8 Mesh Measurement" on page 288) or you can extract Surface data from the Mesh data and apply any built-in or custom GDK-based Surface tools to the resulting data (see 📖 "6 Surface Measurement" on page 419).



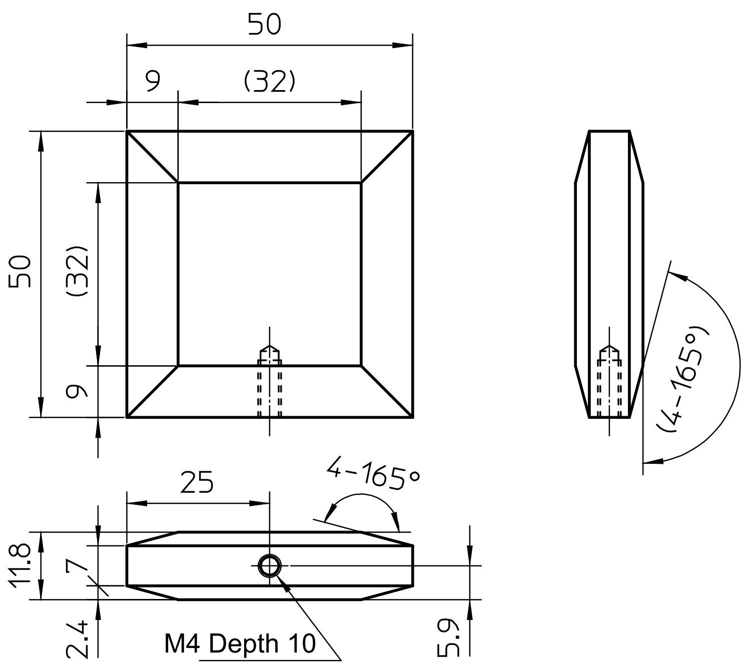
Difference Surface data output resulting from an alignment
(available on the Data tab, used for diagnostics).



Tips

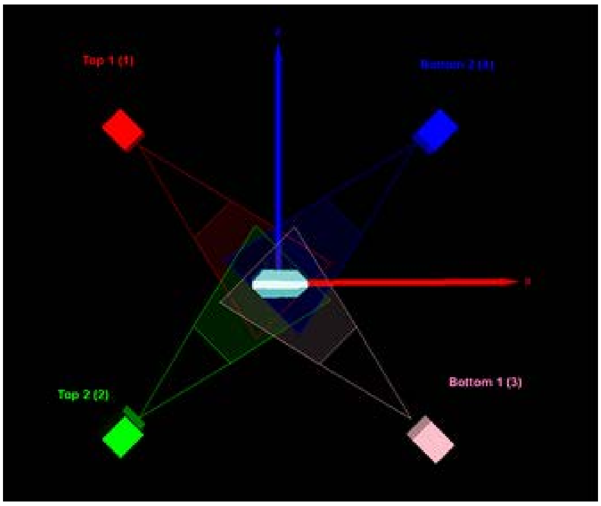
Always make sure that you select Top & Bottom in [Source] when using this tool.

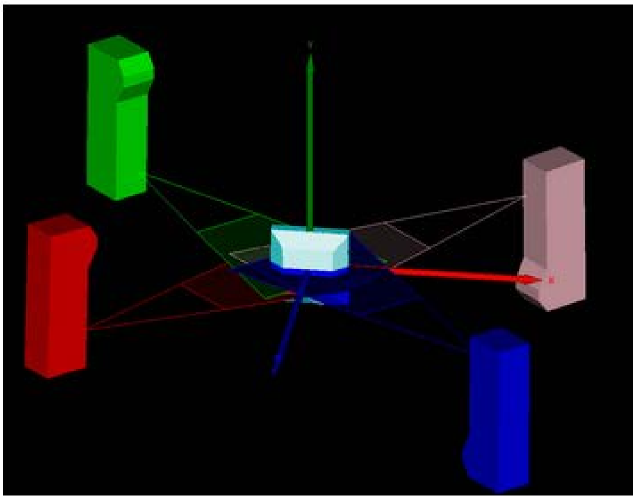
This alignment tool requires the use of a double-sided truncated pyramid alignment target. You can find CAD files for this type of target under Tools\Alignment CAD\Double Sided Pyramid in the Utilities package (e.g., 14405-x.x.xx.x_SOFTWARE_Utilities_SM1008S.zip, available on Mitutoy's web site.). Note that you should adapt the size of the alignment target to the size of the sensors in your system: the target should be scaled so it fills most of the field of view of a sensor.



Example dimensions for mid-size FOV sensors.

The following is a simulated representation of a four-sensor setup around an alignment target:





Tips

Note that after using this tool, on the [Alignment] panel on the [Scan] page, Gocator indicates that the sensor is unaligned.

[Measurements]

Measurement
[Uncertainty] Alignment uncertainty (an indicator of alignment quality).
[Origin X{n}] [Origin Y{n}] [Origin Z{n}] The X, Y, and Z offset transformation calculated for sensor {n}.
[Rotation X{n}] [Rotation Y{n}] [Rotation Z{n}] The X, Y, and Z angle transformation calculated for sensor {n}.
[Processing Time] The time the tool takes to run.

[Data]

Type	Description
[Processed Surface]	Use this for diagnostic purposes.
[Difference Surface]	Use this for diagnostic purposes.
[Segmentation Surface]	Use this for diagnostic purposes.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.

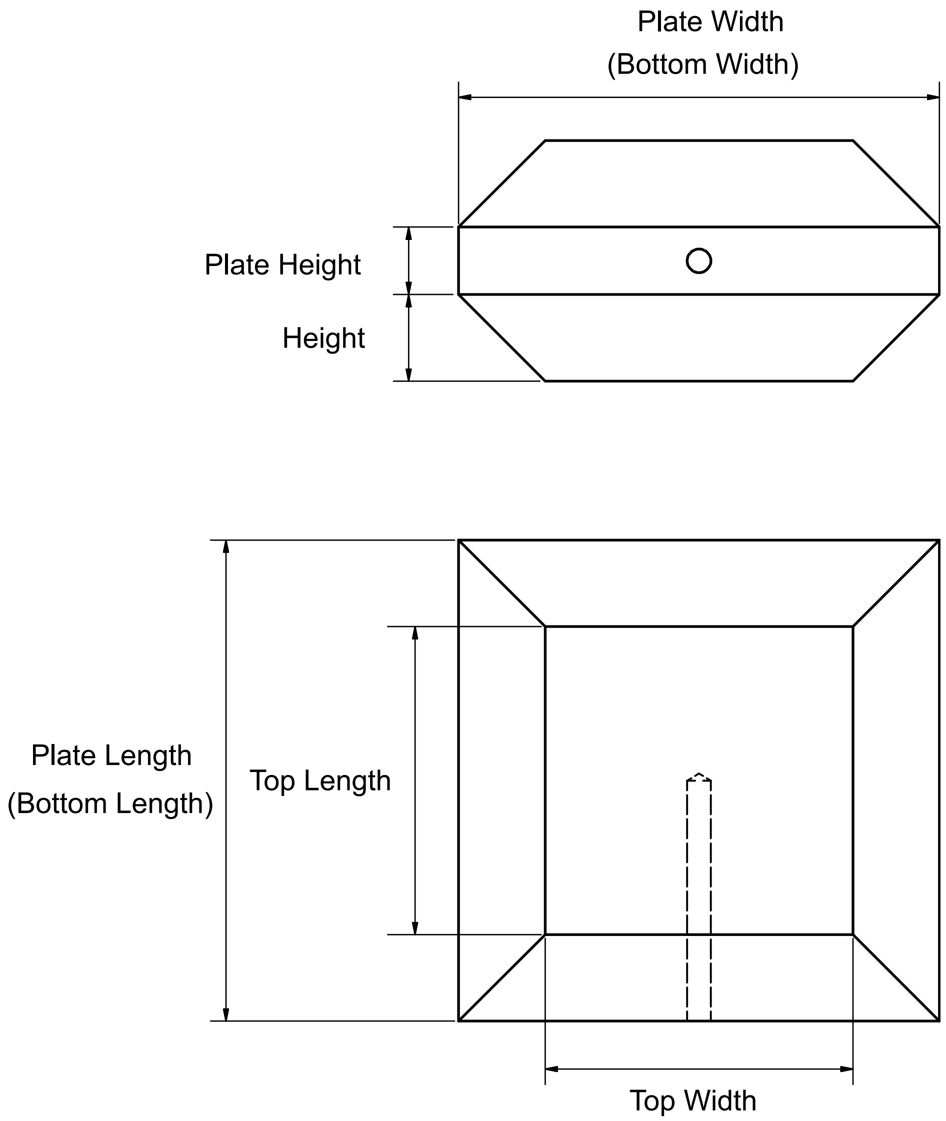
Parameter	Description
[Enable Processing]	Starts the alignment procedure. Make sure to properly configure the tool before enabling this option. Disable it after performing the alignment; otherwise, the tool will continue performing the alignment on new frames of data, which will have an impact on performance.
[Operation]	Actions that apply to the tool's XML initialization files. One of the following: • [Normal]: The tool automatically chooses this operation after you have chosen another operation. • [Load]: Displays a list of initialization files you can load. • [Save]: Saves the tool's settings to an XML initialization file (in C:\GoTools\SurfaceAlign\). Provide the name of the initialization file in the [Configuration Name] parameter and press Enter or Tab. You use the file (by later loading it in the tool) to provide a rough initial estimate of sensor orientation and position to the tool when it performs alignment. • [Delete]: Deletes the initialization file you select.
[Sensor Count]	Indicates the number of sensors in the system.
[Sensor Parameters]	A drop-down that display the settings of the selected sensor. For descriptions of the individual sensor parameters used for the alignment, see "[Sensor Parameters]" on page 202.
[Configure Double-Sided Pyramid]	If enabled, displays parameters that let you configure the pyramid plate's specifications. For descriptions of the pyramid plate parameters, see "[Double-Sided Pyramid Configuration Parameters]" on page 208.
[Transform Forma]t	The transformation format the tool uses. One of the following: • [Standard Angles ABC] • [Euler Angles ZYX] • [Euler Angles XYZ] • [Euler Angles ZYZ] • [Euler Angles ZXZ] • [Affine Angles YZX]
[Fill Gaps]	When this option is enabled, the tool displays a [Gaps Width] parameter (see below).
[Gaps Width]	The kernel the tool uses to initially calculate the surface normal required for alignment. Typically, a value of 4 works for most applications. If alignment fails and you can't track down the issue, try a different value.

Parameter	Description
[Sampling Step]	The step in data points in both directions with which the surface is sampled. Choosing a higher sampling step reduces the processing time the tool requires, but reduces fit accuracy. Useful if the surface being processed has a large number of data points.
[Resolution Reduction]	Reduces the lateral resolution of the heightmap to reduce processing time.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253. Not typically used with this tool.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251. Not typically used with this tool.

[Sensor Parameters]

Parameter	Description
[Sensor Model]	Sets the sensor's model.
[X Reversed {n}]	Enable this setting if the sensor is in a reverse orientation (that is, the sensor's positive Y is the same as the direction of travel of the transport system) and in a top position. If the sensor is also in a bottom position the ring layout, but not reversed, leave this parameter unchecked; otherwise check this parameter.
[Z Reversed {n}]	Enable this setting if the sensor is in a bottom position in a top-bottom layout.
[Rotation X {n}] [Rotation Y {n}] [Rotation Z {n}]	The X, Y, and Z rotations for sensor {n}. In order for the alignment to succeed, you must enter the rough orientation of the sensors.
[X Field of View {n}]	The field of view along the X axis of sensor {n}; this value is model-dependent. Filled by choosing the sensor model in [Sensor Model].
[X Start {n}]	Sets the X start of sensor {n}. Typically half of the largest X FOV (and a negative value).

The following image indicates which parameters (see the table below) correspond to which parts of the alignment target.



[Double-Sided Pyramid Configuration Parameters]

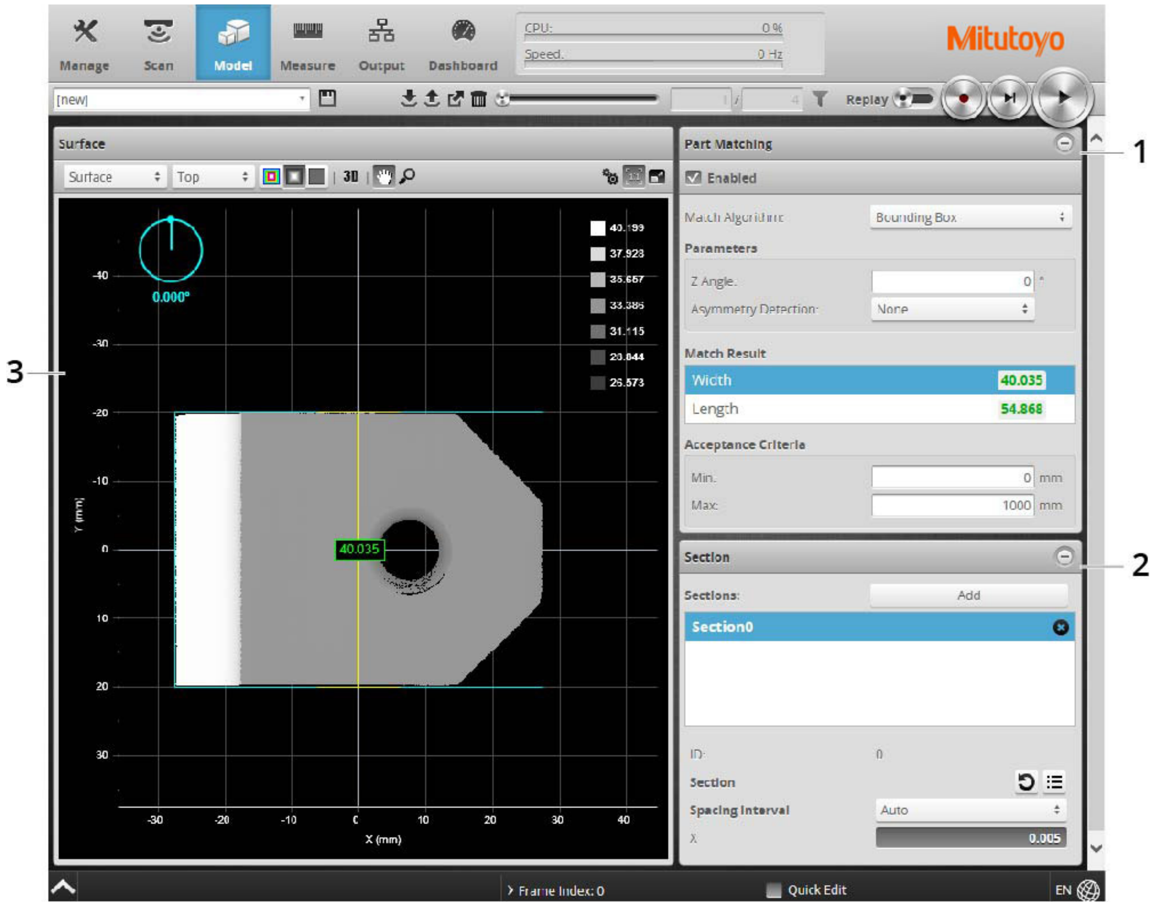
Parameter	Description
[Plate Width] [Plate Length] [Plate Height]	The width, length, and height of the pyramid plate.
[Top Width] [Bottom Width]	The width of the top of the truncated pyramid and the base of the pyramid, respectively.
[Top Length] [Bottom Length]	The length of the top of the truncated pyramid and the base of the pyramid, respectively.
[Height]	The height of the truncated pyramid.

4.6 Models

The following sections describe how to set up part matching using a model, a bounding box, or an ellipse. It also describes how to configure sections.

4.6.1 Model Page Overview

The [Model] page lets you set up part matching and sections.



	Element	Description
1	[Part Matching] panel	Contains settings for configuring models and for part matching.
2	[Section] panel	Contains settings for configuring sections, which let you extract profiles from surfaces.
3	Data Viewer	Displays sensor data and lets you add and remove model edge points.

4.6.2 Part Matching

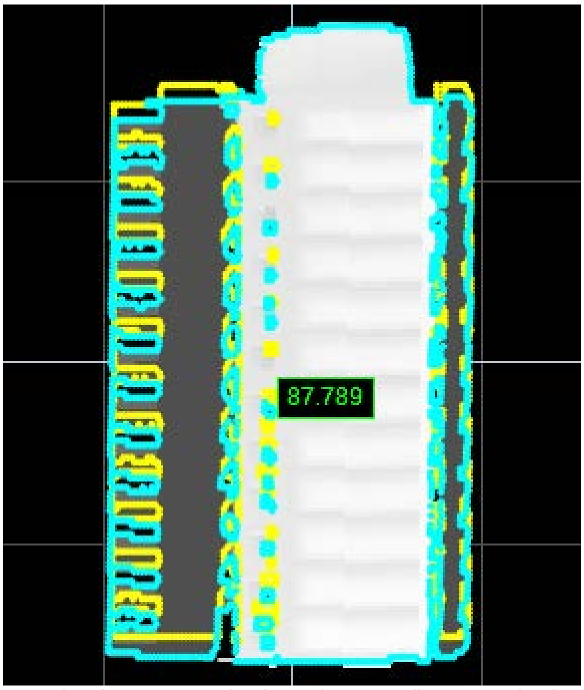
The sensor can match scanned parts to the edges of a model based on a previously scanned part (see 📖 "■Using Edge Detection" on page 210) or to the dimensions of a fitted bounding box or ellipse that encapsulate the model (see 📖 "■Using Bounding Box and Ellipse" on page 221). When parts match, the sensor can rotate scans so that they are all oriented in the same way. This allows measurement tools to be applied consistently to parts, regardless of the orientation of the part you are trying to match.

When the match quality between a model and a part reaches a minimum value (a percentage), or the bounding box or ellipse that encapsulates the part is between minimum and maximum dimension values, the part is "accepted" and any measurements that are added in the [Measure] page will return valid values, as long as the target is in range, etc. If the part is "rejected," any measurements added in the [Measure] page will return an Invalid value. For more information on measurements and decision values, 📖 "4.7 Measurement and Processing" on page 230.

■ Using Edge Detection

When using edge detection for part matching, the sensor compares a model that you must create from a previous scan to a "target" (one of the parts you want to match to the model).

In the data viewer, a model is represented as a yellow outline. The target is represented as a blue outline. If the part match quality above a minimum user-defined level, any measurements configured on the [Measure] page are applied.



Model (yellow outline) and target (blue outline).
Part match quality is 87.789%, which is greater
than the minimum set by the user, so the parts match.

When you create a model, the sensor runs an edge detection algorithm on either the heightmap or intensity image of a scanned part. The resulting model is made up of the detected edge points. The scan used to create the model should be of a reference (or "golden") part to which all other parts will be compared.

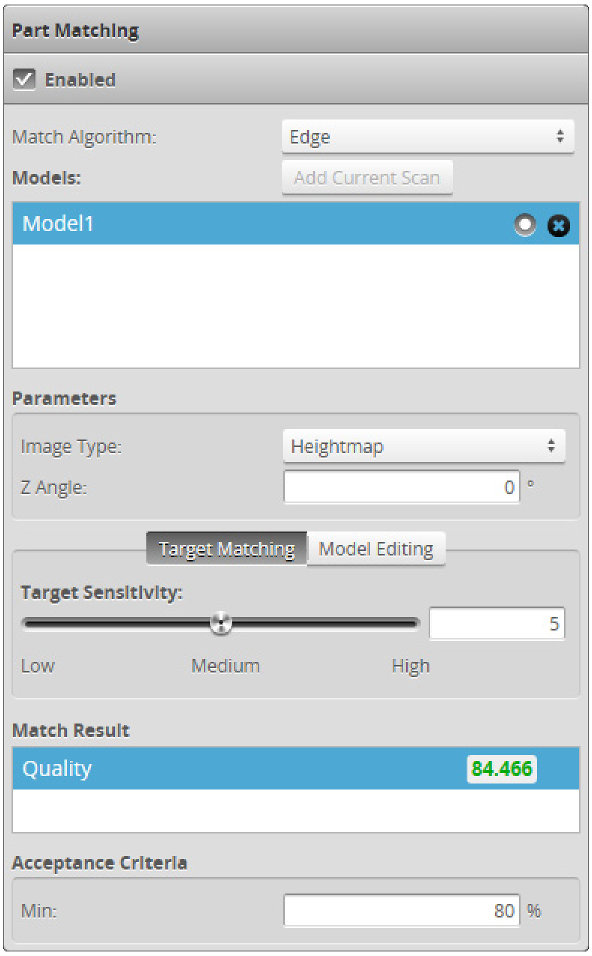
After the model has been created, you optionally modify the model by adjusting the sensitivity (how many edge points are detected), or selectively remove edge points from the model, to improve matching.

Tips
Models are saved as part of a job.

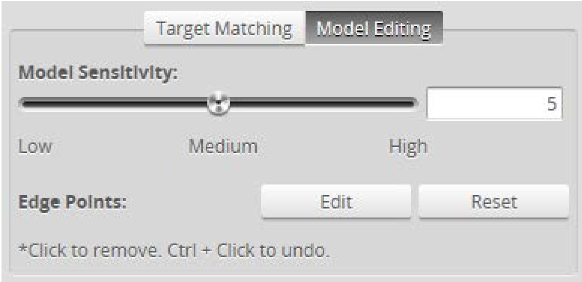
Once you have finished modifying the model, you can also modify target sensitivity, which controls how many edge points are detected on the subsequently scanned targets that will be compared to the model; the same edge detection algorithm used for creating models is used to compare a model to a part.

Typically, setting up edge detection to perform part matching involves the following steps:

1. **Scan a reference part (you can also use replay data that you have previously saved).**
2. **Create a model based on the scan (using either heightmap or intensity data).**
3. **Adjust the model (edge detection algorithm sensitivity and selective removal of edge points).**
4. **Scan another part typical of the parts that would need to match the model.**
5. **Adjust the target sensitivity.**
6. **Set match acceptance level.**



Part Matching panel showing Target Matching tab



Model Editing tab on Part Matching panel

The following settings are used to configure part matching using edge detection.

Setting	Description
[Match Algorithm]	Determines which algorithm the sensor will use to attempt a match. Set this to [Edge] for edge detection.
[Image Type]	Determines what kind of data the sensor will use to detect edges and therefore for part matching. Choose this setting based on the kinds of features that will be used for part matching: [Heightmap]: Surface elevation information of the scanned part will be used to determine edges. This setting is most commonly used. [Intensity]: Intensity data (how light or dark areas of a scanned part are) will be used to determine edges. Use this setting if the main distinguishing marks are printed text or patterns on the parts. The [Acquire Intensity] option must be checked in the [Scan Mode] panel on the [Scan] page for this option to be available.
[Z Angle]	Corrects the orientation of the model to accurately match typical orientation and simplify measurements.
[Target Sensitivity] ([Target Matching] tab)	Controls the threshold at which an edge point is detected on the target's heightmap or intensity image. (The "target" is any part that is matched to the model and which will subsequently be measured if the match is accepted.) Setting [Target Sensitivity] higher results in more edge points. Setting it lower results in fewer edge points and results in higher performance. Use this setting to exclude noise from the detected edges and to make sure distinguishing features are properly detected. The level of this setting should generally be similar to the level of [Model Sensitivity].
[Model Sensitivity] ([Model Editing] tab)	Controls the threshold at which an edge point is detected on the heightmap or intensity image used to create the model. Setting [Model Sensitivity] higher results in more edge points. Setting it lower results in fewer edge points and results in higher performance. Use this setting to exclude noise from the detected edges and to make sure distinguishing features are properly detected. The level of this setting should generally be similar to the level of [Target Sensitivity]. Changing this setting causes the edge detection algorithm to run again at the new threshold. If you have edited edge points manually (removing them selectively), those changes will be lost. For more information, see 📖 "●Modifying a Model's Edge Points" on page 215.

Setting	Description
[Edge Points] ([Model Editing] tab)	The [Edit] button lets you selectively remove edge point that are detected by the edge detection algorithm at the current [Model Sensitivity] setting. For more information, see "●Modifying a Model's Edge Points" on page 215.
[Acceptance Criteria]	Determines the minimum quality level of the match as a percentage value. Part rejected: Quality result is less than Min.

To run part matching, simply make sure that the [Enabled] option is checked on the [Part Matching] panel when the sensor is running. Any measurements that are added and configured on the [Measure] page will be applied to parts if a part match is accepted, regardless of the part's orientation (a successfully matched part is rotated to match orientation of the model), returning a value and decision (as long as the part is in range, etc.). If a part match is rejected, measurements will return an Invalid value.

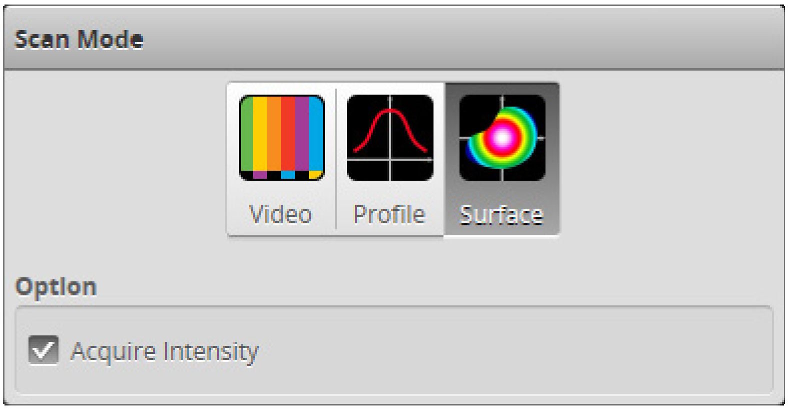
● Creating a Model

SurfaceMeasure1008S creates a model by running an edge detection algorithm on the heightmap or intensity image of a scan. The algorithm is run when a model is first created and whenever the [Model Sensitivity] setting is changed.

To create a model:

1 Go to the [Scan] page.

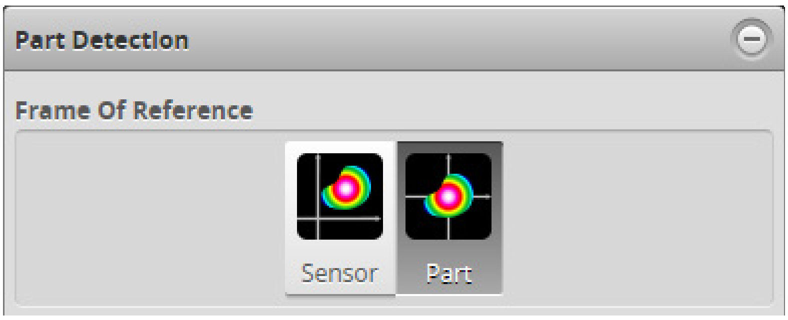
1 In the [Scan Mode] panel, choose [Surface].



You must choose [Surface] in order to scan a part. Furthermore, the [Model] page is only displayed in Surface mode.

2 If you want to use intensity data to create the model, make sure [Acquire Intensity] is checked.

3 In the [Part Detection] panel, choose [Part] for the [Frame of Reference].



Part matching is only available when [Part] has been selected.

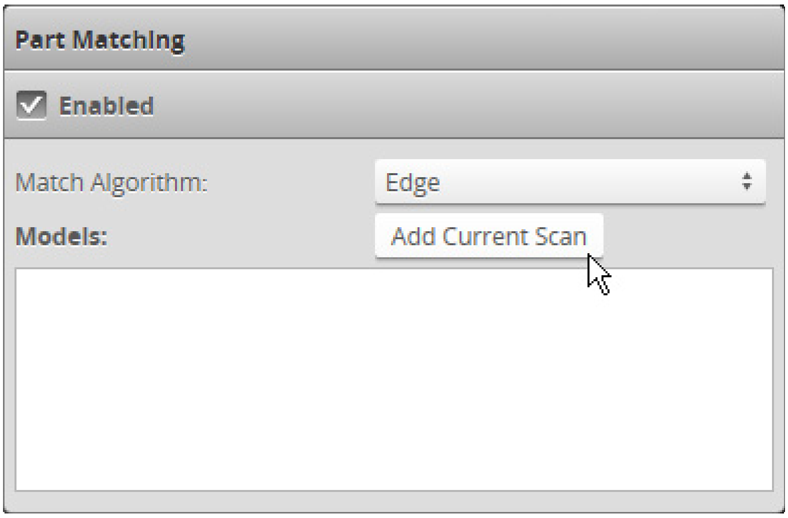
2 **Do one of the following:**

- Scan a reference part.
  See 📖 "4.4 Scan Setup" on page 114 for more information on setting up and aligning a sensor. See 📖 "■Running a Standalone Sensor System" on page 44 or 📖 "■Running a Dual-Sensor System" on page 46 for more information on running a system to scan a part.
- Locate some previously recorded replay data and load it.
  See 📖 "■Recording, Playback, and Measurement Simulation" on page 81 and 📖 "■Downloading, Uploading, and Exporting Replay Data" on page 84 for more information on replay data.

3 **Go to the [Model] page.**

1 Make sure the [Enabled] option is checked in the [Part Matching] panel.

2 In the [Match Algorithm] drop-down, choose [Edge].

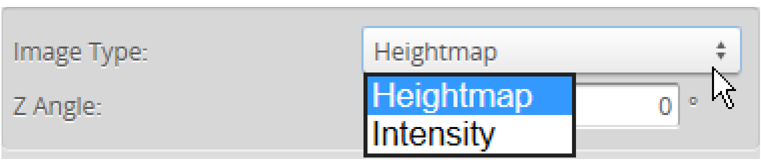


4 **Click [Stop] on the toolbar if the sensor is running.**

5 **Click [Add Current Scan].**

> **Tips**
> After adding the model, the sensor will show that the match quality is 100%, because it is in effect comparing the model to the scan that was used to create the model. This value can be ignored.

6 **In the [Image Type] drop-down, choose [Heightmap] or [Intensity].**



7 **If you need to correct the orientation of the model, provide a value in the [Z Angle] field.**

Correcting the Z angle is useful if the orientation of the model is not close to the typical angle of target parts on the production line.

8 Save the job by clicking the [Save] button .

Models are saved in job files.

See "■Creating, Saving and Loading Jobs (Settings)" on page 79 for more information on saving jobs.

After you have created a model, you may wish to modify it to remove noise to improve its matching capabilities. You may also wish to modify a model to exclude certain areas. For more information, see "●Modifying a Model's Edge Points" on page 215.

Model names can be renamed.

To rename a model:

1 In the [Models] list, double-click on a model name.

2 Type a new name in the model name field.

3 Press Enter or click outside the model name field.

4 Save the job by clicking the [Save] button .

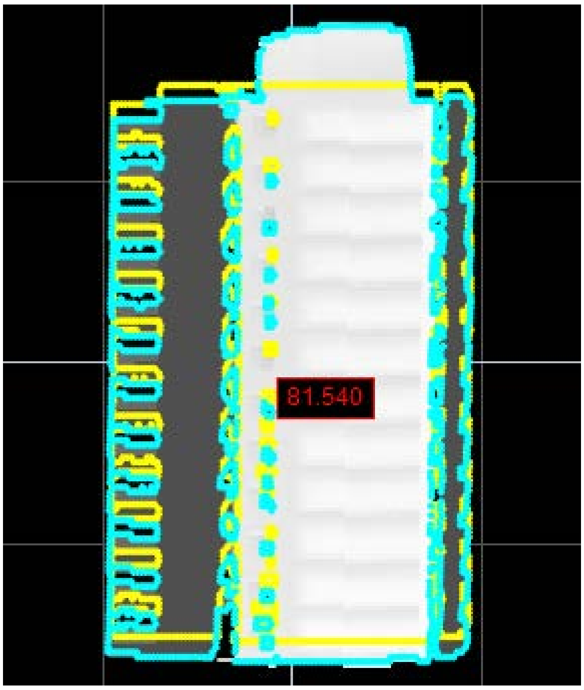
To delete a model, click the button.

● Modifying a Model's Edge Points

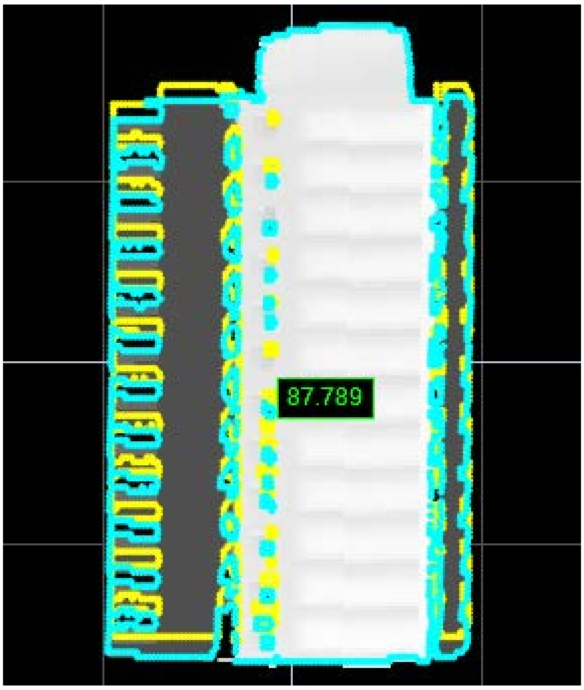
Modifying a model's edge points is useful to exclude noise in the detected edge points and to make sure distinguishing features are properly detected, which can improve matching. You can modify edge points in two ways.

First, you can control the overall number of edge points that are detected by the edge detection algorithm by raising and lowering the edge detection threshold (the [Model Sensitivity] setting). Modifying [Model Sensitivity] causes the edge detection algorithm to run again.

Second, you can fine-tune the model's edge points by selectively removing edge points that are detected by the edge detection algorithm. This could be useful, for example, if an edge on the target parts frequently presents minor variations such as flashing (excess material caused by leakage during molding): the edge points that make up the model can be edited to exclude that region. Editing the model can allow parts to match it more easily.



Edge points along top of model not removed.
Part is rejected. (Min set to 85%.)



Edge points along top of model removed.
Part is accepted. (Min set to 85%.)

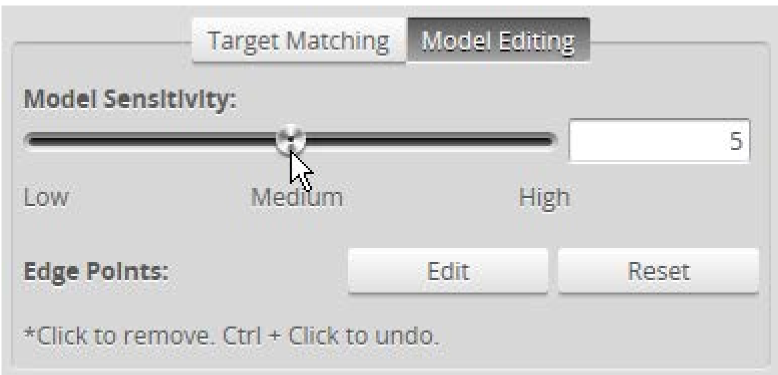
Removing edge points does not cause the edge detection algorithm to run again.

To change model sensitivity:

1 **In the [Models] list, select the model you want to configure by clicking on its selection control.**

2 **Click the [Model Editing] tab.**

3 **Adjust the [Model Sensitivity] slider to exclude noise and to properly detect the distinguishing features that will match parts.**



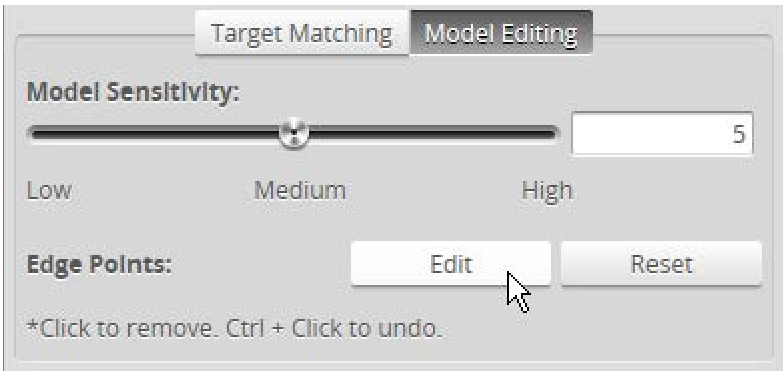
You can also set the sensitivity value manually in the provided text box.

4 **Save the job by clicking the [Save] button.**

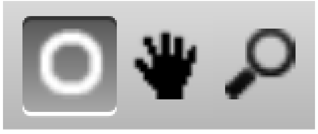
To manually remove model edge points:

1 **In the [Models] list, select the model you want to configure by clicking on its selection control.**

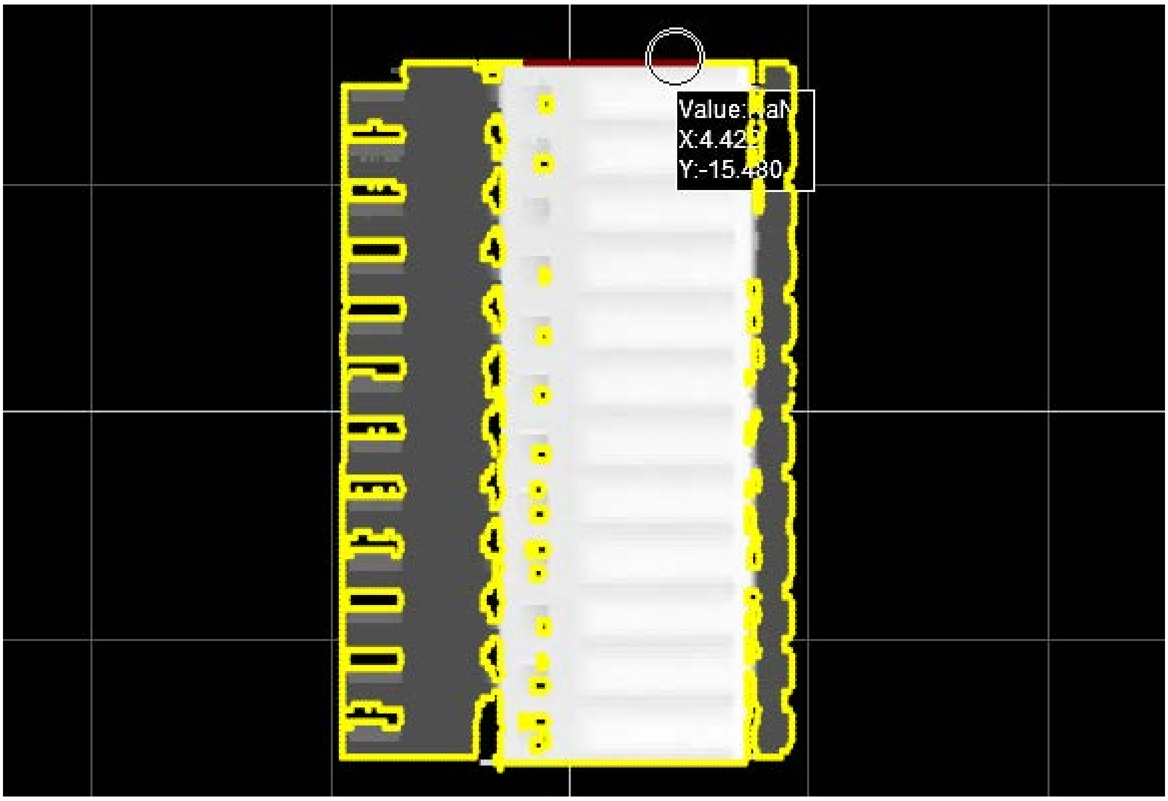
2 **In the [Model Editing] tab, click on the [Edit] button.**



3 **On the toolbar above the data viewer, make sure the [Select] tool is active.**



4 **Click in the data viewer and hold the mouse button while moving the pointer over the edge points you want to remove.**



Points within the circular [Select] tool are removed from the model. Removed edge points turn red in the data viewer.

You can zoom in to see individual edge points by using the mouse wheel or by using the Zoom mode ().

5 **If you have removed too many edge points, use Ctrl + Click in the data viewer to add the edge points back.**

6 **When you have finished editing the model, click [Save] in the [Model Editing] tab.**

7 **Save the job by clicking the [Save] button on the toolbar.**

- Adjusting Target Sensitivity

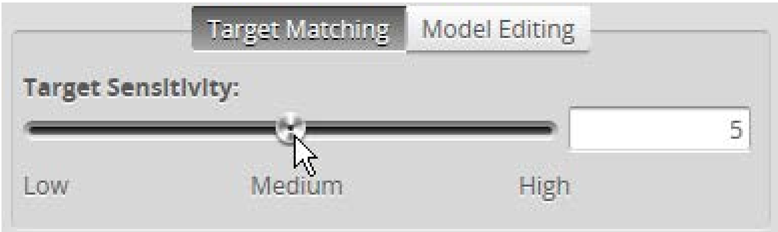
After you have added a model and optionally adjusted it, you must scan a different part, one that is typical of parts that must match the model.

Much in the same way that you can adjust a model's sensitivity, you can adjust the target sensitivity, that is, the threshold at which edge points are detected on the heightmaps or intensity images of parts that you want to match to the model. Adjusting the target sensitivity is useful to exclude noise, improving part matching.

To change target sensitivity:

1 Click the [Target Matching] tab.

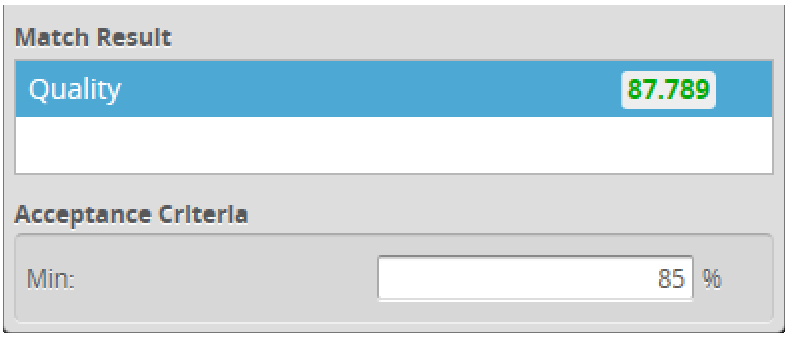
2 Adjust the [Target Sensitivity] setting to exclude noise in order to properly detect the distinguishing features that will allow parts to match.



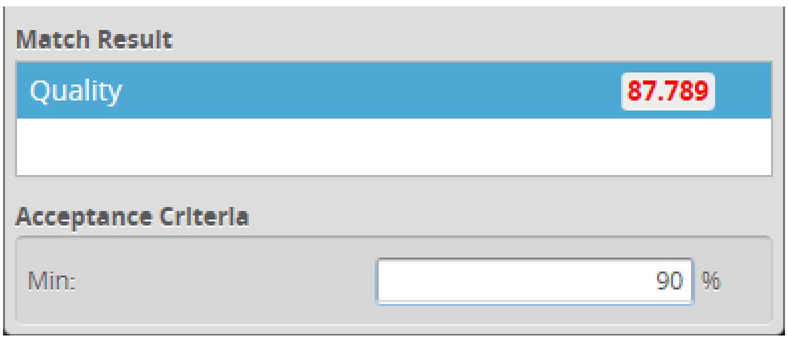
You can also set the sensitivity value manually in the provided text box.

- Setting the Match Acceptance Criteria

In order for a part to match a model, the match quality must reach the minimum set in the [Min] field in [Acceptance Criteria] section of the [Part Matching] panel.



Part accepted: Quality result is greater than Min



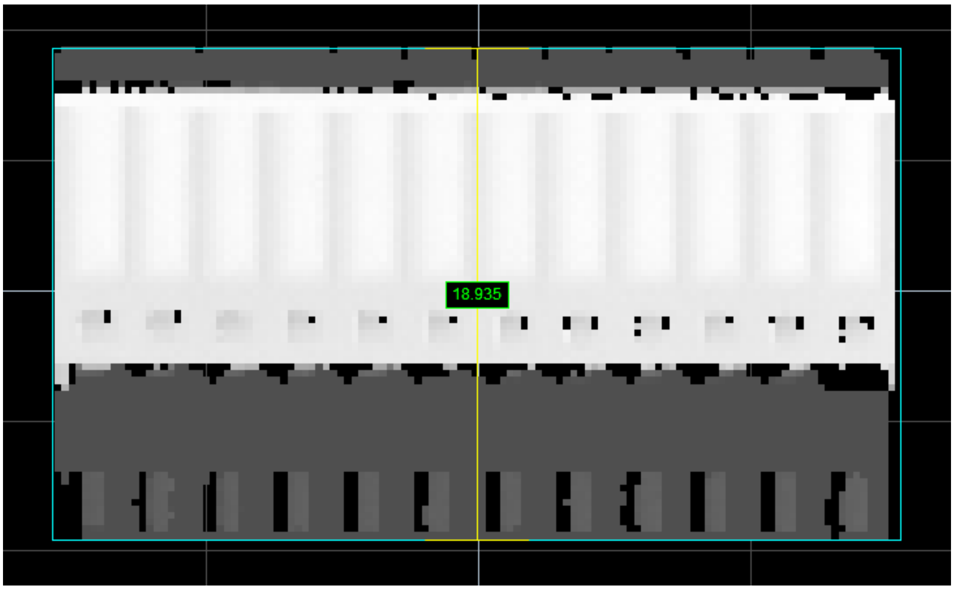
- Running Part Matching

To run part matching, simply make sure that the [Enabled] option is checked on the [Part Matching] panel when the sensor is running. Any measurements that are added and configured on the [Measure] page will be applied to parts if a part match is accepted, regardless of the part's orientation (a successfully matched part is rotated to match orientation of the model), returning a value and decision (as long as the part is in range, etc.). If a part match is rejected, measurements will return an Invalid value.

■ Using Bounding Box and Ellipse

When using a bounding box or an ellipse to match parts, the sensor tests whether a part fits into a bounding box or ellipse that you define. A match will occur regardless of orientation.

In the data viewer, a bounding box or ellipse is displayed with a blue outline. If a part fits in the bounding box or ellipse, any measurements configured on the Measure page are applied.

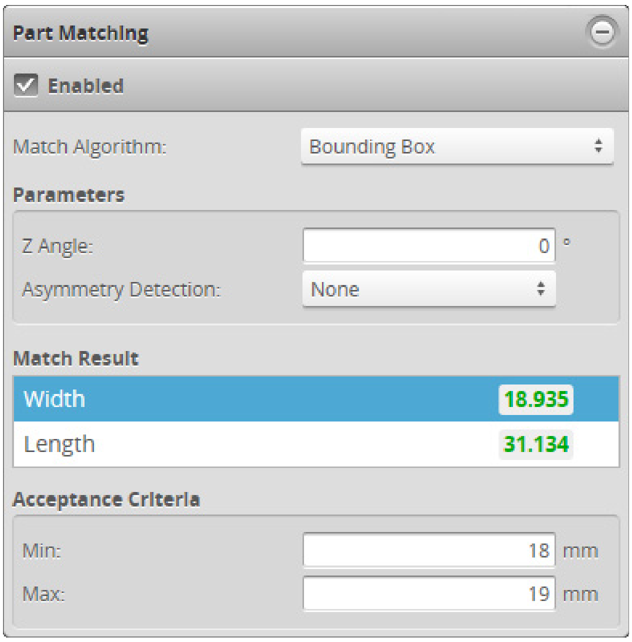


Blue bounding box around a part.
(Yellow lines show currently selected dimension in Part Matching panel.)

Typically, setting up a bounding box or an ellipse to perform part matching involves the following steps:

1 Scan a reference part (you can also use replay data that you have previously saved).

2 Set the characteristics of the bounding box (width and length) or ellipse (major and minor axes).



Part Matching panel (Bounding Box match algorithm)

The following settings are used to configure part matching using a bounding box or ellipse.

Setting	Description
[Match Algorithm]	Determines which algorithm the sensor will use to attempt a match. Set this to [Bounding Box] or [Ellipse].
[Z Angle]	Corrects the orientation of the bounding box or ellipse to accurately match typical orientation and simplify measurements.
[Asymmetry Detection]	Rotates scans based on the asymmetry of the scanned part. The sensor calculates the number of points on each side of the part's centroid in the bounding box or ellipse. [Along Major Axis] – The scan is flipped so that the greater number of points is to the left. [Along Minor Axis] – The scan is flipped so that the greater number of points is on the bottom. [None] – The scan is not flipped.
[Acceptance Criteria]	Determines the minimum and maximum acceptable values of the selected dimension (Width and Length for bounding box, Major and Minor for ellipse) in [Match Result].

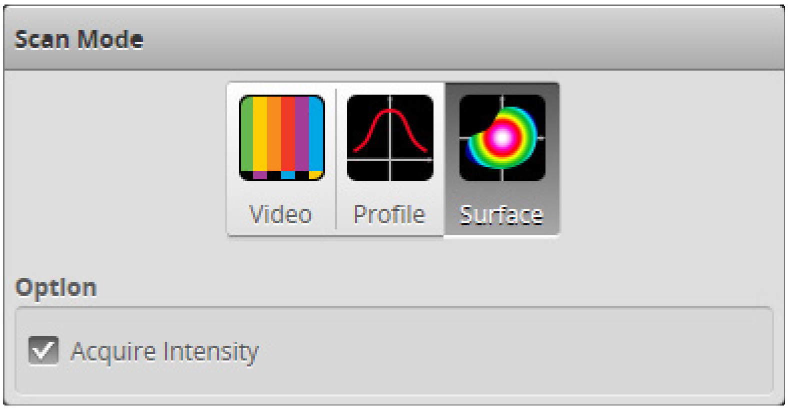
Configuring a Bounding Box or an Ellipse

To use a bounding box or an ellipse to match a part, you must set its dimensions, taking into account expected acceptable variations when compared to a reference (or "golden") part.

To configure a bounding box or ellipse for part matching:

1 Go to the [Scan] page.

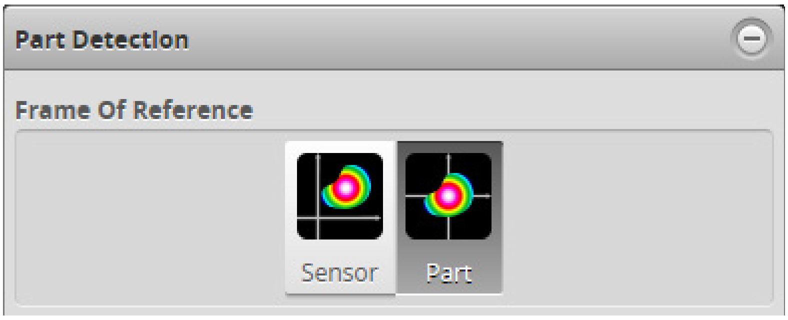
1 In the [Scan Mode] panel, choose [Surface].



You must choose [Surface] in order to scan a part. Furthermore, the [Model] page is only displayed in Surface mode.

Intensity data is not used when part matching using a bounding box or an ellipse, but you can enable the [Acquire Intensity] option if you need intensity data for other reasons.

2 In the [Part Detection] panel, choose [Part] for the [Frame of Reference].



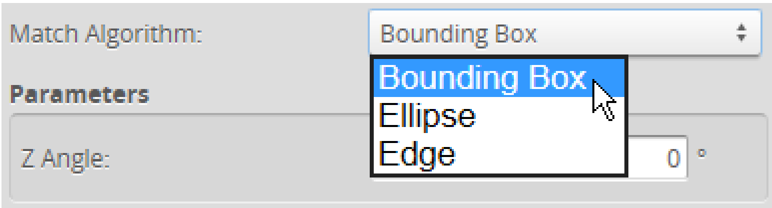
Part matching is only available when [Part] has been selected.

2 Do one of the following:

- Scan a reference part.
  See "4.4 Scan Setup" on page 114 for more information on setting up and aligning a sensor. See "■Running a Standalone Sensor System" on page 44 or "■Running a Dual-Sensor System" on page 46 for more information on running a system to scan a part.
- Locate some previously recorded replay data and load it.
  See "■Recording, Playback, and Measurement Simulation" on page 81 and "■Downloading, Uploading, and Exporting Replay Data" on page 84 for more information on replay data.

3 Go to the [Model] page.

1. Make sure the [Enabled] option is checked in the [Part Matching] panel.
2. In the [Match Algorithm] drop-down, choose [Bounding Box] or [Ellipse].



4 Set [Min] and [Max] of both of the dimensions of the selected match algorithm shape, taking into account expected acceptable variations.

- If you chose [Bounding Box] for the match algorithm, select [Width] and then [Length] in [Match Result], setting the minimum and maximum values acceptable for each dimension.
- If you chose [Ellipse] for the match algorithm, select [Minor] and then [Major] in [Match Result], setting the minimum and maximum values acceptable for each dimension.

5 Save the job by clicking the [Save] button.

See "■Creating, Saving and Loading Jobs (Settings)" on page 79 for more information on saving jobs.

● Running Part Matching

To run part matching, simply make sure that the [Enabled] option is checked on the [Part Matching] panel when the sensor is running. Any measurements that are added and configured on the [Measure] page will be applied to parts if a part match is accepted, regardless of the part's orientation (a successfully matched part is rotated to match orientation of the bounding box or ellipse), returning a value and decision (as long as the part is in range, etc.). If a part match is rejected, measurements will return an Invalid value.

■ Using Part Matching to Accept or Reject a Part

Part matching results only determine whether a measurement is applied to a part. Whether the measurement returns a pass or fail value—its decision—depends on whether the measurement's value is between the [Min] and [Max] values set for the measurement. This decision, in addition to the actual value, can in turn be used to control a PLC for example. The part matching "decision" itself is not passed to the SurfaceMeasure1008S output, but you can simulate this by setting up a measurement that will always pass if it is applied.

For example, you could set up a Position Z measurement, choosing Max Z as the feature type, and setting the [Min] and [Max] values to the measurement range of the sensor. This way, as long as a part matches and the target is in range, etc., the measurement will pass. This measurement decision, which is passed to the SurfaceMeasure1008S's output, could in turn be used to control a PLC.

4.6.3 Sections

In Surface mode, the sensor can also extract a profile from a surface or part using a line you define on that surface or part. The resulting profile is called a “section.” A section can have any orientation on the surface, but its profile is parallel to the Z axis.

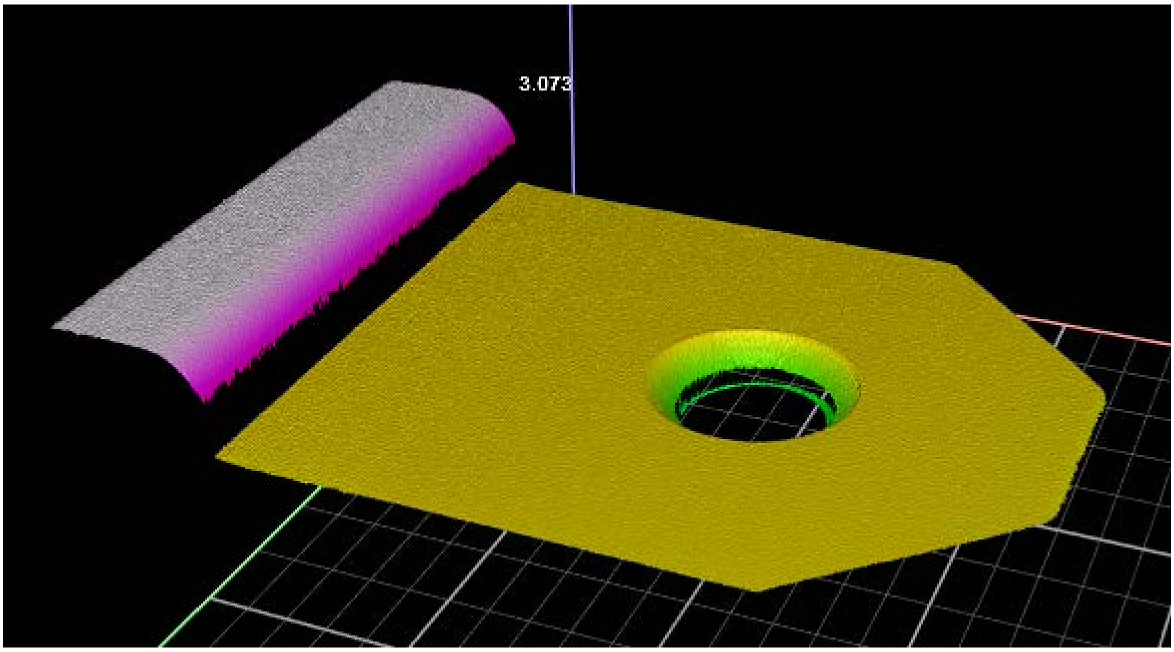
> **Tips**
> You can't create sections from the [Models] page on surface data that is produced by other tools, such as Surface Stitch. You can however create sections on any kind of surface data using the Surface Section tool; for more information, see 📖 "6.28 Section" on page 565.

You can use most profile measurement tools on a section: you can't use tools that work with unresampled data. Using sections and the profile measurements, you can therefore use measurements that are not otherwise possible in Surface mode, for example:

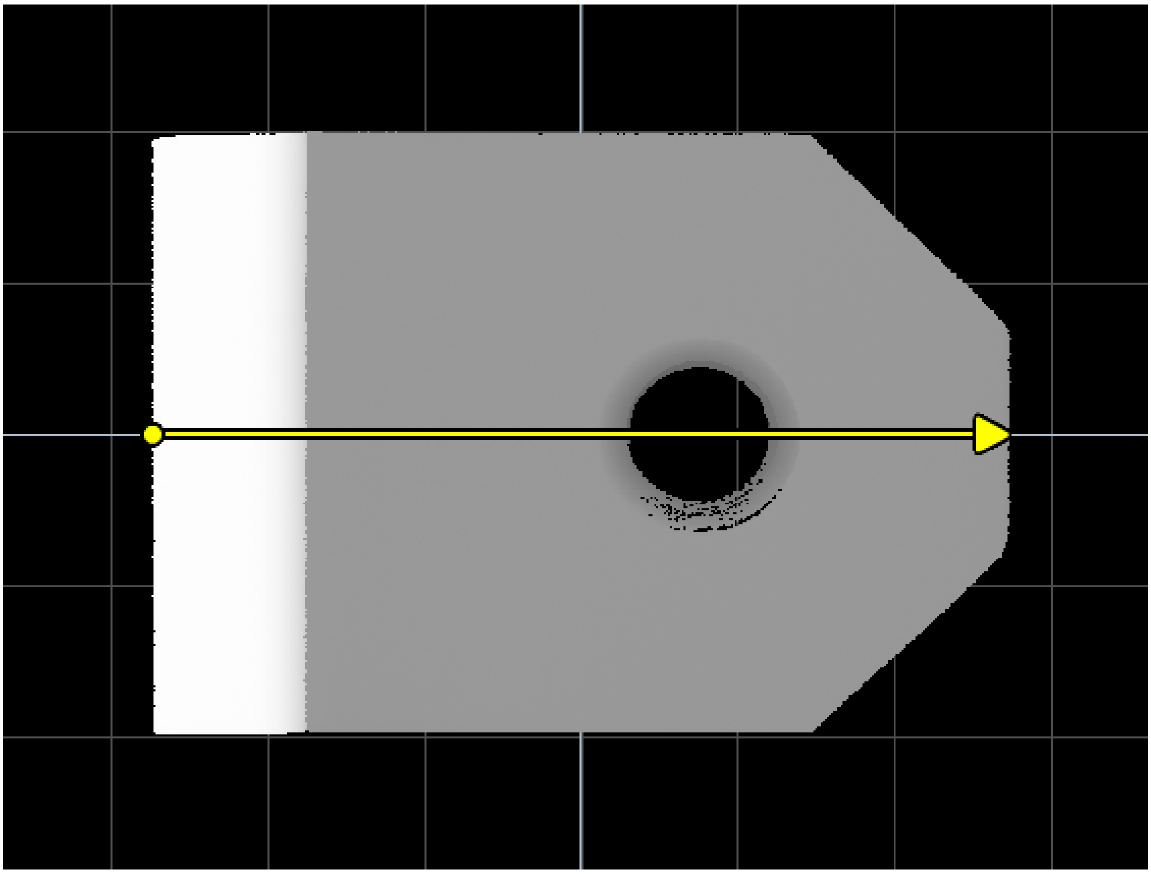
- Gap and flush measurements
- Surface radius measurements (for example, rounded edges or corners)
- Intersections
- Point-to-point dimension measurements between profile features

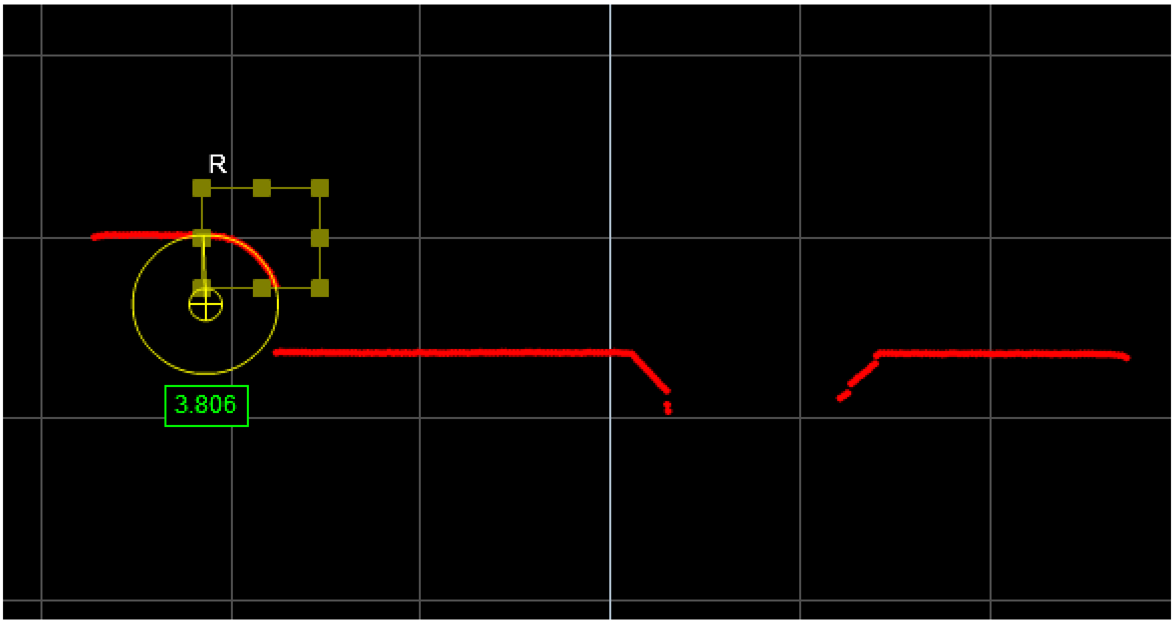
SurfaceMeasure1008S supports multiple sections, letting you take multiple measurements on the same object.

On the [Output] page, in Surface mode, you can output both surface measurements and section-based profile measurements at the same time. The sensor can also output the surfaces and section profiles themselves at the same time.



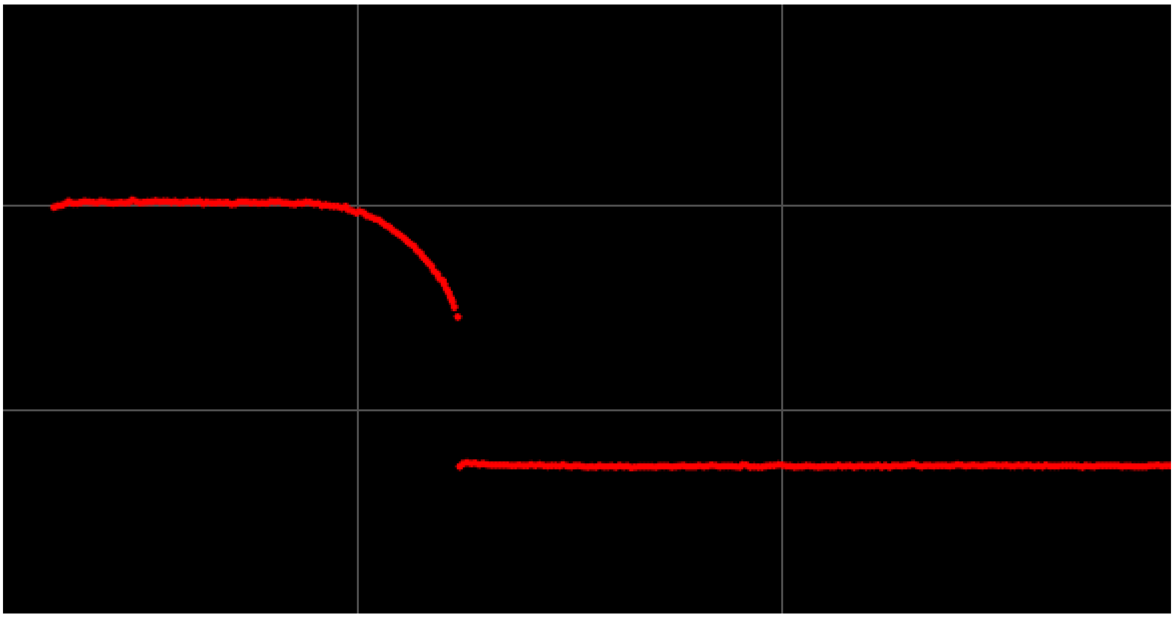
Part in data viewer (3D view)

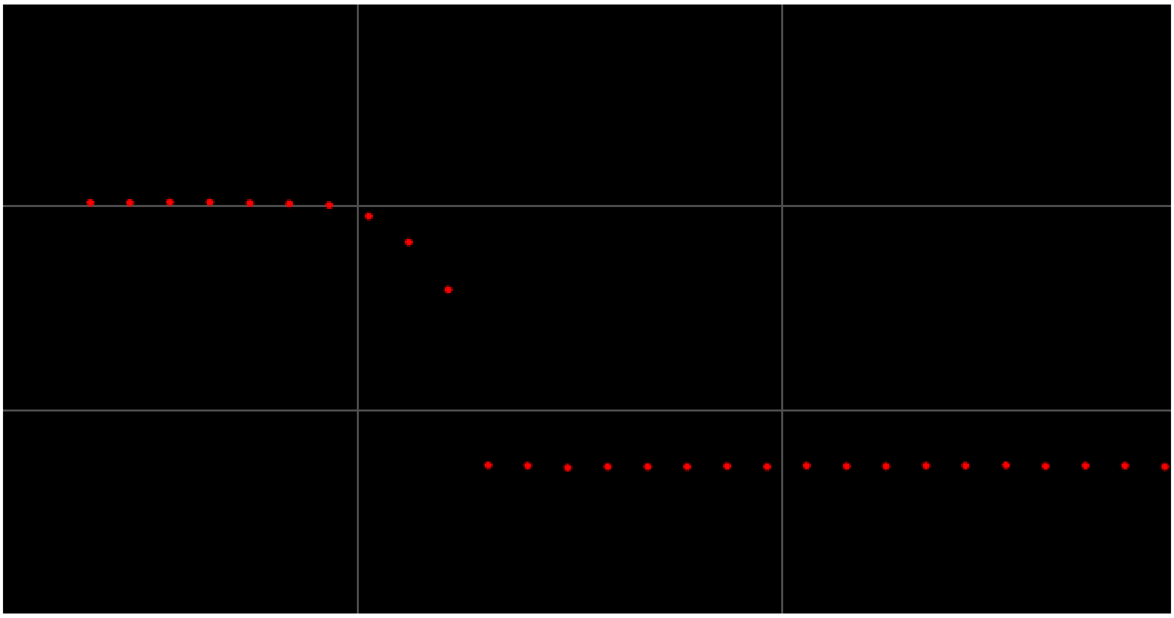

Section defined on top of part (2D view)



Circle Radius measurement running on profile extracted
from surface using defined section

You can configure the sampling distance between points along the section. Reducing the sampling distance reduces the resolution of the profile, but increases the sensor's performance and results in less data being sent over the output.


Minimum spacing interval: highest profile resolution,
greater sensor CPU usage and data output



Maximum spacing interval: lowest profile resolution,
lower sensor CPU usage and data output

Tips

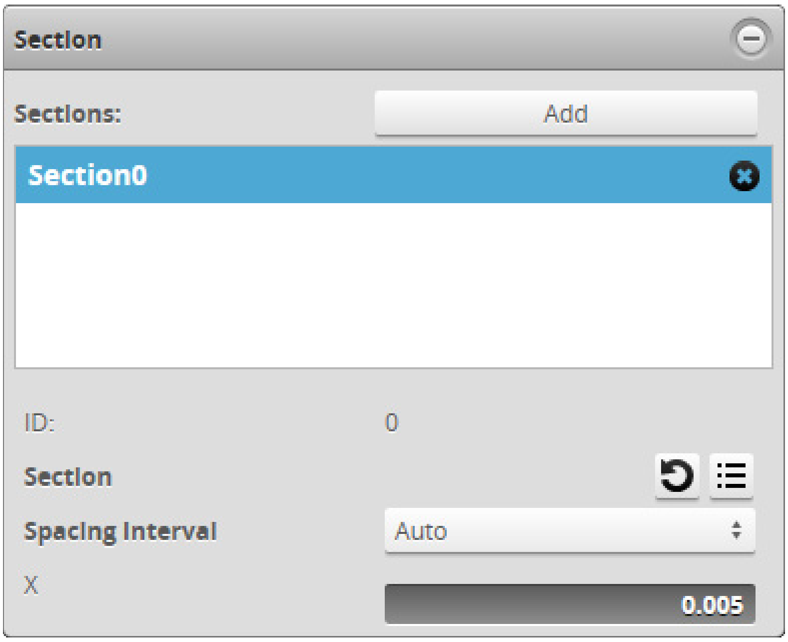
Using a higher spacing interval can produce different measurement results compared to using a smaller spacing interval. You should therefore compare results using different spacing intervals before using sections in production.

The sections you add to a surface are directional, and their start and end points are defined using X and Y coordinates. The start point always corresponds to the leftmost point on the extracted profile, whereas the end point always corresponds to the rightmost point on the extracted profile, no matter the orientation of the section on the surface.

For more information on profile tools, see 📖 "5 Profile Measurement" on page 343.

Creating a Section

Before you create a section, you should first scan a target in Surface mode to create a surface on which you can create the section. You can use either live data or recorded data.



After creating a section, the following settings are available:

Setting	Description
[Spacing Interval]	Determines the space between the points of the extracted profile. [Auto]: The highest resolution, calculated using the X and Y resolution of the scan. [Custom]: Lets you set the spacing interval by using a slider or setting the value manually.
[Section]	Lets you manually set the X and Y coordinates of the start and end points of the section. Setting the coordinates manually is useful if you need to create a section that is perfectly horizontal or vertical. For example, to create a horizontal section, copy the Y value of either the start or end point to the other point's Y field. You can reverse the start and end points by clicking the button. To reset the start and end points to their initial values, click the button.

To create a section:

1 On the [Scan] page, in the [Scan Mode] panel, click [Surface].

2 On the [Model] page, in the [Section] panel, click [Add].

You may need to click the button to expand the panel.

The sensor creates a section on the surface.

3 Rename the section if you want.

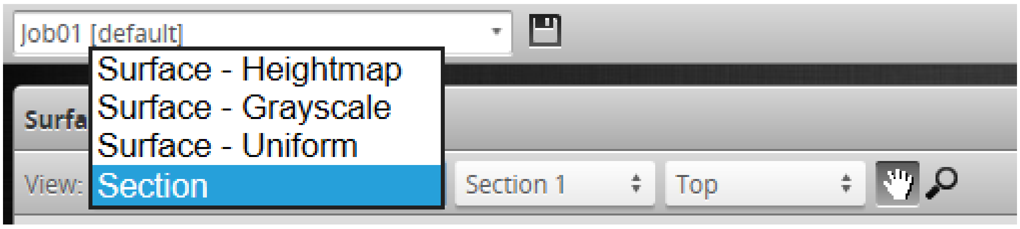
4 Move the section and adjust the start and end points of the section to extract the desired profile.

You can move or adjust the section graphically in the data viewer, or you can manually adjust the X and Y coordinates of the section.

5 (Optional) Adjust the [Spacing Interval].

After you create a section, the profile measurement tools become available in the [Tools] panel on the [Measure] page. If you have created more than one section, you must select it in the tool. For more information on profile measurement tools, see "5 Profile Measurement" on page 343.

The sensor also adds a [Section] option to the [View] drop-down above the data viewer, which lets you view an extracted profile, as well as a section selector drop-down for cases where multiple sections are defined.



Sections are also added to the Stream drop-down in Profile and Feature tools.

If parts are not consistently oriented in the same way from scan to scan, you can use part matching to correct their rotation, if the entire part is visible in the scan. Parts will then be consistently oriented, and sections will fall on the same area on each part. You can also use anchoring to ensure that measurements are consistently placed on a part.

■ Deleting a Section

When you delete a section, the sensor removes any associated measurements. After you remove the last section, the sensor no longer displays profile measurement tools in the [Tools] panel.

To delete a section:

1 On the [Scan] page, in the [Scan Mod] panel, click [Surface].

2 On the [Model] page, in the [Section] panel, click the button of the section you want to delete.

» The sensor deletes the section on the surface.

You may need to click the button to expand the panel.

If you have associated a measurement tool to the section by setting the tool's [Stream] setting to the section, the sensor asks if you want to delete all of the associated measurement tools.

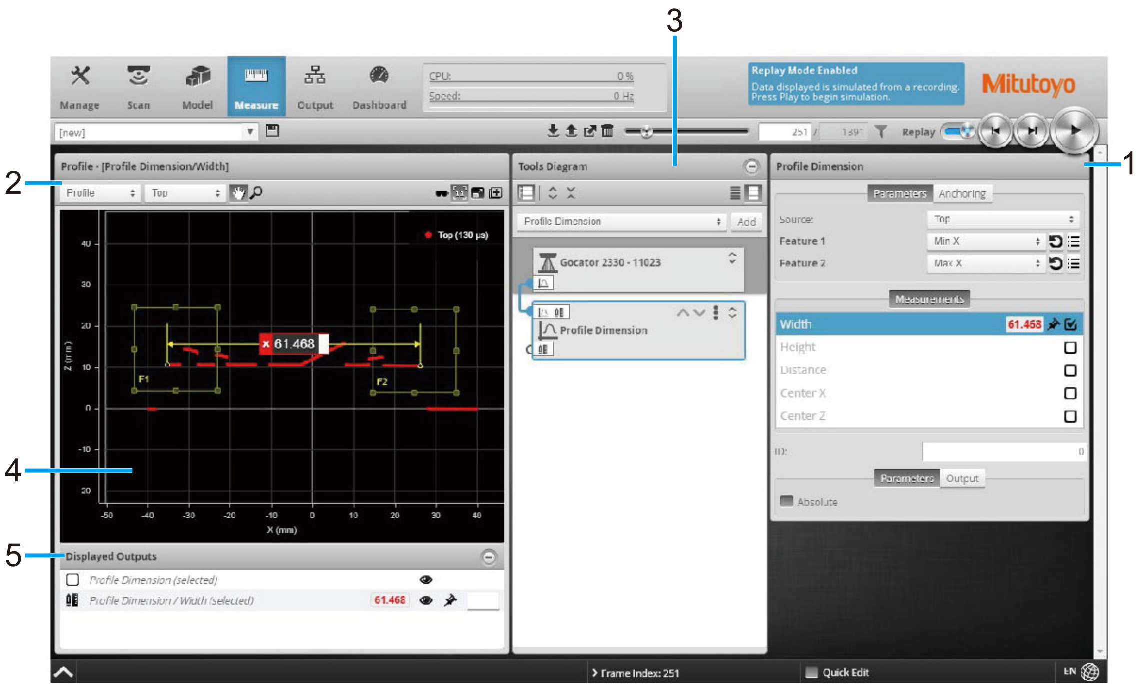
4.7 Measurement and Processing

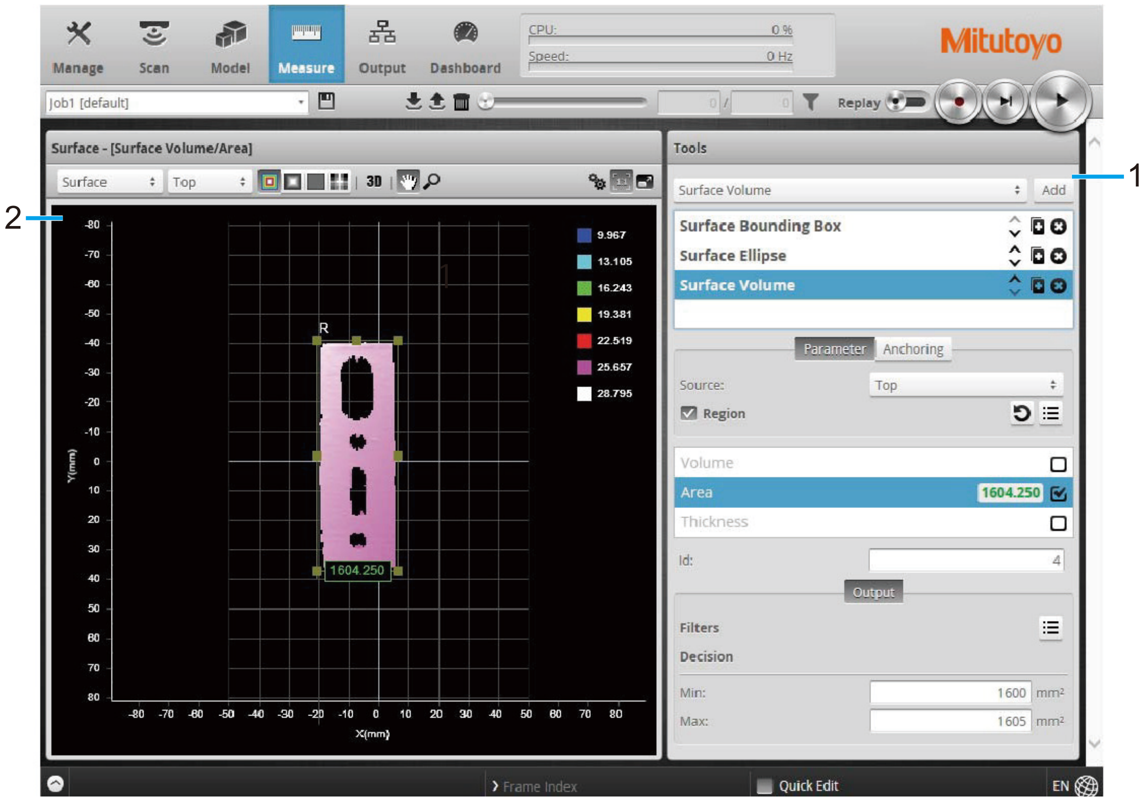
The following sections describe SurfaceMeasure1008S's measurement and processing tools.

4.7.1 Measure Page Overview

Measurement tools are added and configured in the [Measure] page.

The content of the [Tools] panel in the [Measure] page depends on the current scan mode. In Profile mode, the [Measure] page displays tools for profile measurement. In Surface mode, the [Measure] page displays tools for surface measurement. If you have defined a section in Surface mode, profile tools are also displayed. In Video mode, tools are not available.





	Element	Description
1	Tool configuration panel	Used to add, manage, and configure tools and measurements (see 📖 "4.7.3 Tools Panel" on page 234) and to choose anchors (📖 "●Measurement Anchoring" on page 254).
2	Data Viewer	Displays video and scan data, sets up tools, and displays result calipers related to the selected measurement. Parts are displayed using a height map, which is a top-down view of the XY plane, where color represents height. See 📖 "■Data Viewer" on page 232.
3	Tools Diagram	Provides a visual representation of tools and the flow of data between them. For more information, see 📖 "4.7.4 Working with the Tools Diagram" on page 263.
4	Feature Area	Configurable region of interest from which feature points are detected. These feature points are used to calculate the measurements. The number of feature areas displayed depends on which measurement tool is currently selected.
5	Displayed Outputs	Lists the measurements and geometric features currently displayed or pinned in the data viewer. For more information, see 📖 "4.7.5 Pinning Measurements and Features" on page 281.

■ Data Viewer

When the [Measure] page is active, the data viewer can be used to graphically configure measurement regions. Measurement regions can also be configured manually in measurements by entering values into the provided fields (see 📖 "●Regions" on page 238).

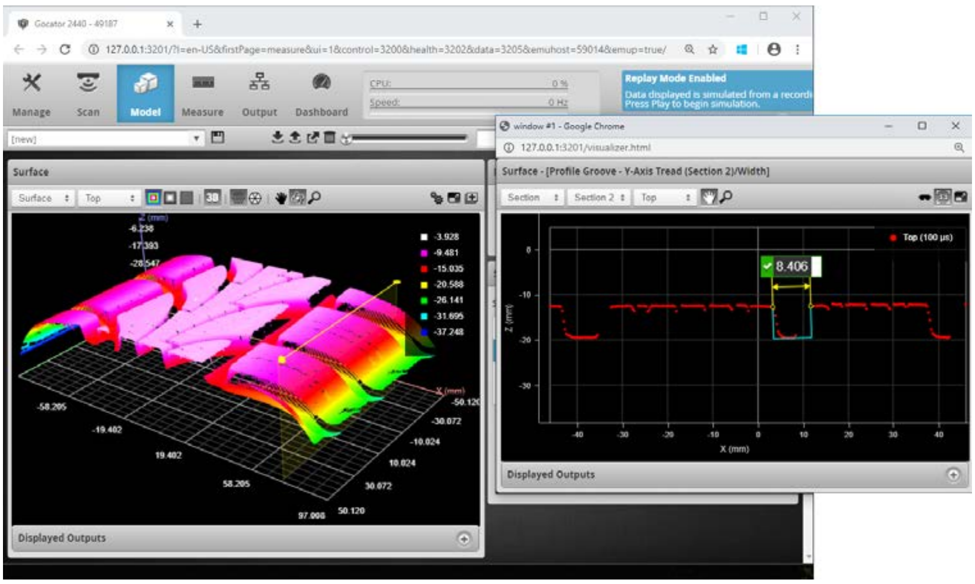
For information on controls in the data viewer, see 📖 "■Data Viewer Controls" on page 156.

For information on setting up measurement regions graphically, see 📖 "■Region Definition" on page 169.

For information on opening and using additional data viewer windows, see 📖 "4.7.2 Using Multiple Data Viewer Windows" on page 232.

4.7.2 Using Multiple Data Viewer Windows

You can open multiple windows outside of the main browser window containing data viewers set to different views and different sets of pinned outputs. This lets you more easily monitor or set up complex applications, for example placing one or more data viewer window in one computer monitor, and others in a different monitor.

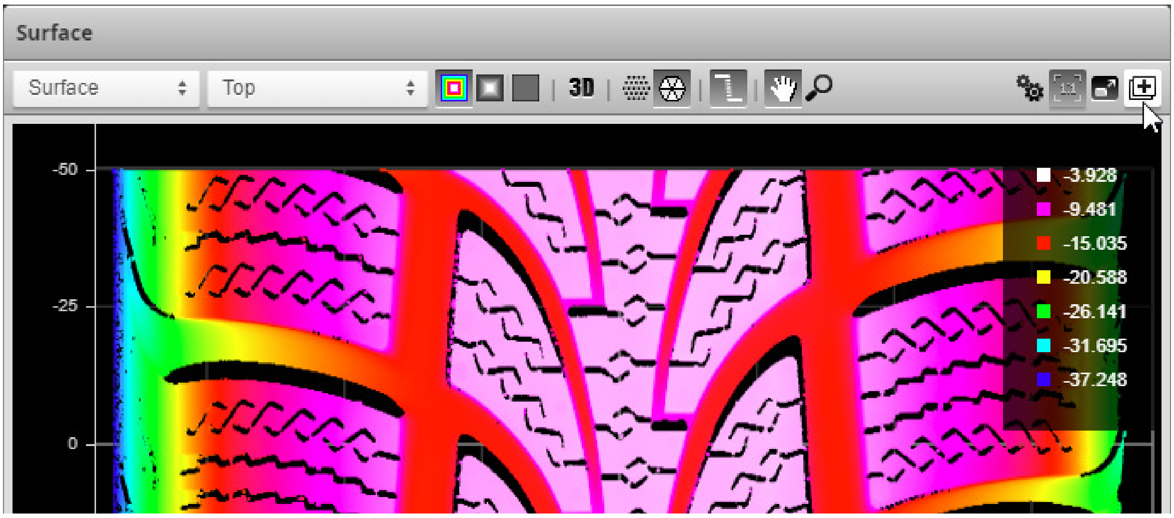


Main view in original browser window showing surface data and a defined section,
and a second window showing a Profile tool running on the section.
The Model page is selected in the Main view to show
where the section is defined on the surface data.

External data viewer windows provide the same functions as the Main View data viewer via the toolbar above the viewer (except for the ability to open a new window). External windows also include a Displayed Outputs panel at the bottom and support the pinning of outputs; pinning in external windows is independent from the Main View data viewer and other external windows. For more information on pinning outputs, see 📖 "4.7.5 Pinning Measurements and Features" on page 281.

To open a new external data viewer window:

1 In the toolbar of the Main View data viewer, click the New Data Viewer button ( ).



A new window opens containing a separate data viewer.

Use the tool bar at the top of the new data viewer to choose and modify the view (Surface vs. section data, color heightmap vs. intensity, 2D vs. 3D, etc.). For more information, see "4.4.8 Data Viewer" on page 156.

Pin outputs to the new data viewer as in the Main View data viewer. For more information, see "4.7.5 Pinning Measurements and Features" on page 281. Any outputs pinned in the Main View when you open a new data viewer window appear already pinned in the new window, but pinning in data viewers is otherwise independent.

4.7.3 Tools Panel

The [Tools] panel lets you add, configure, and manage measurement tools. Tools contain related measurements. For example, the Dimension tool provides Height, Width, and other measurements.

You can also add and remove tools, and connect tool and sensor outputs to tool inputs from within the Tools Diagram panel. The Tools Diagram panel helps make working with complex applications much more easy, but you configure a tool's main parameters from within the Tools panel. For more information on the Tools Diagram panel, see 📖 "4.7.4 Working with the Tools Diagram" on page 263.

Some settings apply to tools, and therefore to all measurements; these settings are found in the [Parameters] tab below the list of tools. Other settings apply to specific measurements, and are found in a [Parameters] tab below the list of measurements; not all measurements have parameters.

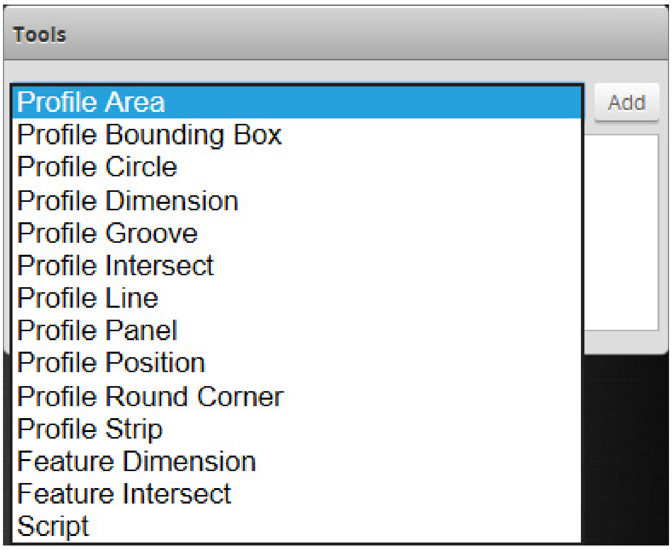
See 📖 "5 Profile Measurement" on page 343 and 📖 "6 Surface Measurement" on page 419 for information on the measurement tools and their settings.

Tips

Tool names in the user interface include the scan mode, but not in the manual. So for example, you will see "Profile Area" or "Surface Bounding Box" in the user interface, but simply "Area" or "Bounding Box" in the manual.

■ Adding and Configuring a Measurement Tool

Adding a tool adds all of the tool's measurements to the [Tools] panel. You can then enable and configure the measurements selectively.



To add and configure a tool:

1. **Go to the [Scan] page by clicking on the [Scan] icon.**
2. **Choose Profile or Surface mode in the [Scan Mode] panel.**

   If one of these modes is not selected, tools will not be available in the [Measure] panel.
3. **Go to the [Measure] page by clicking on the [Measure] icon.**
4. **In the Tools panel, select the tool you want to add from the drop-down list of tools.**
5. **Click on the [Add] button in the Tools panel.**

   The tool and its available measurements are added to the tool list. The tool parameters are listed in the area below the tool list.
6. **(Optional) If you are running a dual-sensor system, choose the sensor that will provide data to the measurement tool in [Source].**

   For more information on sources, see 📖"●Source" on page 238.
7. **(Optional) If the measurement is a profile measurement running on a section, and you have created more than one section, choose the section that will provide data to the measurement in [Stream].**

   For more information on streams, see 📖 "●Stream" on page 236.
8. **Select a measurement at the bottom of the tool panel.**

9 Set any tool- or measurement-specific settings.

For tool- and measurement-specific settings, see the topics for the individual profile or surface tools.

10 Set the [Min] and [Max] decision values.

For more information on decisions, see "●Decisions" on page 251.

11 (Optional) Set one or more filters.

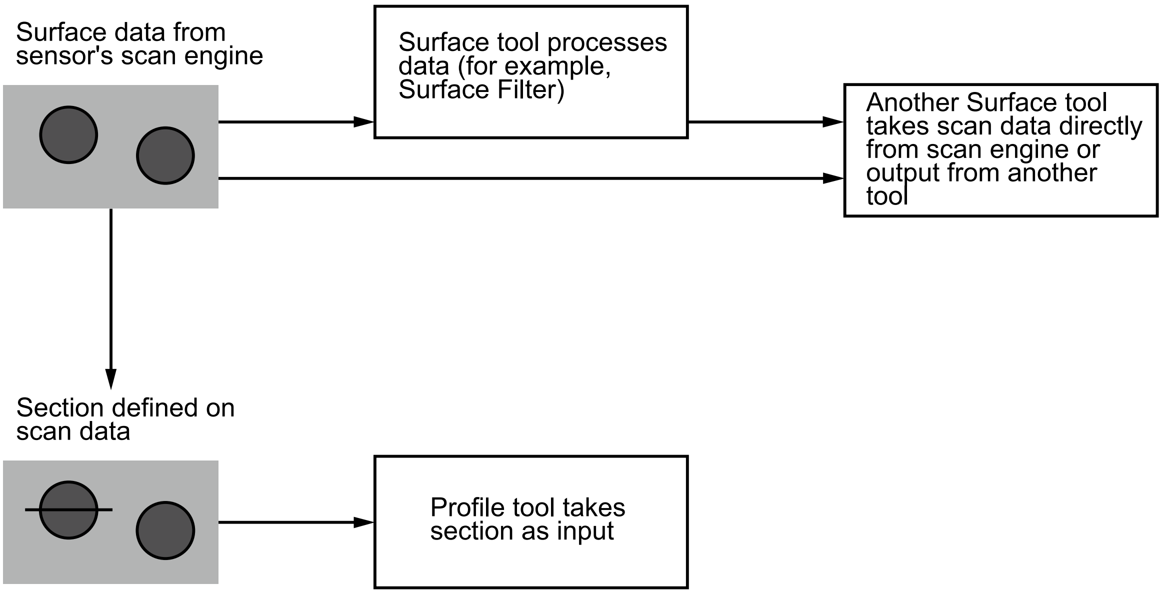
For more information on filters, see "●Filters" on page 253.

12 (Optional) Set up anchoring.

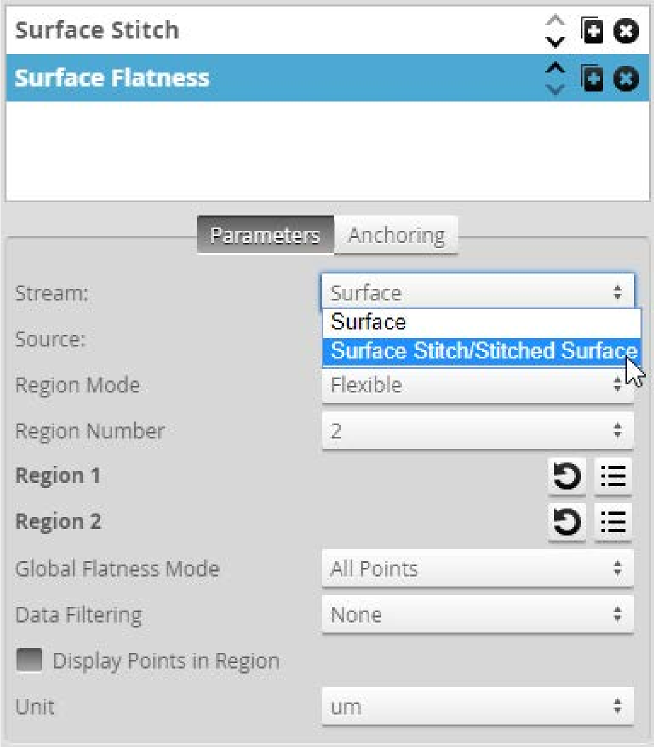
For more information on anchoring, see "●Measurement Anchoring" on page 254.

● Stream

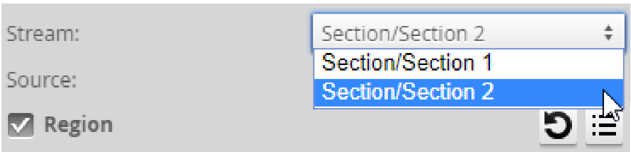
It's possible for more than one type of data to be available for a tool as input. You use the [Stream] drop-down in a tool to choose which type. If only one type of data is available for a tool, the [Stream] drop-down may not be displayed.



For example, many tools can produce processed surface data (such as the Stitched Surface output from the Surface Stitch tool, or the Corrected Surface output from the Surface Vibration Correction tool). When you have added one of these tools, the tool's data output is listed in the [Stream] drop-down, as well as the data that comes directly from the sensor's scanning engine. Surface data coming directly from the sensor's scan engine is always called "Surface" in the [Stream] drop-down. Profile data coming directly from the sensor's scan engine is always called "Profile/Merged" in the [Stream] drop-down. For data that comes from another tool, the convention is {Tool name}/{Data output name}:



[Sections](#) are also listed in the [Stream] setting.



To choose a stream:

1 Go to the [Measure] page by clicking on the [Measure] icon.

> **Tips**
> The [scan mode](#) must be set to the type of measurement you need to configure. Otherwise, the wrong tools, or no tools, will be listed on the [Measure] page.

2 In the [Tools] panel, click on a tool in the tool list.

3 If it is not already selected, click the [Parameter] tab in the tool configuration area.

4 Select the data in the [Stream] drop-down list.

- Source

For dual- or multi-sensor systems, you must specify which sensor, or combination of sensors, provides data for a measurement tool.

Tips

The [Source] setting applies to all of a tool's measurements.

Depending on the layout you have selected, the [Source] drop-down will display one of the following (or a combination). For more information on layouts, see "4.3.3 Layout" on page 96.

Setting	Description
[Top]	The Main sensor in a standalone system. In a dual-sensor system, refers to the Main sensor in Opposite layout, or to the combined data from both the Main and Buddy sensors. In a multi-sensor system, refers to the combined data from all sensors in the top row of the layout grid.
[Bottom]	The Buddy sensor in Opposite layout in a dual-sensor system. In a multi-sensor system, refers to the combined data from all sensors in the bottom row of the layout grid.
[Top & Bottom]	In a dual-sensor system, refers to the combined data from the Main and Buddy sensor. In a multi-sensor system, refers to the combined data from all sensors in the top and bottom row of the layout grid.

To select the source:

1 **Go to the [Measure] page by clicking on the [Measure] icon.**

Tips

The scan mode must be set to the type of measurement you need to configure. Otherwise, the wrong tools, or no tools, will be listed on the [Measure] page.

2 **In the [Tools] panel, click on a tool in the tool list.**

3 **If it is not already selected, click on the [Parameter] tab in the tool configuration area.**

4 **Select the profile source in the [Source] drop-down list.**

- Regions

Many measurement tools use user-defined regions to limit the area in which measurements occur or to help in the identification of a feature ("●Feature Points" on page 247), a fit line ("●Fit Lines" on page 251), or left or right side of the Panel tool (see "5.16 Panel" on page 397). Unlike reducing the active area, reducing the measurement region does not increase the maximum frame rate of the sensor.

Tips

You can disable regions and force a tool to use the entire active area by unchecking the checkbox next to the [Regions] setting. For more information on active area, see "■Active Area" on page 124.

All tools provide region settings under the upper, tool-level [Parameters] tab. This region applies to all of a tool's measurements. Region settings are sometimes found within expandable feature sections in a tool's panel.

Some of Mitutoyo's more recent tools provide "flexible" regions, which in addition to rectangular regions let you create circular and elliptical regions (which can optionally be annular) and polygon regions. These tools also let you use Surface and Surface Intensity data as masks. As of this writing, the following tools have flexible regions:

- Surface Direction Filter
- Surface Filter
- Surface Flatness
- Surface Mask
- Surface OCR
- Surface Segmentation

Other tools are currently limited to rectangular regions. However, you can get "flexible regions" in a tool that doesn't directly support them by using the Surface Mask tool, and using that tool's output as the other tool's input. For more information, see "6.20 Mask" on page 528.

For information on setting "flexible" regions, see "Flexible Regions" on page 240.

> **Tips**
> In 2D mode, the tool region defaults to the center of the current data view, not the global field of view. In 3D mode, the region defaults to the global field of view.

Use the region reset button ( ) to set the size of a region to its default. This is useful after zooming in or out in the data viewer.

Standard Regions

The standard regions are limited to rectangles or boxes.

To configure standard regions:

1 **Go to the [Measure] page by clicking on the [Measure] icon.**

> **Tips**
> The scan mode must be set to the type of measurement you need to configure. Otherwise, the wrong tools, or no tools, will be listed on the [Measure] page.

2 **In the [Tools] panel, click on a tool in the tool list.**

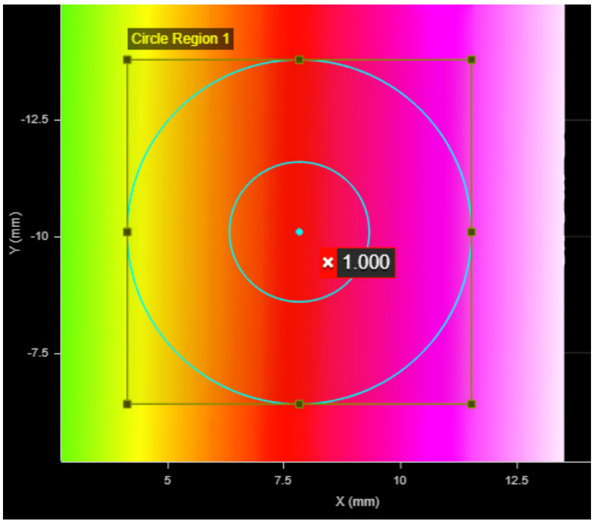
3 **Configure the region using the mouse in the data viewer.**

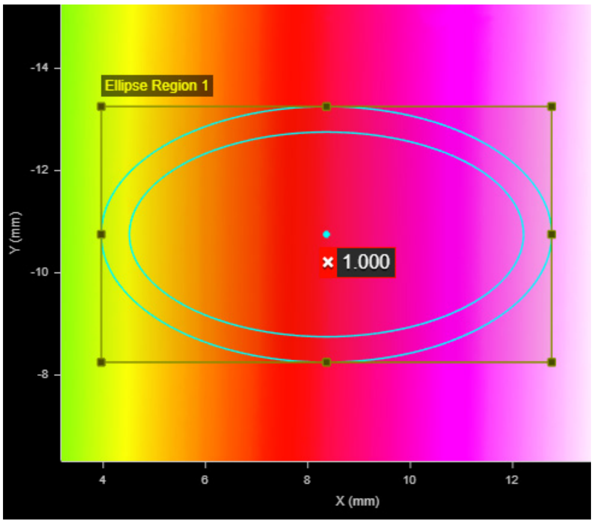
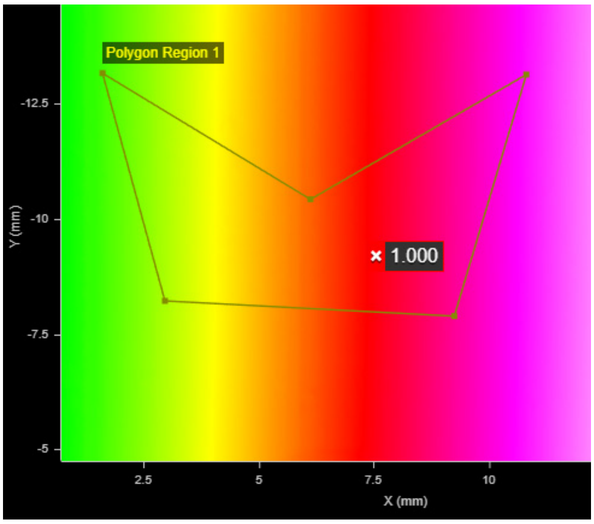
You can also configure regions manually by clicking the expand button ( ) and entering values in the fields. This is useful if you need to set precise values.

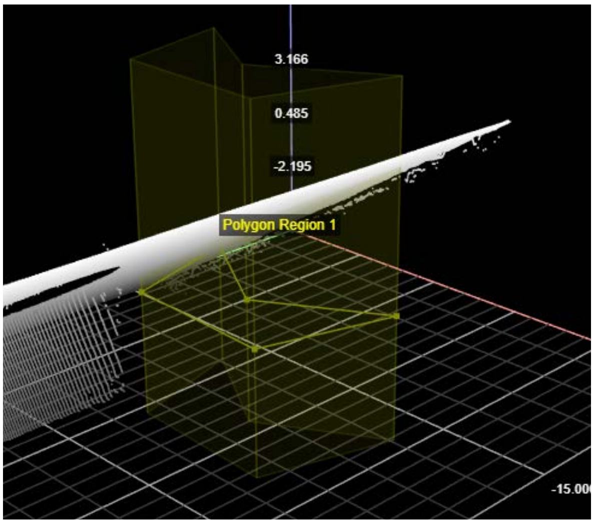
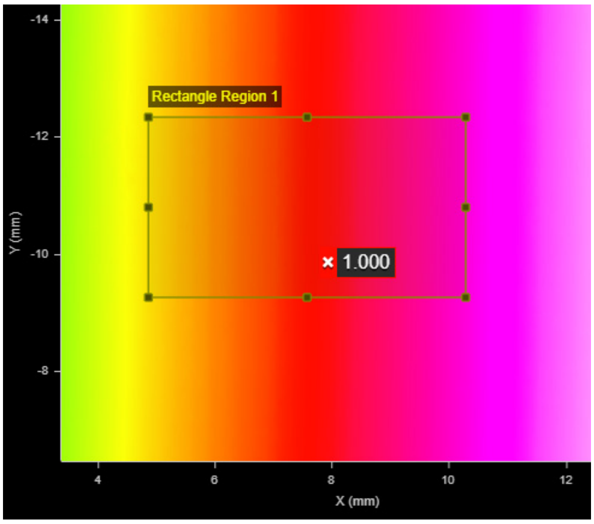
Flexible Regions

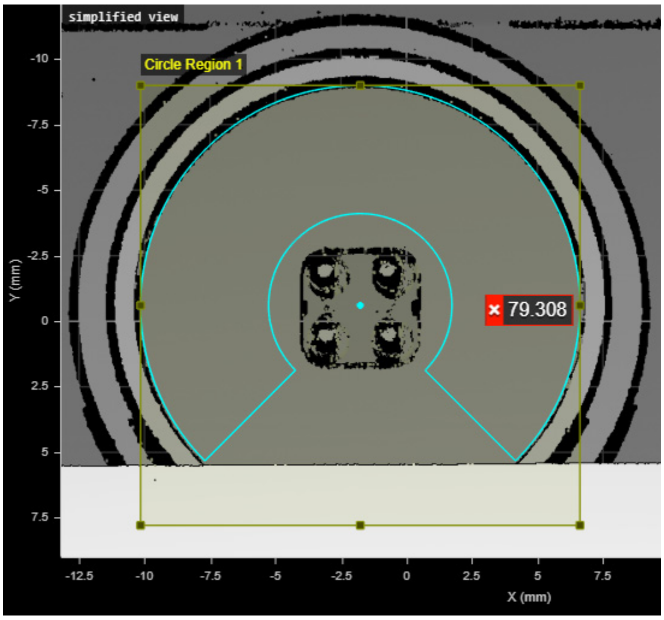
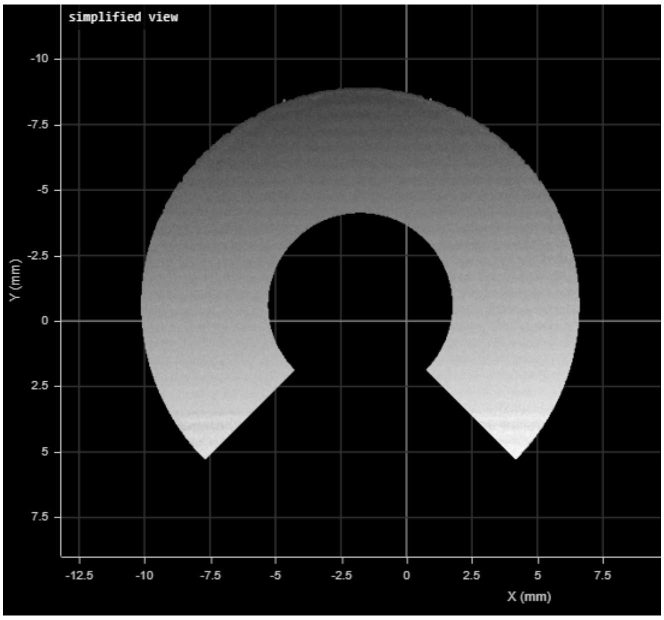
The following parameters are available in tools that support flexible regions

Flexible Region Parameters

Parameter	Description
Number of Regions	The number of regions the tool uses to extract surface data. You can define up to 15 or 16 regions. This parameter is not available in some tools. When you specify more than one region, the regions are initially stacked on top of one another, in the same location.
[Mask Type {n}] [Region Type {n}]	For each mask (in the Surface Mask tool) or region, the type. Regions can overlap. One of the following. (For more information on the settings you use with the Circle and Ellipse types, see "Working with Circular and Elliptical Regions" on page 244. [Circle] Extracts a circular region from the surface data, constrained by a square region. Set the region's inner circle (inner cyan circle below) using the [Inner Circle Diameter] parameter to extract annular data. Use the [Sector Start Angle] and [Sector Angle Range] settings to extract a partial circular or elliptical region. 

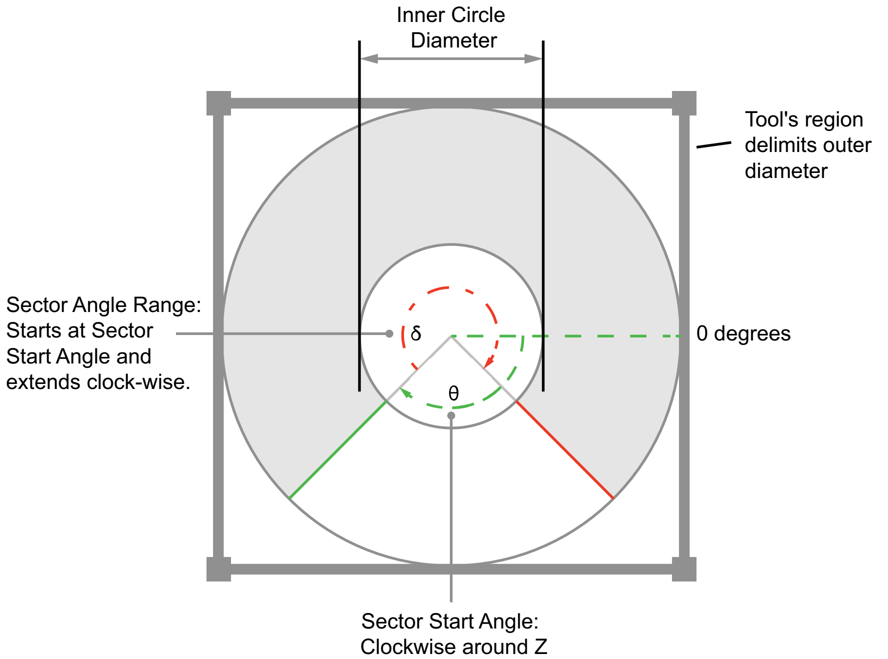
Parameter	Description
	[Ellipse] Extracts an elliptical region from the surface data, constrained by a square or rectangular region. Set the region's inner ellipse (inner cyan ellipse below) using the [Inner Ellipse Major Axis] and [Inner Ellipse Minor Axis] parameters to extract annular data. Use the [Sector Start Angle] and [Sector Angle Range] settings to extract a partial circular or elliptical region.  [Polygon] Extracts a polygonal region with the number of vertices specified in [Vertex Count]. You can define the shape of the polygon using a mouse in the data viewer, dragging and dropping the vertex points. 

Parameter	Description
	Note that you can't adjust the height of a polygon region: it occupies the entire vertical space available:  [Rectangle] Extracts a rectangular region from the surface data.  [Surface] Uses the Surface data you select in [Mask Source] to create a mask. [Surface Intensity] Uses the intensity data you select in [Mask Source] to create a mask. Set the [Low Threshold] and [High Threshold] parameters as required.
[Inner Circle Diameter]	Only available when [Region Type {n}] is set to [Circle]. Defines the diameter of the inner circle. Set this parameter to a value greater than 0 to extract a ring of data. Set this parameter to 0 to extract a circle of data.
[Inner Ellipse Major Axis] [Inner Ellipse Minor Axis]	Only available when [Region Type {n}] is set to [Ellipse]. These parameters define the major and minor axes of the inner ellipse, respectively Set this parameter to a value greater than 0 to extract a ring of data. Set this parameter to 0 to extract an elliptical disk of data.

Parameter	Description
[Sector Start Angle] [Sector Angle Range]	Only available when [Region Type {n}] is set to [Circle or Ellipse] Use these parameters together to extract a partial ring of data. [Sector Start Angle] controls the starting angle of the data, whereas [Sector Angle Range] controls the length of the arc. Note that the angles and ranges in these parameters are measured clockwise around Z, where 0 degrees is along the positive X axis. For example, in the first image below, [Sector Start Angle] is set to 135, and [Sector Angle] Range is set to 270. The resulting extracted partial ring (or annular data) is shown below that.   For more information on how these settings work together, see "Working with Circular and Elliptical Regions" on page 244.
[Mask Source]	Only available when [Region Type {n}] is set to [Surface] or [Surface Intensity]. The Surface or Surface Intensity data the tool uses to create a mask.
[Low Threshold] [High Threshold]	Only available when [Region Type {n}] is set to [Surface Intensity]. The low and high thresholds the tool uses in combination with the intensity mask.

Working with Circular and Elliptical Regions

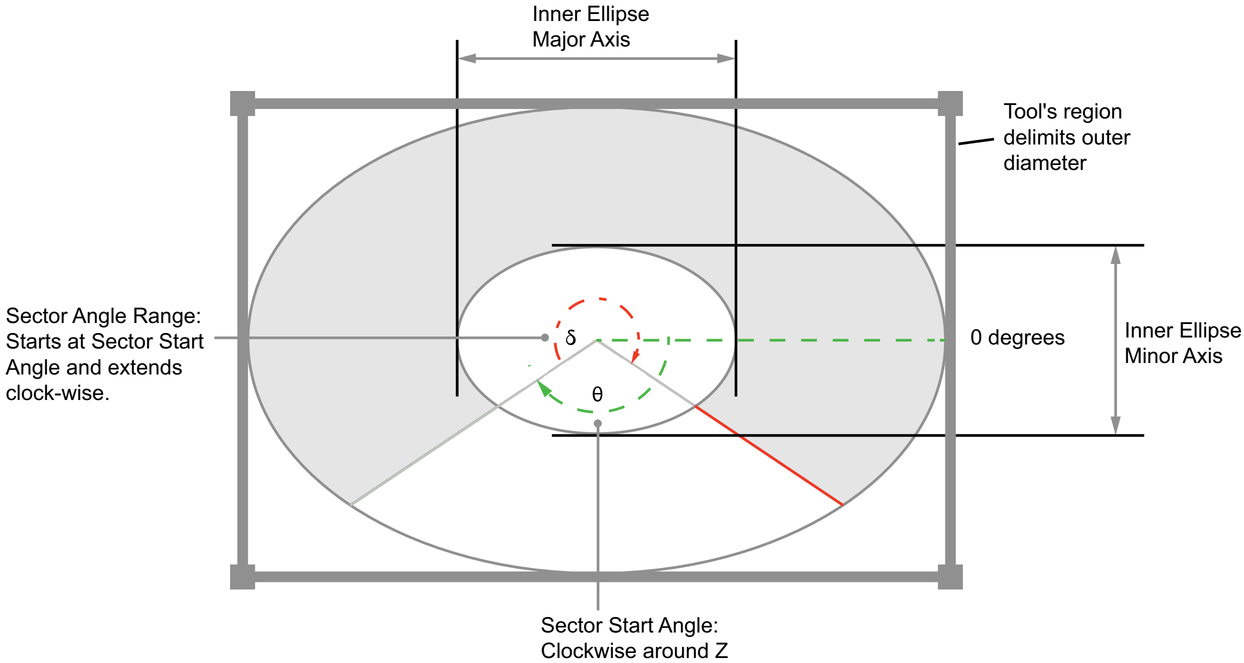
When you set a region's type to Circle or Ellipse, the tool displays several additional settings that work together to define the region. [Sector Start Angle] and [Sector Angle Range] work together to define the start and end of a partial circular/elliptical region (solid or annular). A region will be annular if [Inner Circle Diameter] is non-zero. Note that the "length" of the partial region extends from the start angle. In the following illustration, the start angle (θ) is 135 degrees relative to the 0-degree point indicated below, and the region extends 270 degrees (δ) from that, clockwise around Z.



Sector Start Angle starts at the 0-degree point around Z.

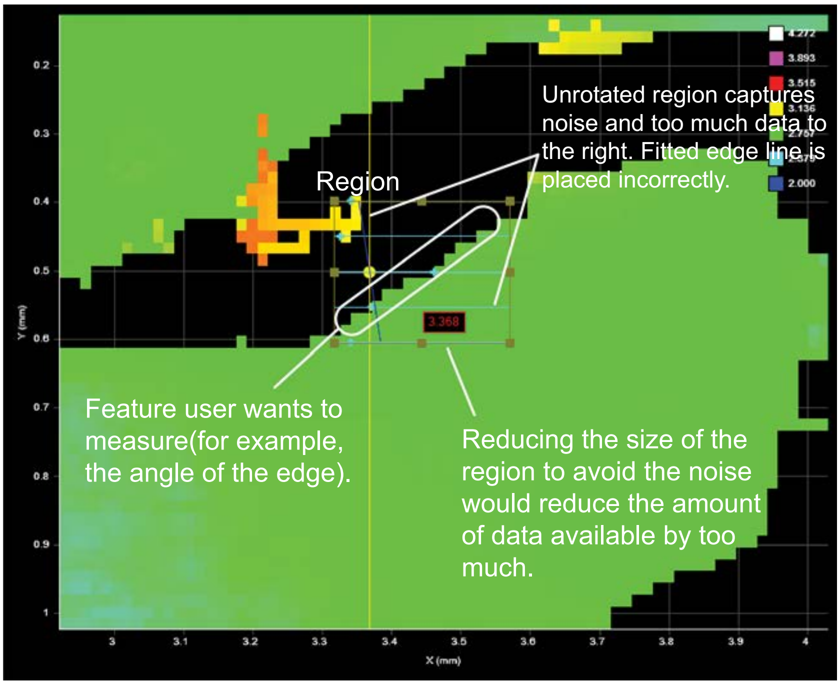
Note that the angles defining a partial circular/elliptical region are relative to the region, and not the sensor's coordinate system. So a region rotated 30 degrees using its [Z Angle] setting rotates the start angle and angle range by 30 degrees.

When you set a region type to Ellipse, instead of the inner circle diameter, you must set the major and minor axes of the inner ellipse.



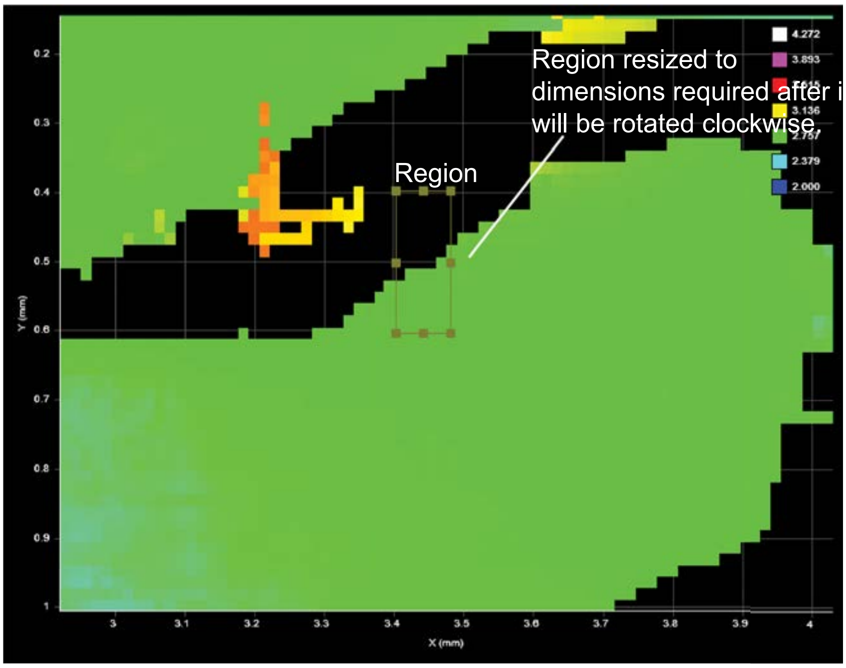
Region Rotation

The measurement region of some tools can be rotated by setting the region's [Z Angle] to better accommodate features that are on an angle on a target. By rotating the measurement region, data not related to the feature can often be excluded, improving accuracy of measurements.



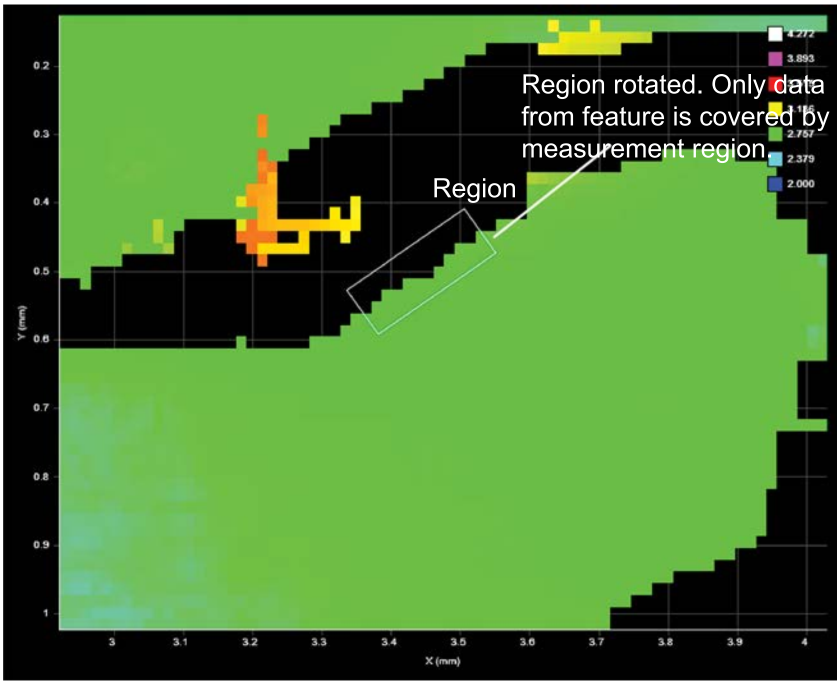
To rotate measurement regions:

1 Determine the length and width of the region that will be required once it is rotated.



2 Expand the [Region] setting and then set a value in [Z Angle].

The region rotates clockwise around the Z axis relative to the X axis.



Once the region has been rotated, you can modify its size and location in the data viewer using the mouse. You can also modify its dimensions and its location manually by changing the region's values in the [Region] setting.

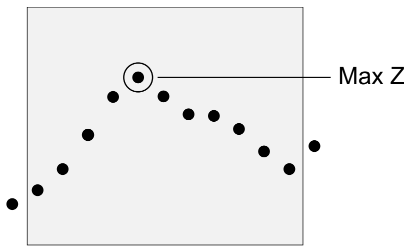
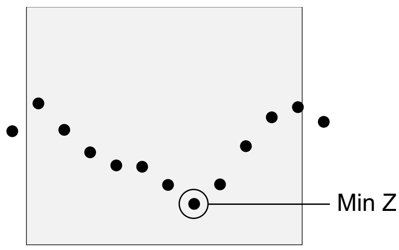
Tips

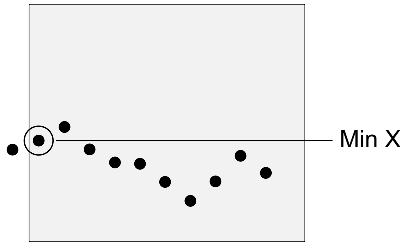
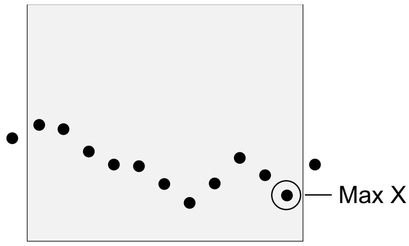
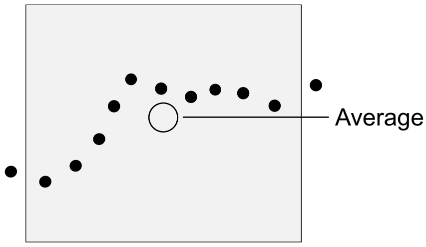
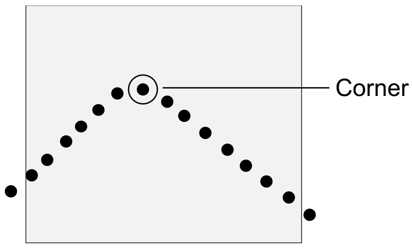
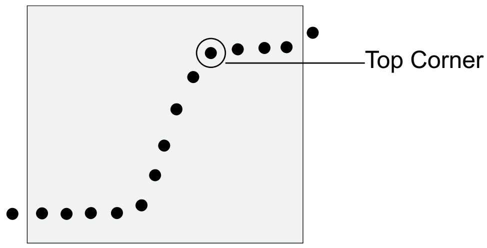
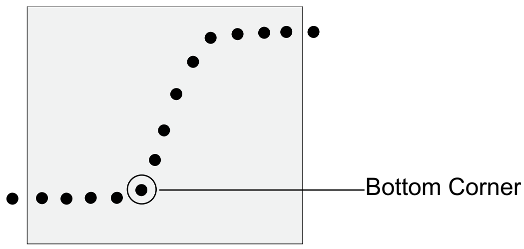
Some tools let you disable regions entirely and force the measurement tool to use the entire active area by unchecking the checkbox next to the [Regions] setting. For more information on active area, see 📖 "■Active Area" on page 124.

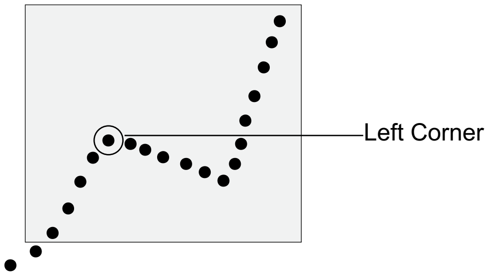
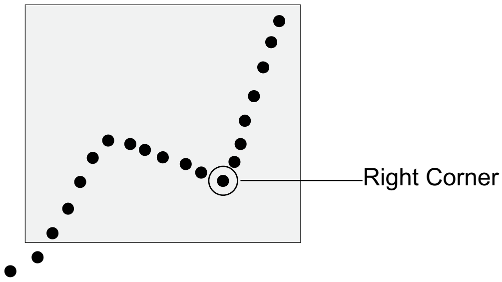
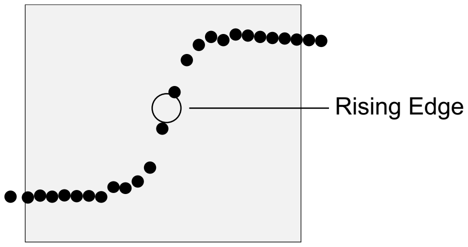
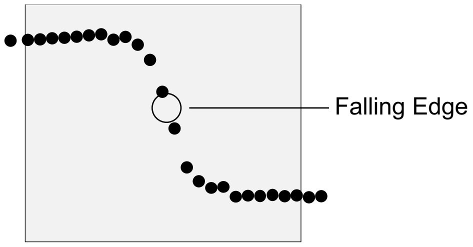
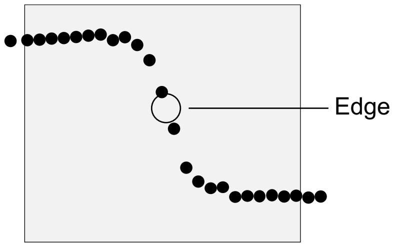
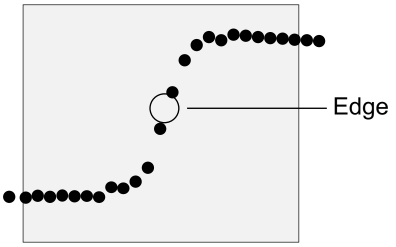
● Feature Points

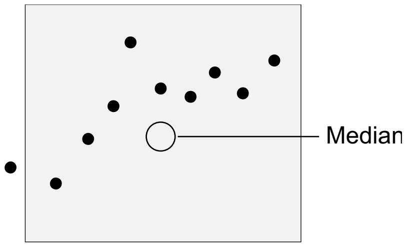
Dimensional and positional measurements detect feature points found within the defined measurement region and then compare measurement values taken at the selected point with minimum and maximum thresholds to produce a decision. Feature points are selected in one or more [Feature] dropdowns in a tool and are used for all of the tool's measurements.

The following types of points can be identified in a measurement region.

Point Type	Examples
[Max Z] Finds the point with the maximum Z value in the region of interest.	
[Min Z] Finds the point with the minimum Z value in the region of interest.	

Point Type	Examples
[Min X] Finds the point with the minimum X value in the region of interest.	
[Max X] Finds the point with the maximum X value in the region of interest.	
[Average] Determines the average location of points in the region of interest.	
[Corner] Finds a dominant corner in the region of interest, where corner is defined as a change in profile slope.	
[Top Corner] Finds the top-most corner in the region of interest, where corner is defined as a change in profile shape.	
[Bottom Corner] Finds the bottom-most corner in the region of interest, where corner is defined as a change in profile shape.	

Point Type	Examples
[Left Corner] Finds the left-most corner in the region of interest, where corner is defined as a change in profile shape.	
[Right Corner] Finds the right-most corner in the region of interest, where corner is defined as a change in profile shape.	
[Rising Edge] Finds a rising edge in the region of interest (moving from left to right).	
[Falling Edge] Finds a falling edge in the region of interest (moving from left to right).	
[Any Edge] Finds a rising or falling edge in the region of interest.	 

Point Type	Examples
[Median] Determines the median location of points in the region of interest.	

Geometric Features

Most Surface tools, and many Profile tools, can output features that Feature tools can take as input to produce measurements. These features are called geometric features. Feature tools use these entities to produce measurements based on more complex geometry. (For more information on Feature tools, see "4.7.9 Feature Measurement" on page 301.)

SurfaceMeasure1008S's measurement tools can currently generate the following kinds of geometric features:

[Points]: A 2D or 3D point. Can be used for point-to-point or point-to-line measurements.

[Lines]: A straight line that is infinitely long. Useful for locating the orientation of an enclosure or part, or to intersect with another line to form a reference point that can be consumed by a Feature tool.

[Planes]: A plane extracted from a surface. Can be used for point-to-plane distance or line-plane intersection measurements.

[Circles]: A circle extracted from a sphere.

The following tables list the tools that can generate geometric features. (Tools that can't generate geometric features are excluded.)

Geometric features generated by Surface tools

Tool	Point	Line	Plane	Circle
Bounding Box	X			
Countersunk Hole	X			
Edge	X	X		
Ellipse	X	X		
Hole	X			
Opening	X			
Plane			X	
Position	X			
Segmentation	X			
Sphere	X			X
Stud	X			
Volume				

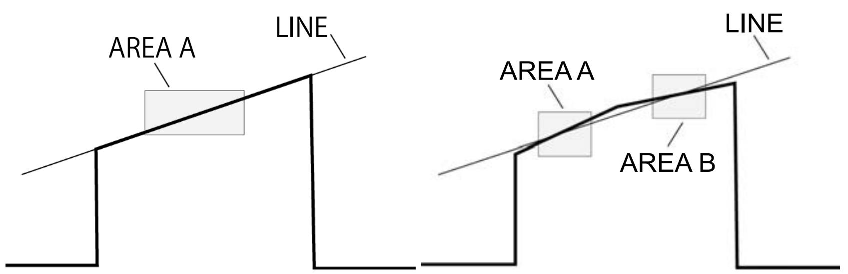
Geometric features generated by Profile tools

Tool	Point	Line
Area	X	
Bounding Box	X	
Circle	X	
Intersect	X	X
Line	X	X
Position	X	

The Feature Intersect tool can also produce an intersect point. Script tools do not currently take geometric features as input.

- Fit Lines

Some measurements involve estimating lines in order to measure angles or intersection points. A fit line can be calculated using data from either one or two fit areas.

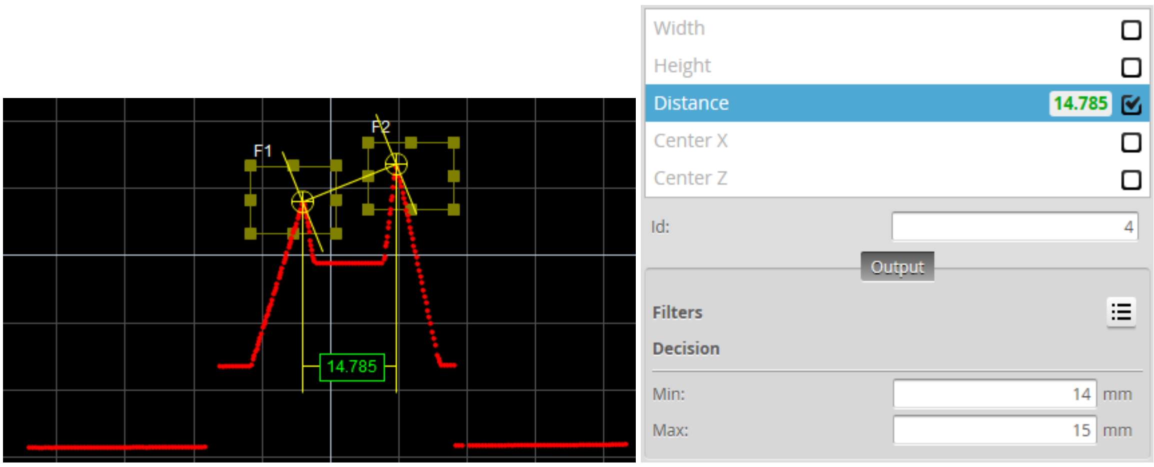


A line can be defined using one or two areas. Two areas can be used to bypass discontinuity in a line segment.

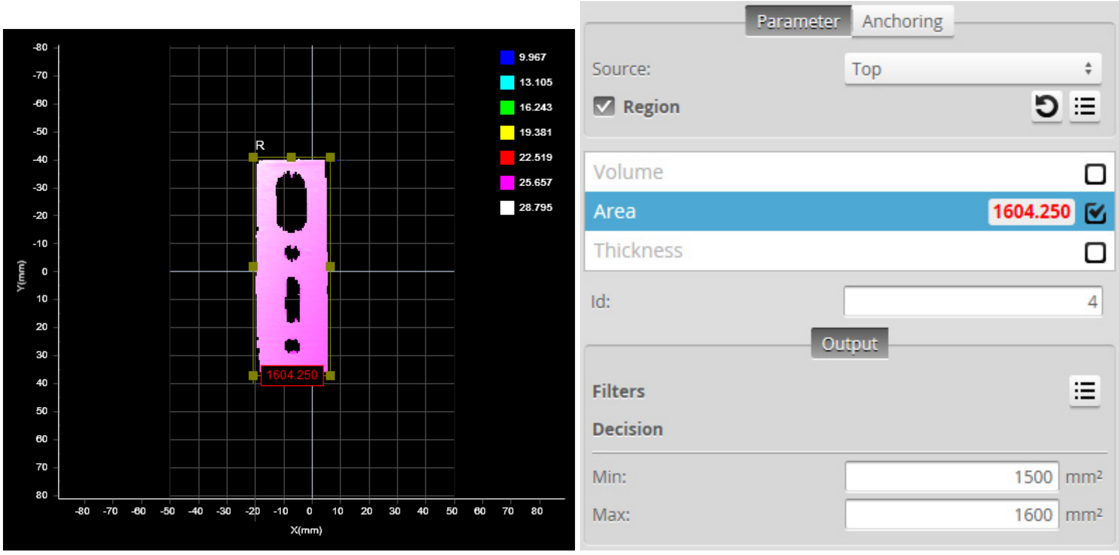
- Decisions

Results from a measurement can be compared against minimum and maximum thresholds to generate pass / fail decisions. The decision state is pass if a measurement value is between the minimum and maximum threshold. In the data viewer and next to the measurement, these values are displayed in green. Otherwise, the decision state is fail. In the user interface, these values are displayed in red.

All measurements provide decision settings under the [Output] tab.



Value (14.785) within decision thresholds (Min: 14, Max: 15). Decision: Pass



Value (1604.250) outside decision thresholds (Min: 1500, Max: 1600). Decision: Fail

Along with measurement values, decisions can be sent to external programs and devices. In particular, decisions are often used with digital outputs to trigger an external event in response to a measurement. See 📖 "4.8 Output" on page 326 for more information on transmitting values and decisions.

To configure decisions:

1 Go to the [Measure] page by clicking on the [Measure] icon.

> **Tips**
> The scan mode must be set to the type of measurement you need to configure. Otherwise, the wrong tools, or no tools, will be listed on the [Measure] page.

2 In the [Tools] panel, click on a tool in the tool list.

3 In the measurement list, select a measurement.

To select a measurement, it must be enabled. See 📖 "■Enabling and Disabling Measurements" on page 259 for instructions on how to enable a measurement.

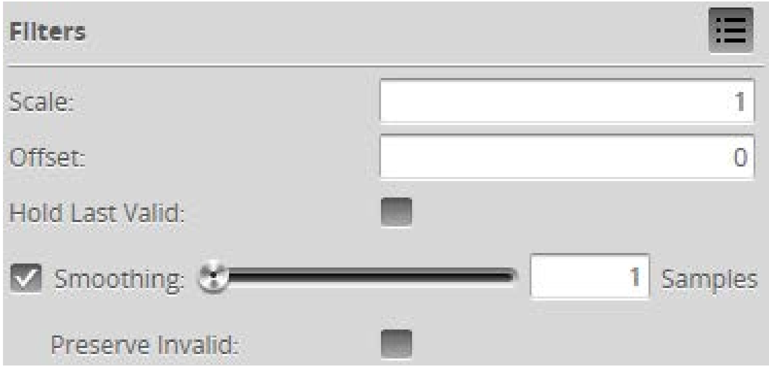
4 Click on the [Output] tab.

For some measurements, only the [Output] tab is displayed.

5 Enter values in the [Min] and [Max] fields.

- Filters

Filters can be applied to measurement values before they are output from the sensors.



All measurements provide filter settings under the [Output] tab. The following settings are available.

Filter	Description
Scale and Offset	The [Scale] and [Offset] settings are applied to a measurement value according to the following formula: Scale * Value + Offset [Scale] and [Offset] can be used to transform the output without the need to write a script. For example, to convert the measurement value from millimeters to thousands of an inch, set [Scale] to 39.37. To convert from radius to diameter, set [Scale] to 2. For more information on scripts, see "4.7.10 Scripts" on page 321.
Hold Last Valid	Holds the last valid value when the measurement is invalid.
Smoothing	Averages the valid measurements in the number of preceding frames specified in [Samples]. Use this to reduce the impact of random noise on a measurement's output. If [Hold Last Valid] is enabled, the smoothing filter uses the last valid measurement value until a valid value is encountered.
Preserve Invalid	When enabled, smoothing is only applied to valid measurements and not to invalid results: invalid results are not modified and are sent to output as is. When disabled, smoothing is applied to both valid and invalid results. (This setting is only visible when [Smoothing] is enabled.) If [Hold Last Valid] is enabled, results will always be valid, in which case this setting does nothing.

To configure the filters:

1 Go to the [Measure] page by clicking on the [Measure] icon.

> **Tips**
> The scan mode must be set to the type of measurement you need to configure. Otherwise, the wrong tools, or no tools, will be listed on the [Measure] page.

2 In the [Tools] panel, click on a tool in the tool list.

3 In the measurement list, select a measurement.

To select a measurement, it must be enabled. See "■Enabling and Disabling Measurements" on page 259 for instructions on how to enable a measurement.

4 Click on the [Output] tab.

For some measurements, only the [Output] tab is displayed.

5 Expand the [Filters] panel by clicking on the panel header or the ⊕ button.

6 Configure the filters.

Refer to the table above for a list of the filters.

- Measurement Anchoring

When parts that a sensor is scanning move on a transport mechanism such as a conveyor, their position typically changes from part to part in one or both of the following ways:

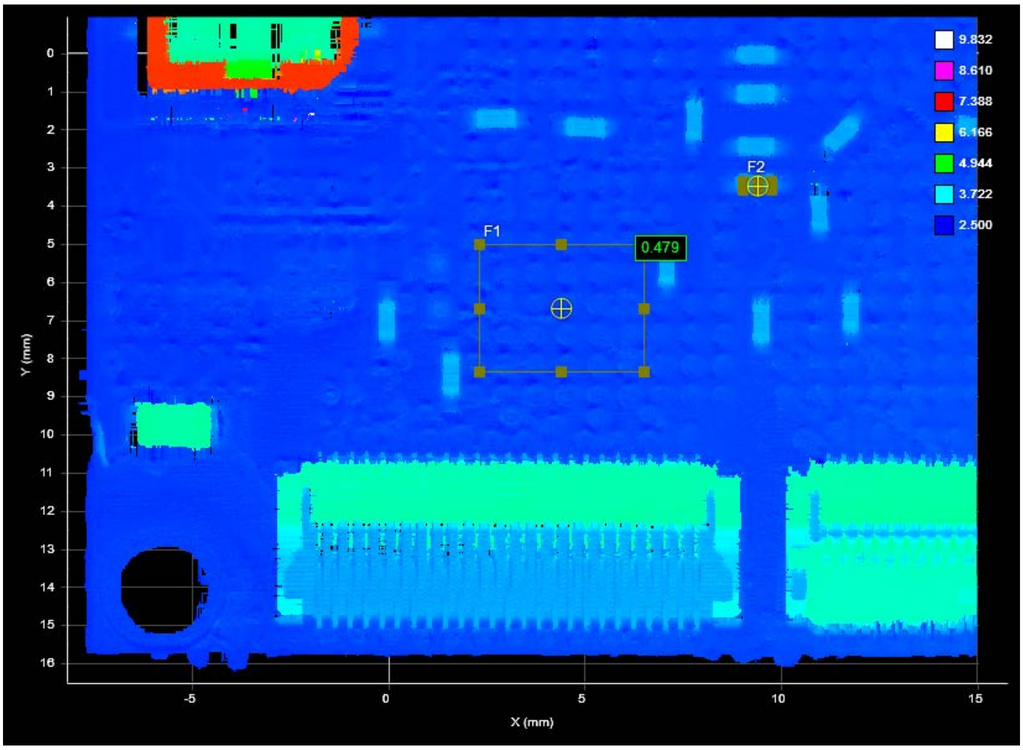
- along the X, Y, and Z axes (basically, horizontally and vertically)
- around the Z axis (orientation angle)

When the position and angle variation between parts is minor—for example, when scanning electronic parts in trays—you can anchor one tool to one or more measurements from another tool to compensate for these minor shifts. As a result, SurfaceMeasure1008S can correctly place the anchored tool's measurement regions on each part. This increases the repeatability and accuracy of measurements.

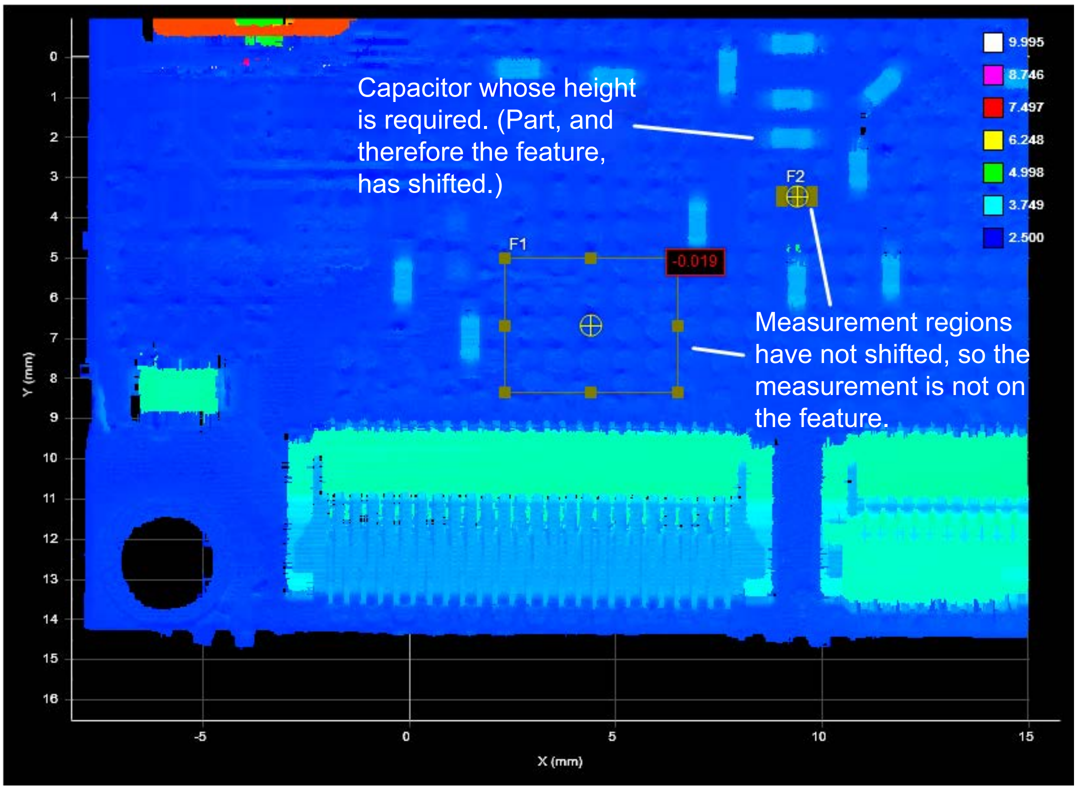
Tips

For cases where movement from part to part is more drastic, you can use part matching to compensate. However, in order for part matching to work properly, the entire part typically must be visible in the field of view.

For example, the following image shows a surface scan of a PCB. A Surface Dimension height measurement returns the height of a surface-mount capacitor relative to a nearby surface (the F1 region).

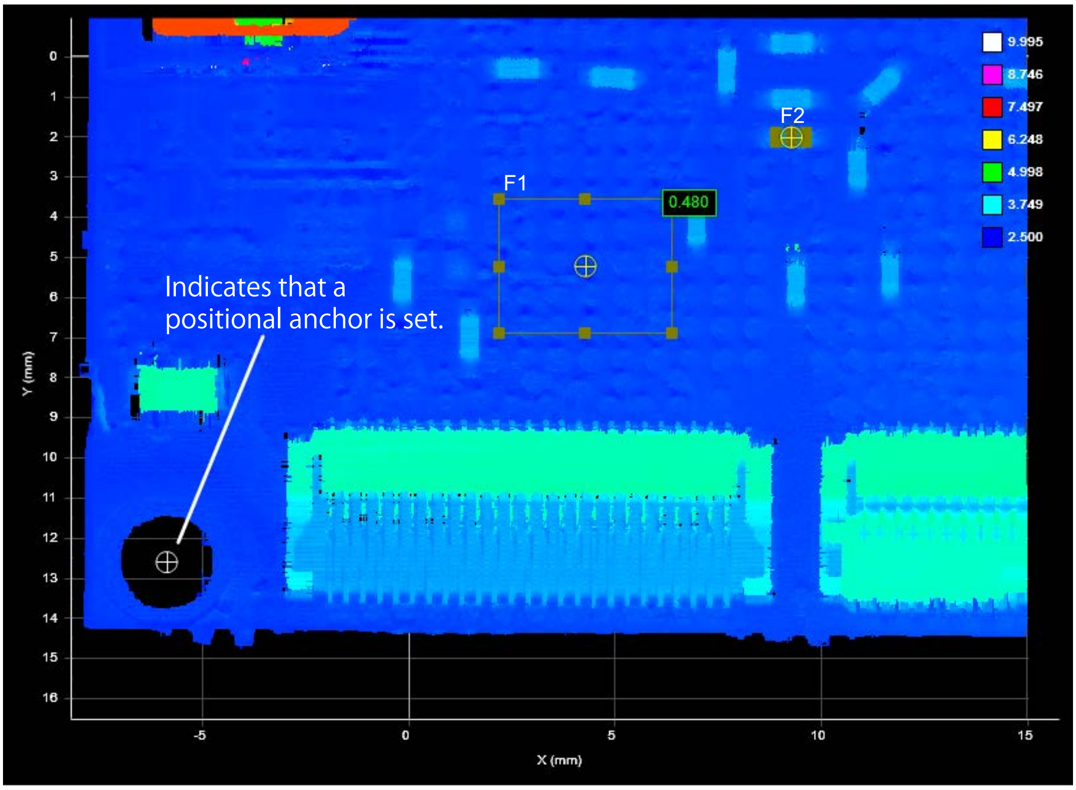


In the following scan, the part has shifted, but the measurement regions remain where they were originally configured, in relation to the sensor or system coordinate system, so the measurement returned is incorrect:

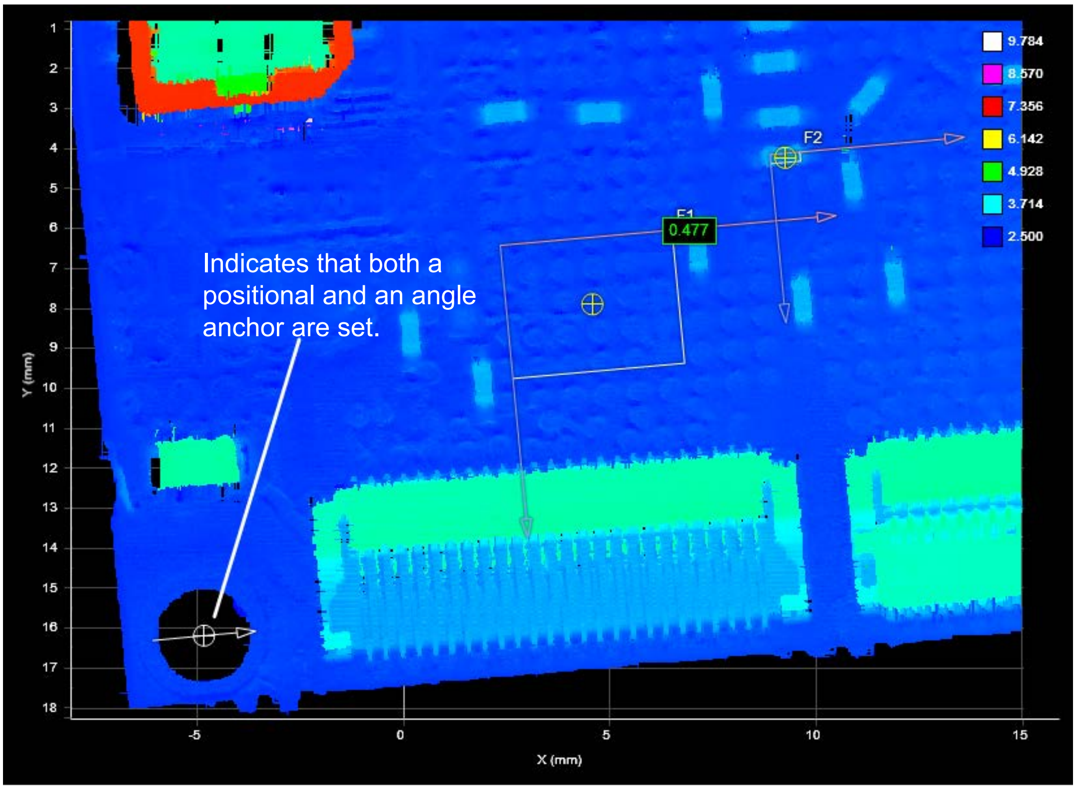


When you set a tool's anchor source, an offset is calculated between the anchored tool and the anchor source. This offset is used for each frame of scanned data: the anchored tool's measurement region is placed in relation to the anchor source, at the calculated offset.

In the following image, after the Surface Dimension tool is anchored to the X and Y measurements from a Surface Hole tool (placed over the hole to the lower left), SurfaceMeasure1008S compensates for the shift—mostly along the Y axis in this case—and returns a correct measurement, despite the shift.



You can combine the positional anchors (X, Y, or Z measurements) with an angle anchor (a Z Angle measurement) for optimum measurement placement. For example, in the following scan, the part has not only shifted on the XY plane but also rotated around the Z axis. Anchoring the Surface Dimension tool to the Z Angle measurement of a Surface Edge tool (placed on the lower edge in this case) compensates for the rotation, and the anchored tool returns a correct measurement.



Tips
If Z Angle anchoring is used with both X and Y anchoring, the X and Y anchors should come from the same tool.

Tips
If Z Angle anchoring is used without X or Y anchoring, the tool's measurement region rotates around its center. If only one of X or Y is used, the region is rotated around its center and then shifted by the X or Y offset.

Several anchors can be created to run in parallel. For example, you could anchor the measurements of one tool relative to the left edge of a target, and anchor the measurements of another tool relative to the right edge of a target.

You can combine positional anchors (X, Y, or Z) with angle anchors (Z Angle) for optimum measurement placement.

To anchor a profile or surface tool to a measurement:

1 Place a representative target object in the field of view.

In Profile mode

1. Use the [Start] or [Snapshot] button to view live profile data to help position the target.

In Surface mode

1. Select a Surface Generation type ("4.4.6 Surface Generation" on page 146) and adjust Part Detection settings (see "4.4.7 Part Detection" on page 149) if applicable.
2. Start the sensor, scan the target, and then stop the sensor.

2 On the [Measure] page, add a suitable tool to act as an anchor.

A suitable tool is one that returns an X, Y, or Z position or Z Angle as a measurement value.

3 Adjust the anchoring tool's settings and measurement region, and choose a feature type (if applicable).

You can adjust the measurement region graphically in the data viewer or manually by expanding the [Regions] area.

The position and size of the anchoring tool’s measurement regions define the zone within which movement will be tracked.

Tips
If you intend to use angle anchoring and the part in the initial scan is rotated too much, you may need to rotate the anchoring tool's region to accomodate this rotation. For more information on region rotation, see "●Regions" on page 238.

See "●Feature Points" on page 247 for more information on feature types.

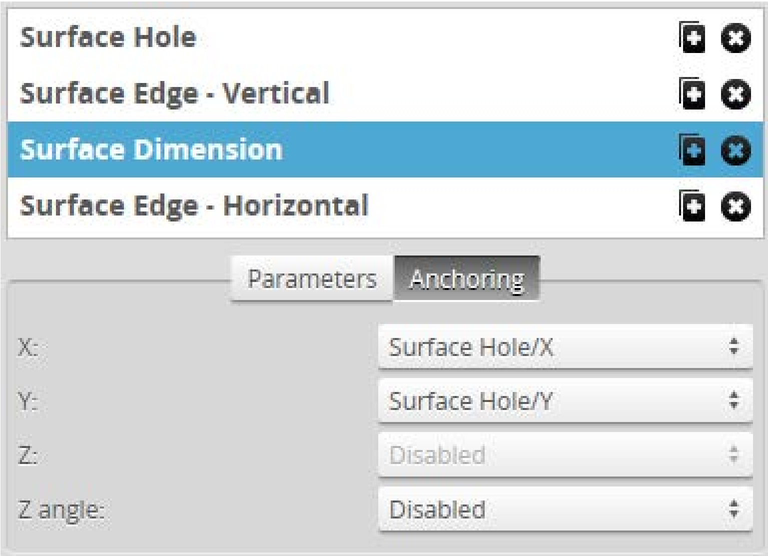
4 Add the tool that you want to anchor.

Any tool can be anchored.

5 **Adjust the tool and measurement settings, as well as the measurement regions, on a scan of the representative target.**

6 **Click on the tool's [Anchoring] tab.**

7 **Choose an anchor from one of the drop-down boxes.**



If the sensor is running, the anchored tool's measurement regions are shown in white to indicate the regions are locked to the anchor. The measurement regions of anchored tools cannot be adjusted.

The anchored tool's measurement regions are now tracked and will move with the target's position and angle under the sensor, as long as the anchoring measurement produces a valid measurement value. If the anchoring measurement is invalid, for example, if part moves outside its measurement region, the anchored tool will not show the measurement regions at all and an "Invalid-Anchor" message will be displayed in the tool panel.

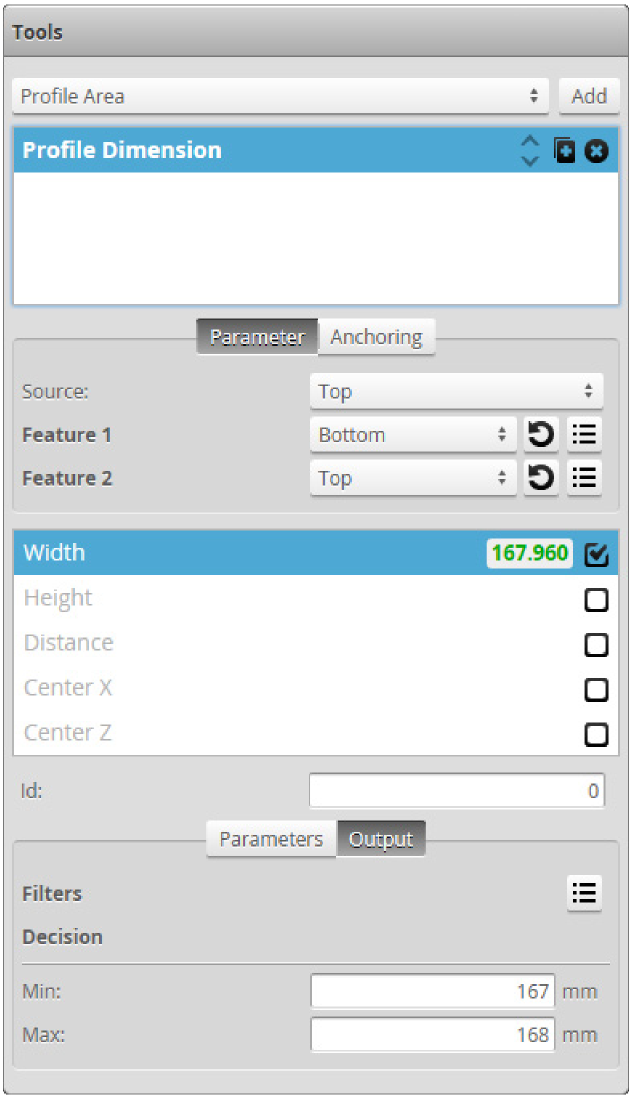
8 **Verify that the anchored tool works correctly on other scans of targets in which the part has moved slightly.**

To remove an anchor from a tool:

1 **Click on the anchored tool's Anchoring tab and select [Disabled] in the X, Y, or Z drop-down.**

Enabling and Disabling Measurements

All of the measurements available in a tool are listed in the measurement list in the [Tools] panel after a tool has been added. To configure a measurement, you must enable it.



To enable a measurement:

1 Go to the [Scan] page by clicking on the [Scan] icon.

2 Choose Profile or Surface mode in the [Scan Mode] panel.

If one of these modes is not selected, tools will not be available in the [Measure] panel.

3 Go to the [Measure] page by clicking on the [Measure] icon.

4 In the measurements list, check the box of the measurement you want to enable.

» The measurement will be enabled and selected. The [Output] tab, which contains output settings will be displayed below the measurements list. For some measurements, a [Parameters] tab, which contains measurement-specific parameters, will also be displayed.

To disable a measurement:

1. **Go to the [Scan] page by clicking on the [Scan] icon.**
2. **Choose Profile or Surface mode in the [Scan Mode] panel.**
3. **Go to the [Measure] page by clicking on the [Measure] icon.**
4. **In the measurement list, uncheck the box of the measurement you want to disable.**

   » The measurement will be disabled and the [Output] tab (and the [Parameters] tab if it was available) will be hidden.

Editing Tool, Input, or Output Names

You can change the names of tools you add in SurfaceMeasure1008S. You can also change the names of their measurements. This allows multiple instances of tools and measurements of the same type to be more easily distinguished in the SurfaceMeasure1008S web interface. The measurement name is also referenced by the Script tool.

To change a tool or measurement name:

1. **Go to the [Scan] page by clicking on the [Scan] icon.**
2. **Choose Profile or Surface mode in the [Scan Mode] panel.**

   If one of these modes is not selected, tools will not be available in the [Measure] panel.
3. **Go to the [Measure] page by clicking on the [Measure] icon.**
4. **Do one of the following:**
   - [Tool]: In the tool list, double-click the tool name you want to change
   - [Measurement]: In a tool's measurement list, double-click the measurement name you want to change.
5. **Type a new name.**
6. **Press the Tab or Enter key, or click outside the field.**

   » The name will be changed.

Changing a Measurement ID

The measurement ID is used to uniquely identify a measurement in the SurfaceMeasure1008S protocol or in the SDK. The value [must] be unique among all measurements.

To edit a measurement ID:

1. **Go to the [Scan] page by clicking on the [Scan] icon.**
2. **Choose Profile or Surface mode in the [Scan Mode] panel.**

   If one of these modes is not selected, tools will not be available in the [Measure] panel.
3. **Go to the [Measure] page by clicking on the [Measure] icon.**

4 **In the measurement list, select a measurement.**

To select a measurement, it must be enabled. See 📖 "■Enabling and Disabling Measurements" on page 259 for instructions on how to enable a measurement.

5 **Click in the ID field.**

6 **Type a new ID number.**

The value must be unique among all measurements.

7 **Press the Tab or Enter key, or click outside the ID field.**

» The measurement ID will be changed.

■ Duplicating a Tool

You can quickly create a copy of a previously added tool in SurfaceMeasure1008S. All settings of the original are copied. This is useful, for example, when you need almost identical tools with only minor variations, such as different Min and Max values.

To duplicate a tool:

1 **Go to the [Scan] page by clicking on the [Scan] icon.**

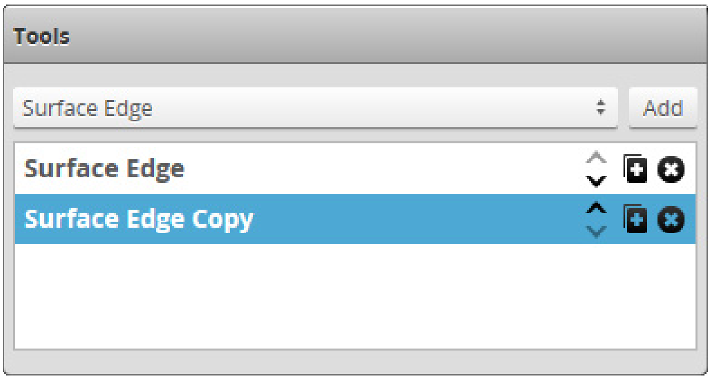
2 **Choose Profile or Surface mode in the [Scan Mode] panel.**

If one of these modes is not selected, tools will not be available in the [Measure] panel.

3 **Go to the [Measure] page by clicking on the [Measure] icon.**

4 **In the tool list, click the Duplicate button (⧉) of the tool you want to duplicate.**

» A copy of the tool appears below the original.



5 **Configure the copy as desired and rename it if necessary.**

For information on renaming a tool, see 📖 "■Editing Tool, Input, or Output Names" on page 260.

Removing a Tool

Removing a tool removes all of its associated measurements.

To remove a tool:

1. **Go to the [Scan] page by clicking on the Scan icon.**

2. **Choose Profile or Surface mode in the [Scan Mode] panel.**

   If is not selected, tools will not be available in the [Measure] panel.

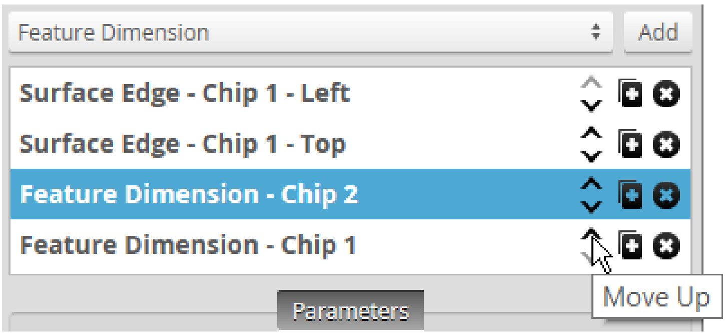
3. **Go to the [Measure] page by clicking on the [Measure] icon.**

4. **In the tool list, click on the Duplicate button ( ) of the tool you want to duplicate.**

   A copy of the tool appears below the original.

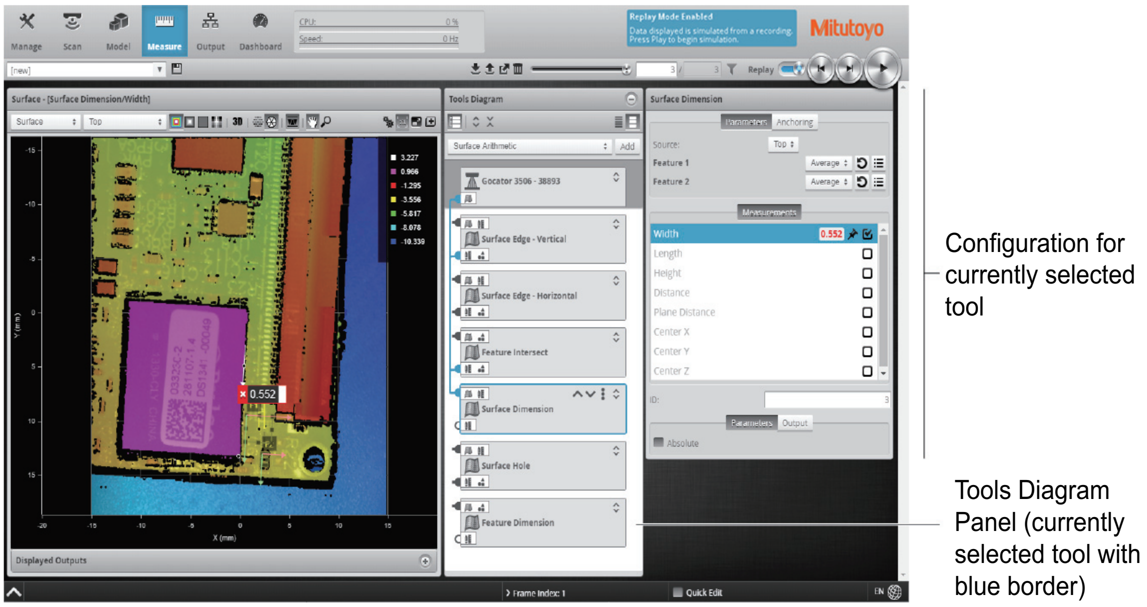
Reordering Tools

When you add or duplicate a tool, the tool is added to the bottom of the list in the [Tools] panel. You can reorder tools in the web interface to organize tools more logically. For example, you could group tools that output geometric features with the tools that use them. Or you could group tools you use as anchors with the tools that use those anchors.



4.7.4 Working with the Tools Diagram

The Tools Diagram provides a visual representation of the data flow in a sensor system (the output from a sensor, and the input and output of tools). It lets you create and view complex tool chains with drag-and-drop and other mouse operations, letting you implement and maintain applications demanding multiple, interconnected tools, quickly and easily.



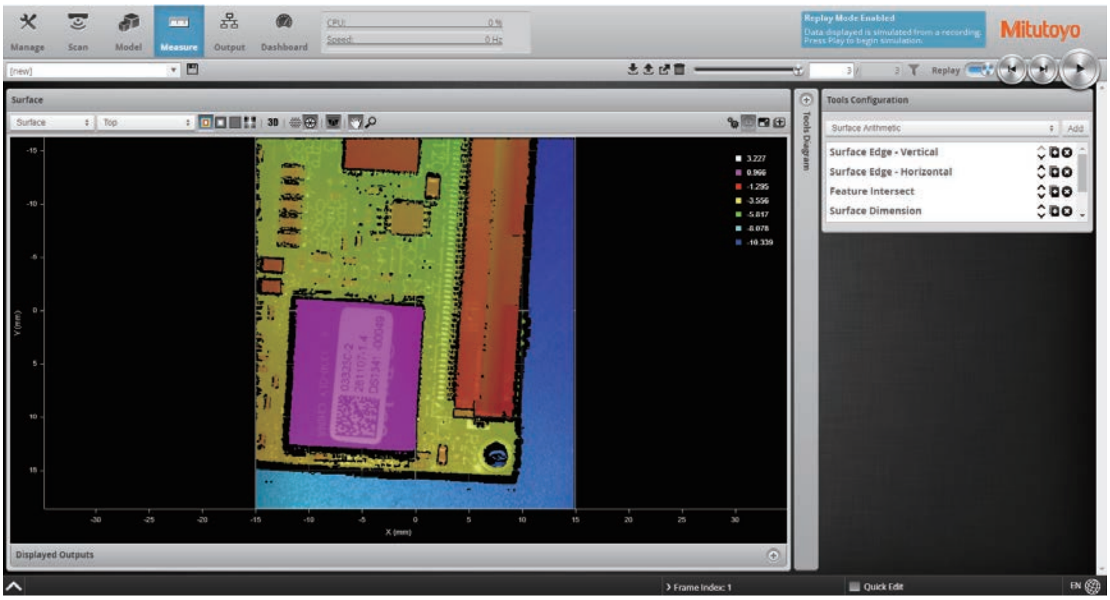
All data types and their relationships between tools are displayed:

- Profile data (either directly from a sensor's output or from tool output)
- Surface data (either directly from a sensor's output or from tool output)
- Measurements (for use as anchors)
- Geometric features
- Tool data output (some data outputs are intended to be consumed only by SDK applications and can't be used as part of a tool chain withing SurfaceMeasure1008S)

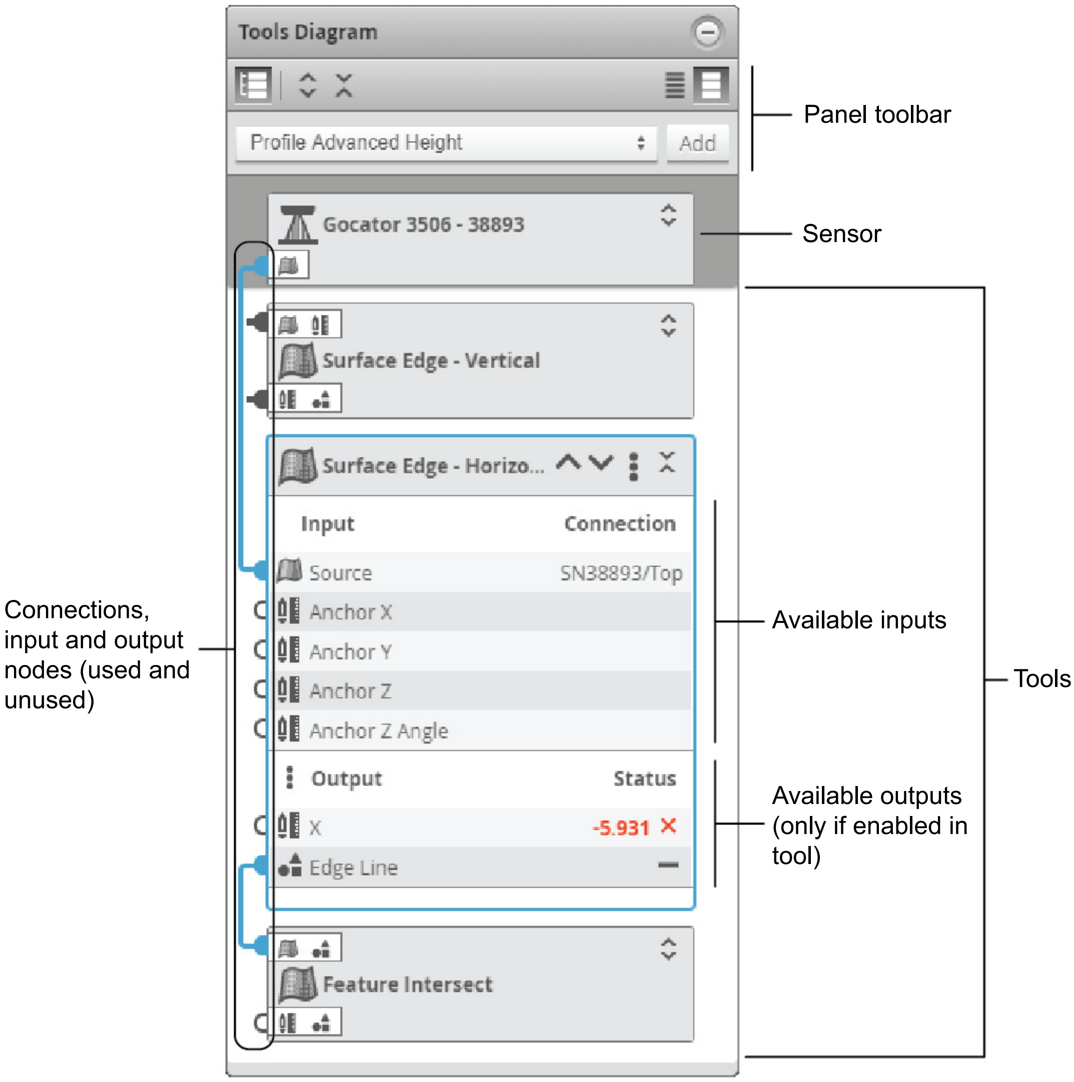
For details on how the Tools Diagram panel displays information, see 📖 "■Understanding the Data Flow in Tool Chains" on page 271.

For details on how to connect and disconnect, see 📖 "■Connecting Tools" on page 275.

The Tools Diagram panel is open by default. When the panel is open, the parameters of the tool selected in the panel are to the right of the Tools Diagram panel. You can close the Tools Diagram panel by clicking the ⊖ button at the top of the panel. When you close it, the tool drop-down list and button used to add tools moves to the Tools Configuration panel.

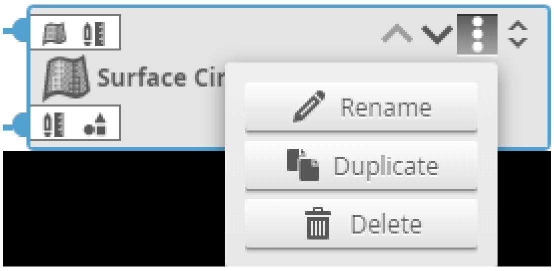


The following illustrates the main aspects of the Tools Diagram panel.



Tools Diagram panel showing sensor, tools, outputs/inputs, and data flow connections.

At the top of a tool, a drop-down menu provides functions to rename, duplicate, and delete the current tool. For more information, see the topics below.



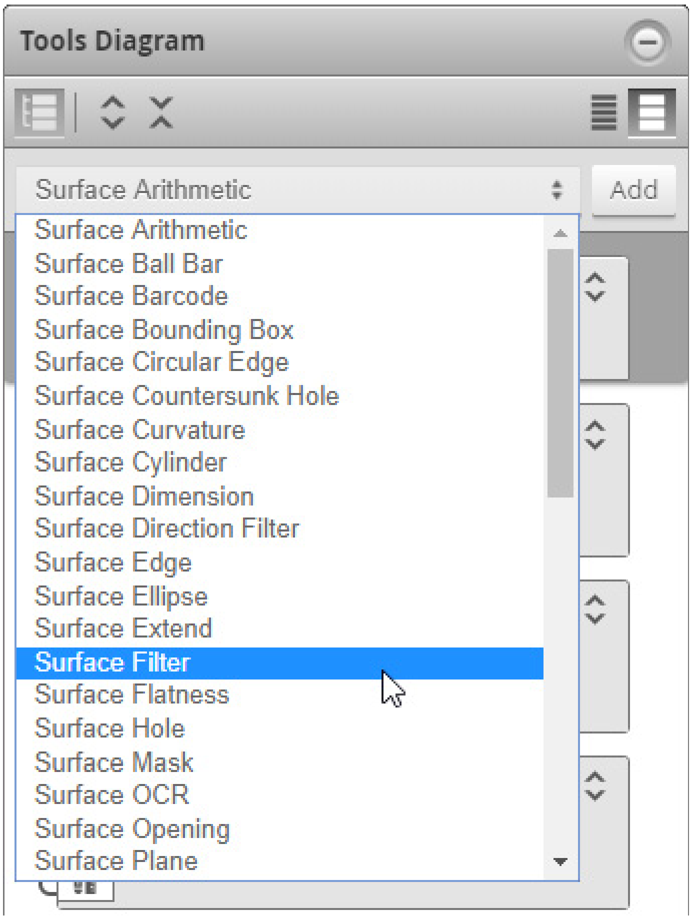
Action menu (collapsed tool)

■ Adding a Tool

In the Tools Diagram panel, you add a tool using the drop-down and the [Add] button below the panel's toolbar.

To add a tool in the Tools Diagram panel

1 In the drop-down at the top of the panel, choose a tool to add.



2 **Click Add.**

» The tool appears at the bottom of the Tools Diagram panel.

After you have added a tool, you must configure it.

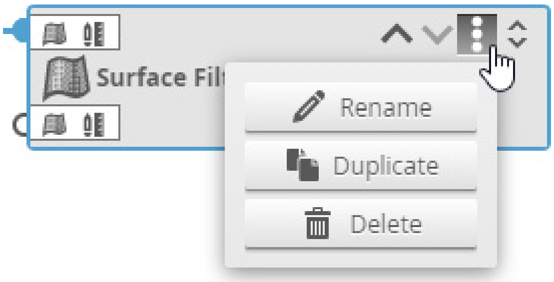
■ Deleting a Tool

In the Tools Diagram panel, you delete a tool using the Action menu of an individual tool.

To delete a tool in the Tools Diagram panel

1 Click the Action menu icon.

» A context menu appears.



2 In the context menu, choose [Delete].

» The tool is removed from the Tools Diagram panel.

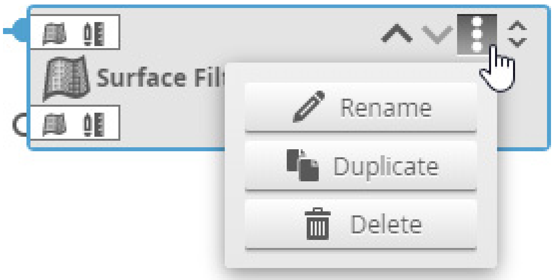
■ Renaming a Tool

In the Tools Diagram panel, you rename a tool using the Action menu of an individual tool.

To rename a tool in the Tools Diagram panel

1 Click the Action menu icon.

» A context menu appears.



2 In the context menu, choose [Rename].

3 In the tool name field, rename to the tool.

4 Press Enter on the keyboard or click the check icon (see above).

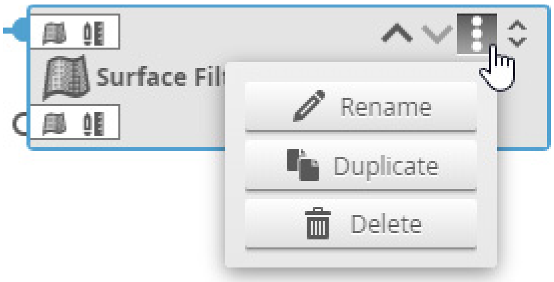
■ Duplicating a Tool

In the Tools Diagram panel, you duplicate a tool using the Action menu of an individual tool.

To duplicate a tool in the Tools Diagram panel

1 **Click the Action menu icon.**

2 **A context menu appears.**



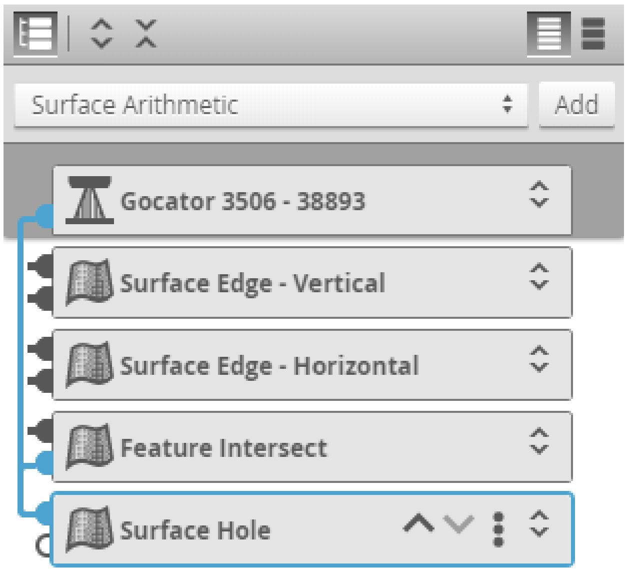
3 **In the context menu, choose [Duplicate].**

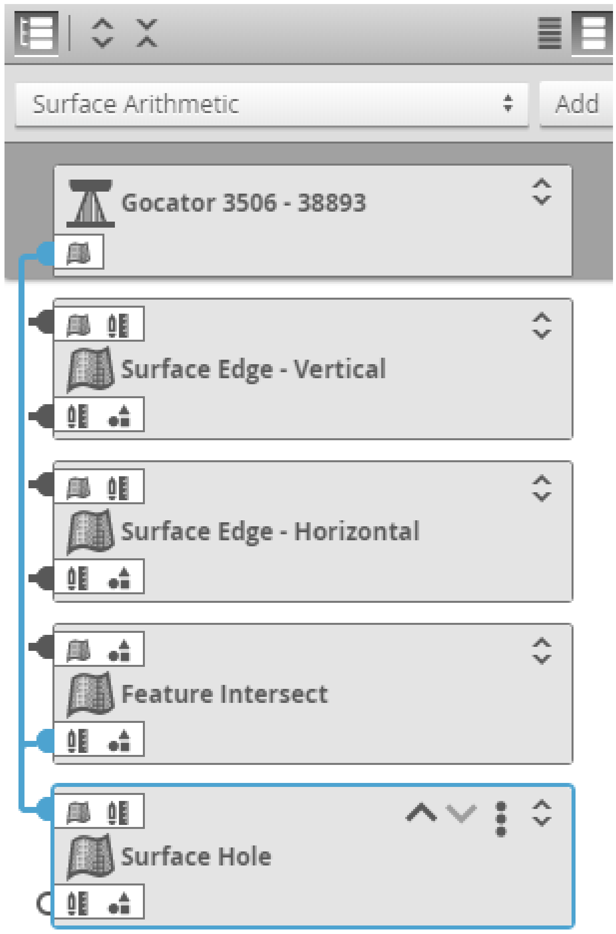
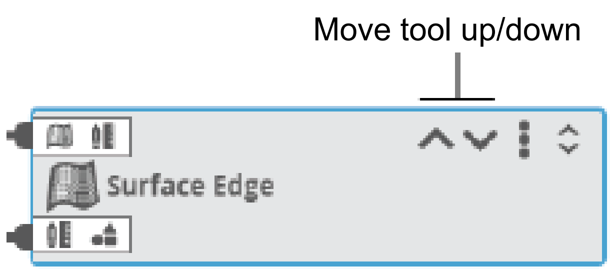
» A copy of the tool appears below the tool you copied, with “Copy” appended to its name.

■ Displaying and Ordering Tools

The buttons at the top of the Tools Diagram panel let you control how the panel displays sensors, tools, and the data flow (tool chain). Buttons at the top of individual tools let you organize the tools in the list, as well as name, duplicate, and delete them.

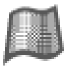
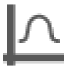
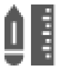
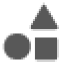
The following describes the toolbar's functions:

	Item	Description
1	Show/Hide Connections	Toggles displaying lines showing the data flow related to the selected item (the sensor or a tool). The connection lines let you see at a glance how the tools are chained together. You can highlight subsections of connections to better understand the data flow. For more information see "■Understanding the Data Flow in Tool Chains" on page 271. For more information on connecting and disconnecting tools, see "■Connecting Tools" on page 275 and "■Disconnecting Tools" on page 280.
2	Open All	Expands all the sensor and tools in the Tools Diagram panel, displaying a list of available inputs and enabled outputs for each one.
3	Close All	Collapses all items in the Tools Diagram panel.
4	Compact View	Hides the list of small input and output icons that indicate the types of the inputs and outputs the sensor or a tool has. 

	Item	Description
5	Standard View	Shows small icons that indicate the types of the inputs and outputs the sensor or a tool has. The icons are only shown on collapsed sensors or tools. For a list of inputs and outputs, see 📖 "■Data Types" on page 271.  Use the up / down buttons next to the Action menu on individual tools to move the tool up or down in the panel. Note that the order of tools in the Tools Diagram panel does not affect the data flow. However, you can order tools to make the data flow clearer. 

■ Data Types

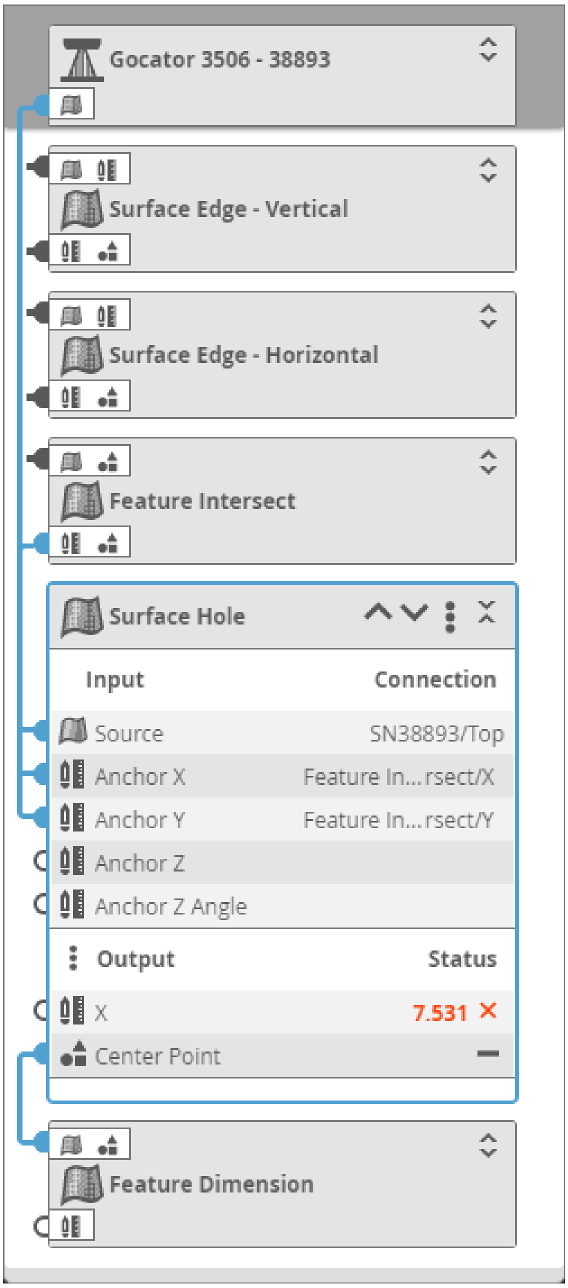
SurfaceMeasure1008S represents data types in the Tools Diagram panel by an icon. Larger icons indicate the type of a tool (for example, a Profile tool vs. a Surface tool). Smaller icons are used to indicate the types of a tool's inputs and outputs when the Tools Diagram panel is set to Standard view (the small icons are hidden in Compact view); for more information on views, see "■Displaying and Ordering Tools" on page 269.

Icon	Description
	Surface data.
	Profile data.
	Range data.
	Measurement.
	Geometric feature.
	Tool data output.

■ Understanding the Data Flow in Tool Chains

The rectangular elements displayed in the Tools Diagram panel represent a sensor at the top (dark grey area) and any tools you have added below that. Sensors display output connection nodes, whereas tools display both input and output connection nodes.

The appearance of nodes changes depending on whether they are connected and whether they are selected. Connections that are used are filled. Connections that are not used are empty. When a sensor or tool is expanded, you can see which specific inputs or outputs are used and part of the tool chain. For example, in the expanded Surface Circular Edge tool below, we can see that the first three inputs (Source and two anchors, receiving their input from the sensor at the top and from Feature Intersect, respectively) and the Center output are involved in the chain of sensor and tools.

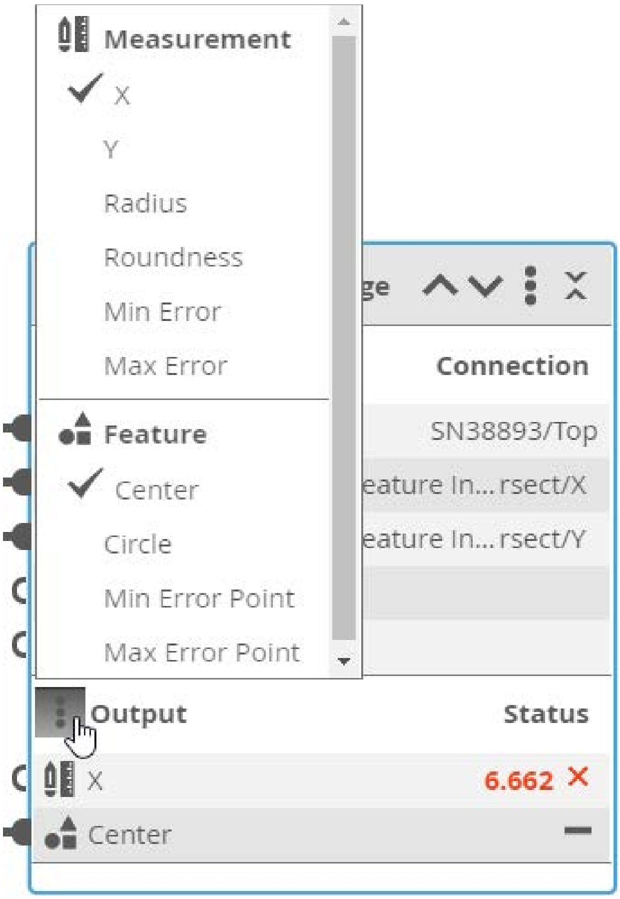


When a tool is collapsed, however, you only know that at least one input or output is used (or none at all). For example, looking at the collapsed Feature Dimension tool at the bottom, we know that at least one input (the connection node at the top) is used, and that none of the tool's outputs are used. Also, we know that inputs and outputs of the three collapsed tools at the top are used, but not exactly which ones.

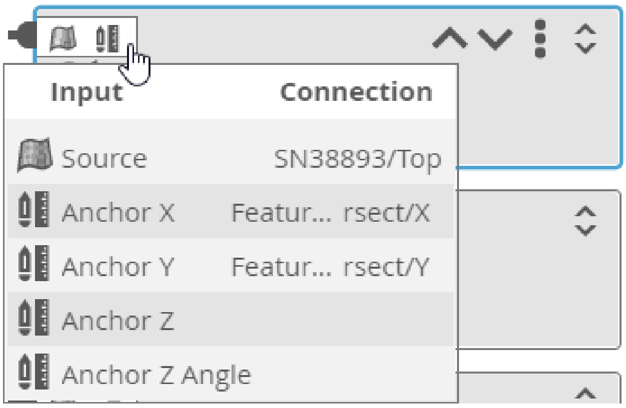
In both cases (collapsed or note), the data flow of the selected item is indicated by dark blue connection lines. For more information, see below.

By default, sensors and tools are collapsed, but you can expand them individually by clicking the expand / collapse button at the top right of a tool to display the complete list of available inputs and outputs. Note that for an output to be listed in the Outputs section, it must be enabled in the tool's configuration: in the tool's Output list, only enabled outputs are listed.

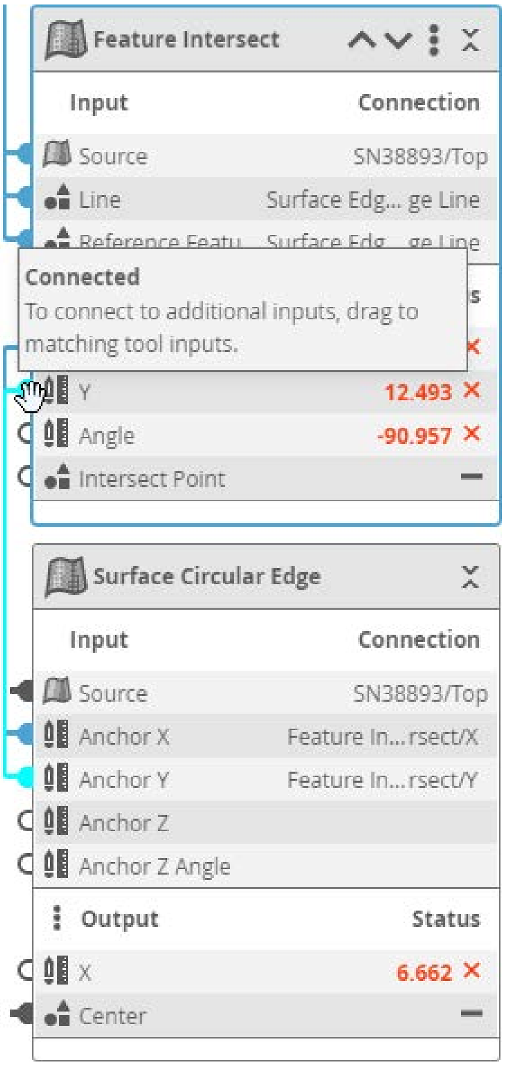
To see a complete list of a tool's outputs (as opposed to only the enabled ones), at the top of the tool's Output section, click the Output menu button (⋮). A pop-up list of all available outputs displays, indicating the enabled outputs with a checkmark.



When a tool is collapsed, you can "peek" the available inputs or the enabled outputs by clicking one of the horizontal lists of small icons (Standard view only).



If you hover the mouse pointer over a blue connected node, a part of the blue connection line is high-lighted to indicate what it is connected to. In the image below, you can see that by hovering over an out-put (the Y measurement of the Feature Intersect tool at the top) is used as an input (the Y anchor) of the Surface Circular Edge at the bottom.

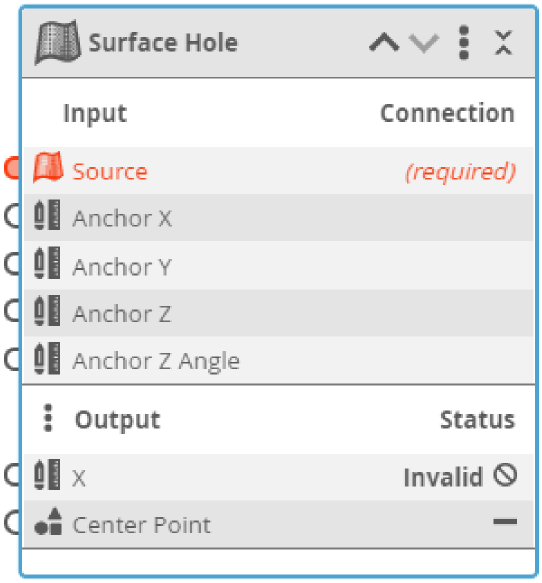


Tips

Script tools take no input in the Tools Diagram panel, as all outputs are available to these tools via their script functions.

If you remove a tool whose output is used by another tool as input, that input is displayed in red in the Tools Diagram panel to show that you must reconnect them.

Collapsed tool with a missing input



Expanded tool with a missing input

For information on connecting outputs to inputs, see "■Connecting Tools" on page 275.

■ Connecting Tools

The Tools Diagram panel lets you quickly connect tools using drag-and-drop operations.

> **Tips**
> Displaying the connections (using the Display Connections button at the top of the panel) while connecting tools may be helpful.

In the following, we connect a geometric feature output from one tool to the input of another tool. However, the same procedure applies when connecting other kinds of outputs to inputs, such as connecting a measurement from one tool to one of the anchors available in another tool, or when connecting Surface output (such as the output from the Surface Filter tool) to the Source input of another tool (which is initially set to the direct output of a sensor).

To connect a tool's output to another tool's input:

1. **Make sure you have added at least two tools and that you have configured the tools higher in the tool chain.**

   The output you want to connect must be enabled in the first tool.

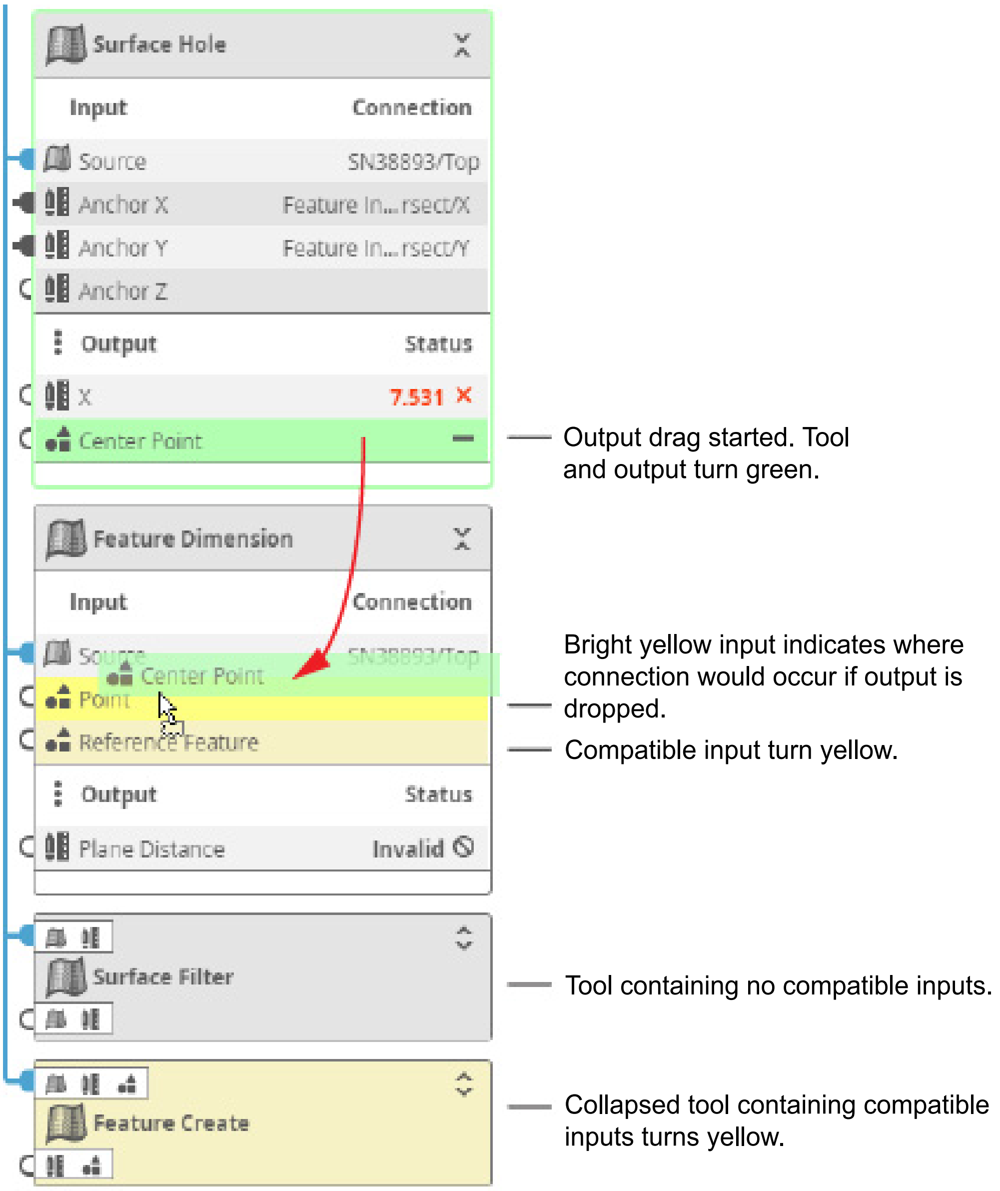
   For information on adding tools, see "■Understanding the Data Flow in Tool Chains" on page 271.

2. **Locate the tool whose output you want to use (the "source" tool).**

3 Do one of the following:

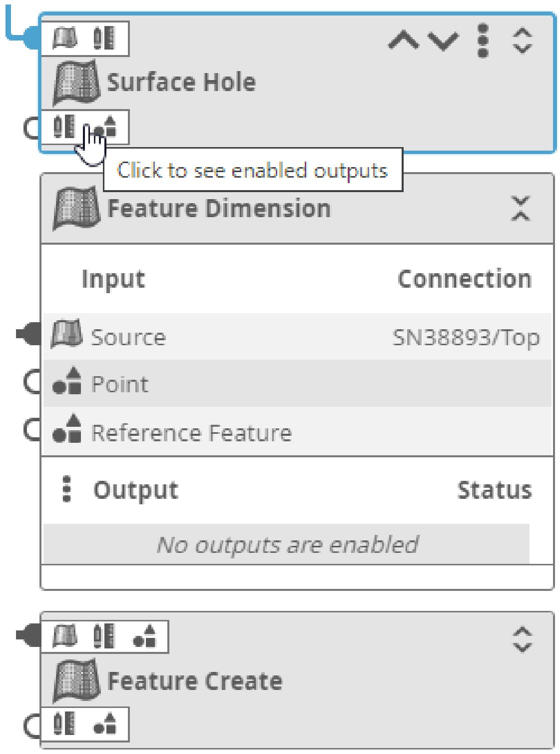
With an expanded tool

1 Click and hold the output you want to connect to the other tool's input and drag it to the input.

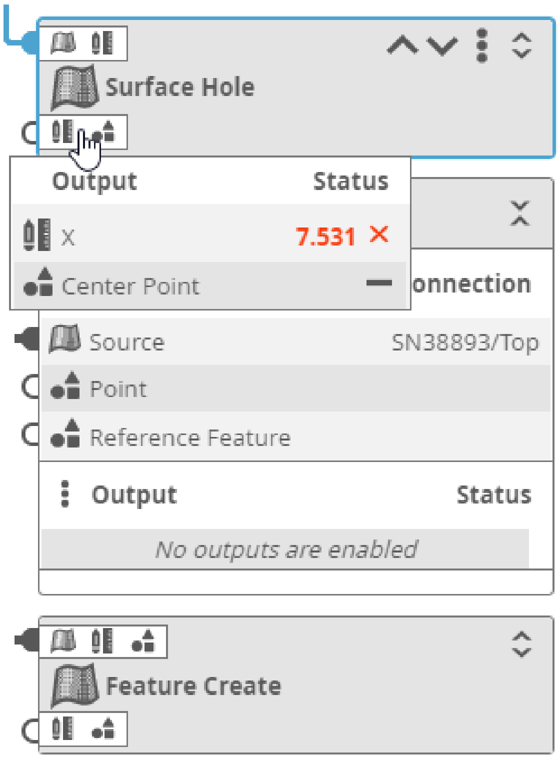


With a collapsed tool

1 Click the small output types at the bottom of the tool to expand the list of



» A list of enabled outputs is displayed in a pop-up list.



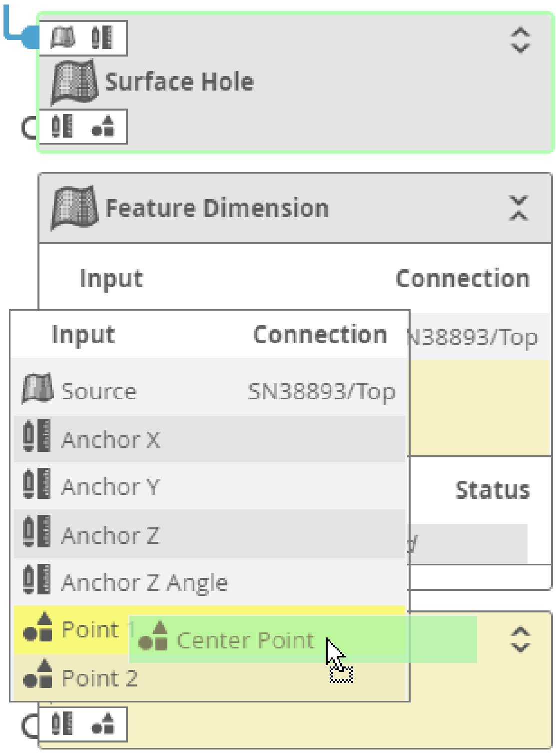
2 In the pop-up list, click and hold the output you want to connect to the other tool's input and drag it to the input.

» The source tool's border and the dragged output turn green.

» Compatible inputs turn yellow.

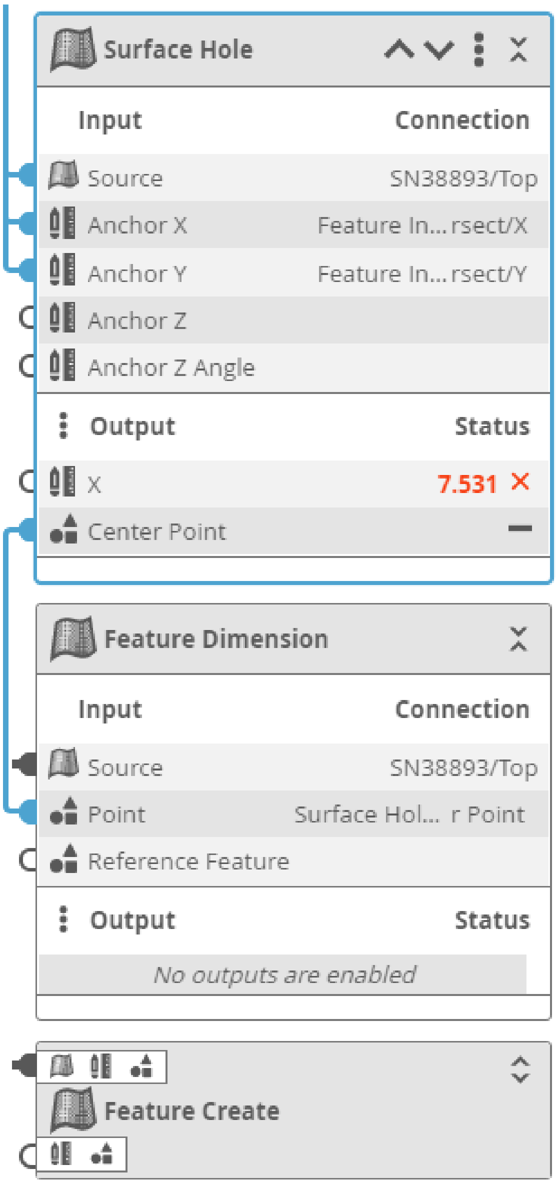
» The input to which the output will be linked if you drop it is highlighted in bright yellow (in the image above, this is the Point input).

Collapsed tools containing compatible inputs also turn yellow. If you move an output over a collapsed tool, a popup showing the tool's available inputs is displayed.

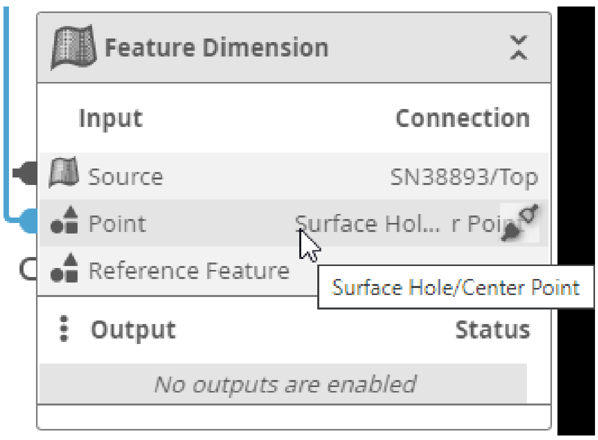


4 **Drop the output on the desired input.**

A new connection appears between the first tool's output and the second tool's input (below, between the Surface Hole tool's Center Point output and the Point input in the Feature Dimension tool).



Tips
You can see the full name of an input or an output in a tooltip if you hover the mouse pointer over it.



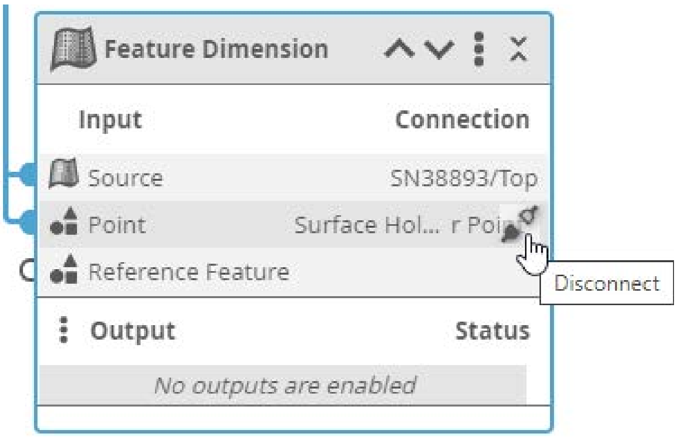
■ Disconnecting Tools

You can quickly disconnect an input in the Tools Diagram panel, but only if the tool containing the input is expanded.

To disconnect an input in a tool:

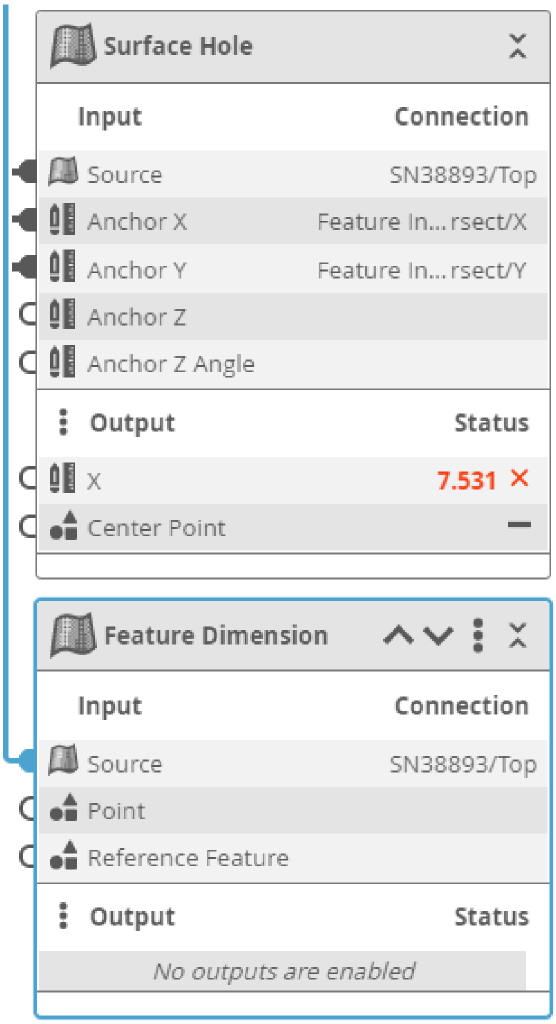
1 If the tool isn't expanded, click the Expand button at the top of the tool.

2 In the expanded tool, move the mouse pointer over the input you want to disconnect and move it to the right until the pointer is over the Disconnect icon.



3 Click the Disconnect icon.

The input is disconnected from the other tool's output. (Below, the connection between Center Point and Point is removed.)

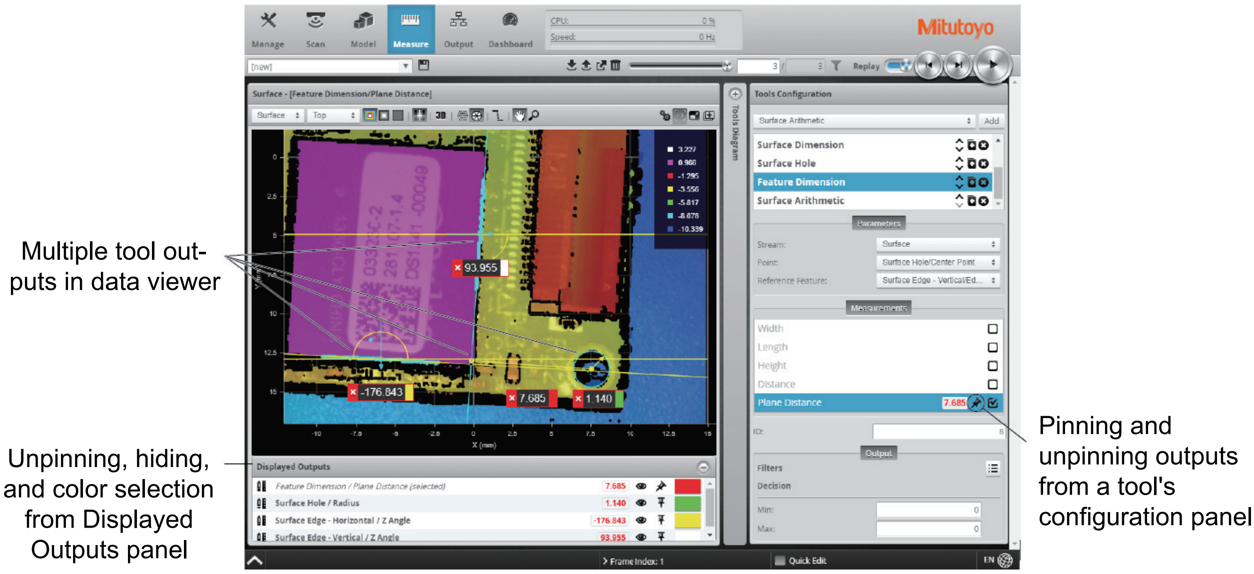


4.7.5 Pinning Measurements and Features

You can “pin” one or more tool outputs (measurements and geometric features) to a data viewer. When these outputs are pinned, they remain visible in a data viewer at all times, even when you click on a different tool, measurement, or feature in one of the lists the web interface displays. When no tool outputs are pinned, only the currently selected tool output is displayed in the data viewer. Pin information is stored in job files, so particular monitoring or configuration setups are automatically retrieved when you load a job containing pinned outputs.

Pinning outputs is useful if you want to monitor multiple, independent measurements while the SurfaceMeasure1008S is running in production. Pinning is also useful when setting up tools: you can change the parameters of a tool (such as a filter) earlier in a tool chain and immediately see the impact that modification has on another tool later in the chain. This minimizes toggling and clicking between tools and measurements. Pins are automatically stored as measurements in job files.

In the following image, a Feature Dimension Plane Distance measurement (measuring the distance between the corner of a CPU and a mounting hole) is currently selected. Three other measurement (Surface Edge Z Angle measurements on two sides of the CPU and a Surface Hole Radius measurement to the lower right) are pinned.

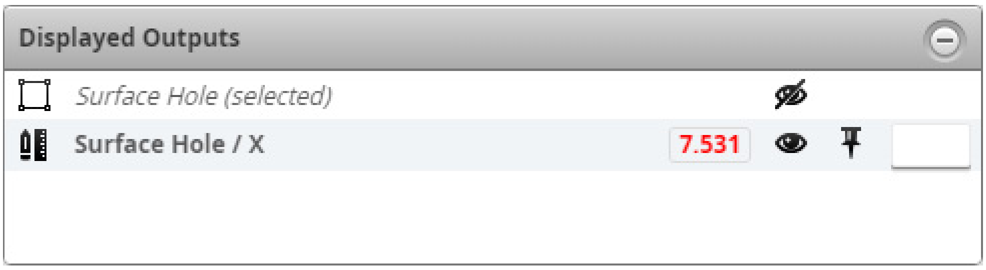


Data viewer showing the currently selected measurement and three pinned measurements.

You pin and unpin tool outputs from a tool’s configuration panel (in the list to the right of the data viewer). You can also pin and unpin outputs on the Dashboard page (the procedure is very similar); however, pinned outputs in the Dashboard are not independent from those in the main data viewer. You can pin outputs independently when you have multiple data viewer windows open (for more information, see "4.7.2 Using Multiple Data Viewer Windows" on page 232).

You can unpin and hide outputs in the [Displayed Outputs] panel below the data viewer, and pin the currently selected output. You can also choose the color of the measurement value. The currently selected but unpinned output is indicated by “(selected)” in the panel's list, meaning it is automatically but temporarily added: it will be removed from the panel's list when you switch to another output.

Tools (distinct from their outputs) with definable regions of interest can also appear in the list: this lets you temporarily hide the regions to reduce the visual elements in the data viewer. For example, in the following, the region definable in the Surface Hole tool is hidden, independently of the Surface Hole X measurement:

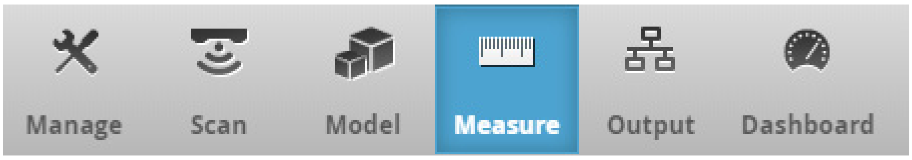


The naming convention for outputs in the [Displayed Outputs] panel is as follows:

Tool_icon Tool_name / Measurement_name

To pin or unpin a tool output from a tool's configuration panel:

1 **Go to the [Measure] page.**



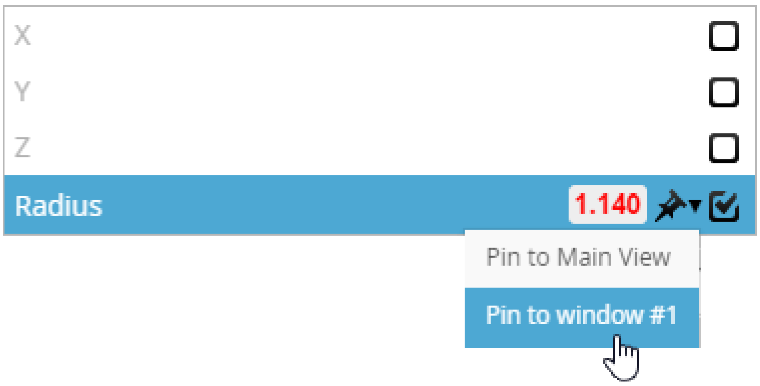
2 **In a previously added and configured tool, go to the [Measurements] or [Features] tab.**

3 **In the tab, locate the output you want to pin or unpin and do one of the following:**

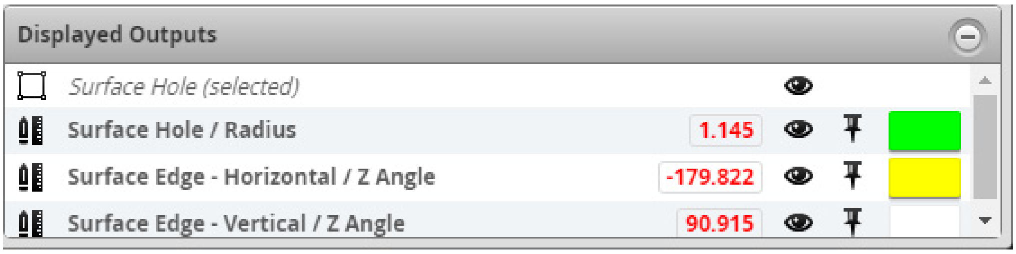
Pin an output:

1 If only the Main View data viewer is open, click the pin icon next to the output you want to pin.

2 If you have opened additional data viewer windows, click the pin icon and choose the view to pin the output to from the drop-down.



» The output is added to the list in the [Displayed Outputs] panel in the data viewer you chose and is pinned in that data viewer.



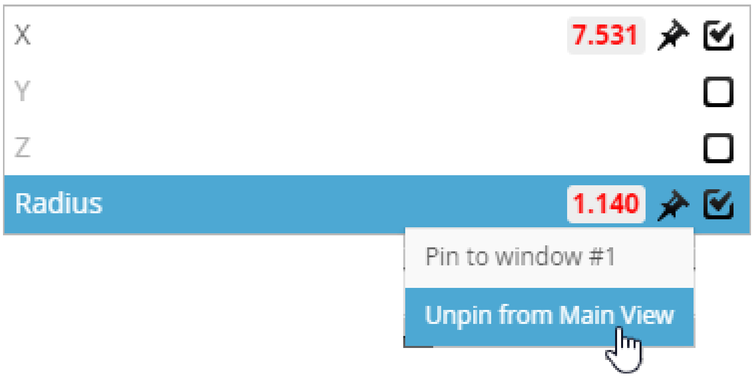
For more information on using multiple data viewer windows, see "4.7.2 Using Multiple Data Viewer Windows" on page 232.

Unpin an output:

1 If only the Main View data viewer is open, click the pin icon next to the output you want to unpin.

2 If you have opened other data viewer windows, you choose which one from which to unpin the output.

For more information on using data viewer windows, see "4.7.2 Using Multiple Data Viewer Windows" on page 232.

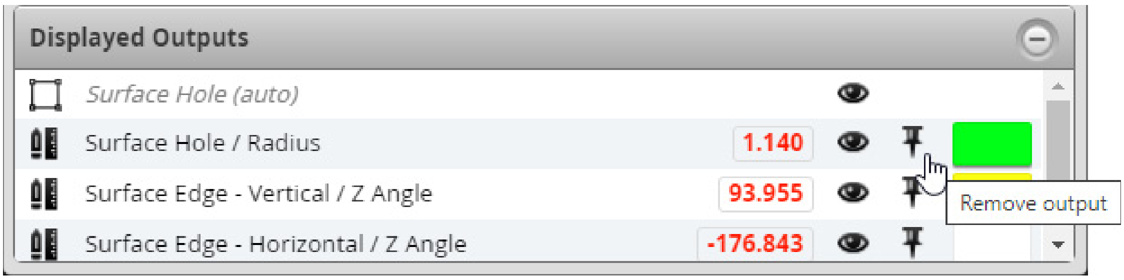


The output is removed from the [Displayed Outputs] panel and is no longer displayed in the data viewer, unless it is currently selected in a tool's list of outputs.

In the [Displayed Outputs] panel below a data viewer, you can also manage the pinned outputs of that data viewer, unpinning and hiding outputs, and choosing a measurement value's color.

To unpin an output in the Displayed Outputs panel:

- In the Displayed Outputs panel, click the pin next to the output you want to remove.



» The output is removed from the list in the panel, and is no longer displayed in the data viewer, unless it is currently selected in a tool's configuration.

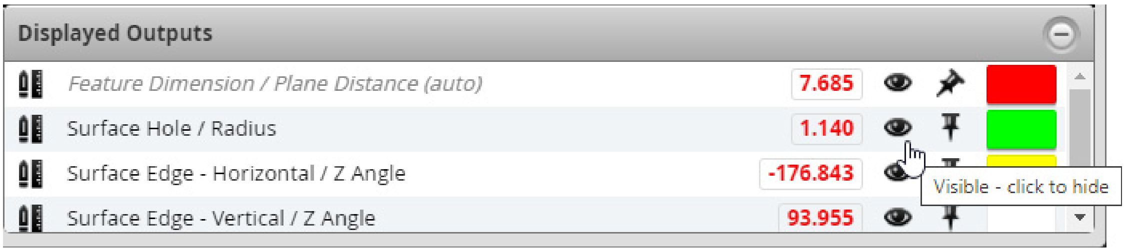
You can temporarily hide an output in a data viewer to make it easier to work with the data viewer. The state of outputs (shown vs. hidden) is not stored in the job file.

To hide or show an output in the Displayed Outputs panel:

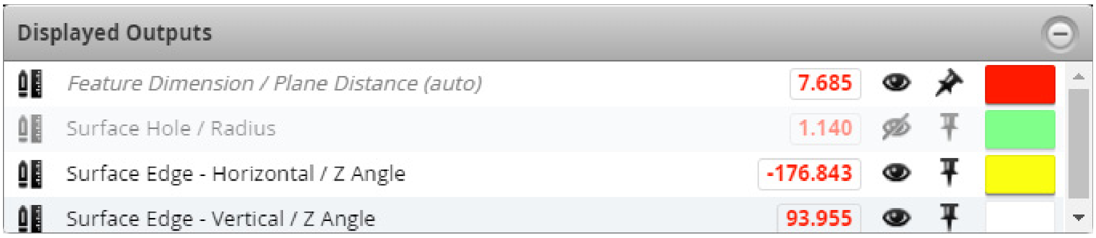
1 In the Displayed Outputs panel, do one of the following:

Hide an output:

1 Click the eye icon ( ) of the output you want to hide

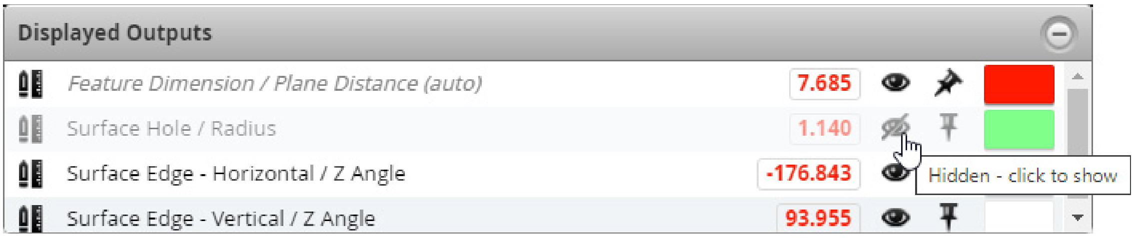


» The output in the panel is greyed out and it is no longer displayed in the data viewer. The output is still pinned to the data viewer.

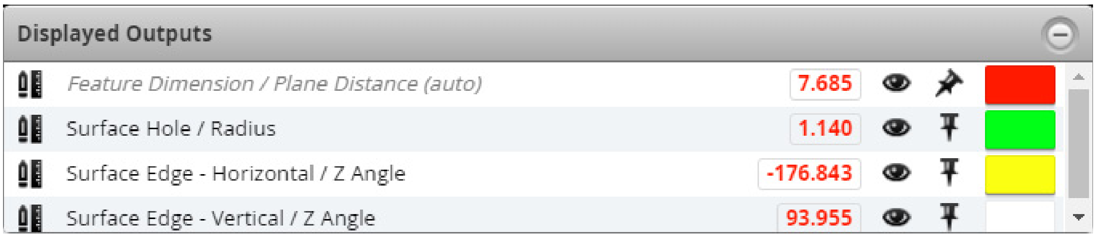


Show a hidden output:

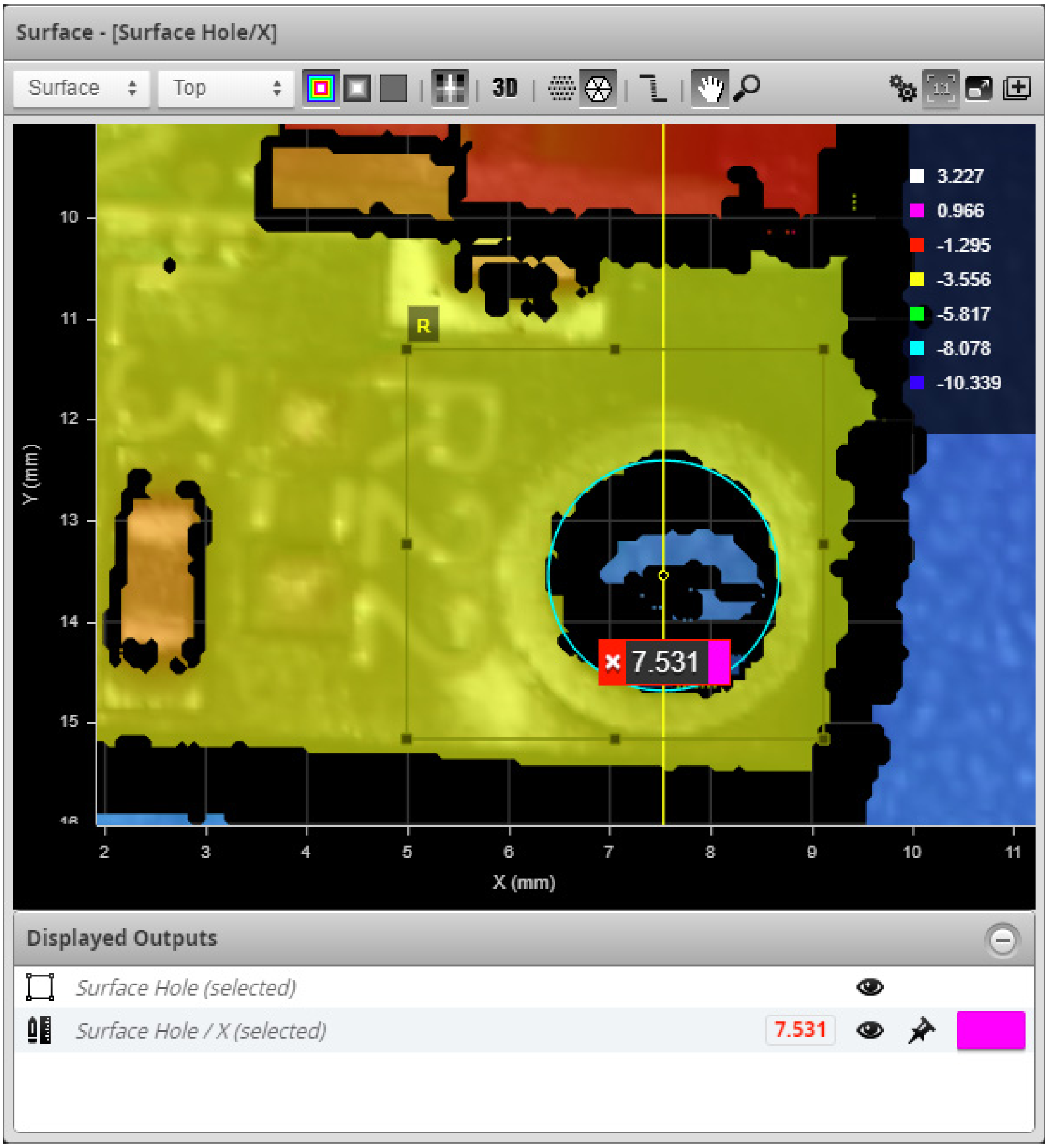
1 Click the barred eye icon ( ) of the output you want to hide.



» The output returns to the visible state.

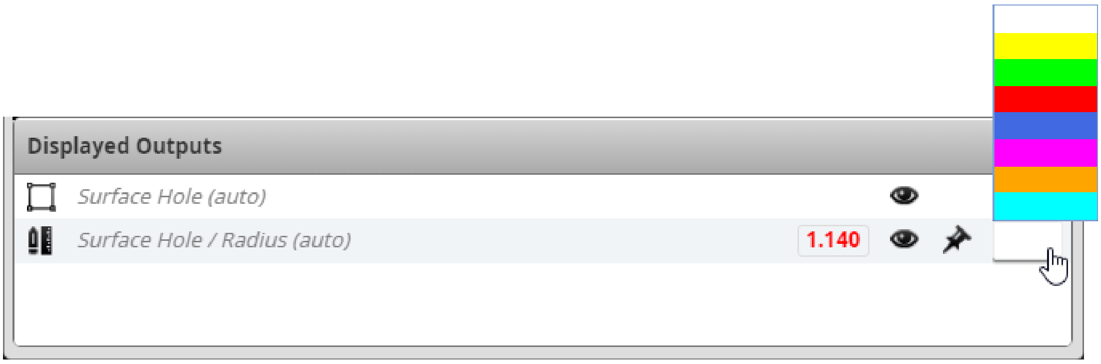


You can choose the color of the right vertical part of a measurement value that's displayed in a data viewer. In the following image, the color associated with the Surface Hole X measurement value has been set to magenta:

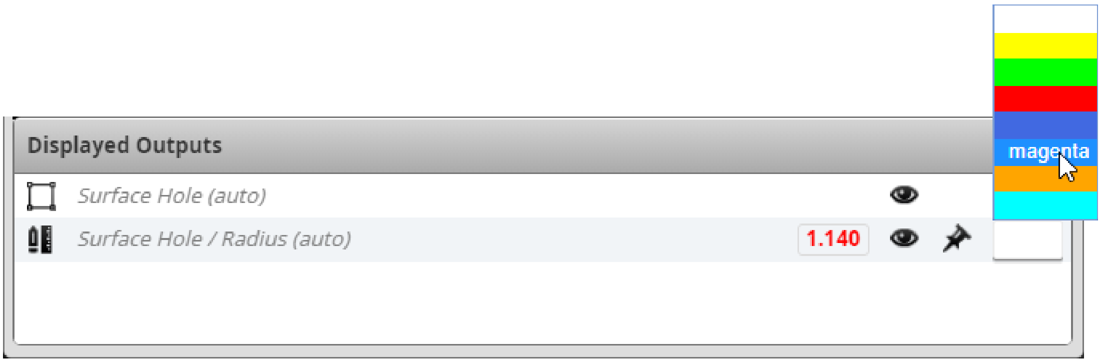


To change a measurement value's associated color:

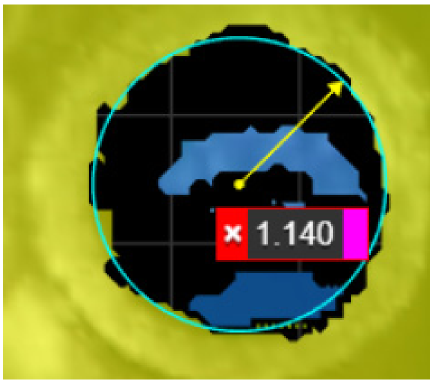
1 **In the Displayed Outputs panel, click one of the rectangles of color.**



2 **In the color picker, choose a color.**



» The color associated with a measurement value is changed.



4.7.6 Profile Measurement

See "5 Profile Measurement" on page 343.

4.7.7 Surface Measurement

See "6 Surface Measurement" on page 419.

4.7.8 Mesh Measurement

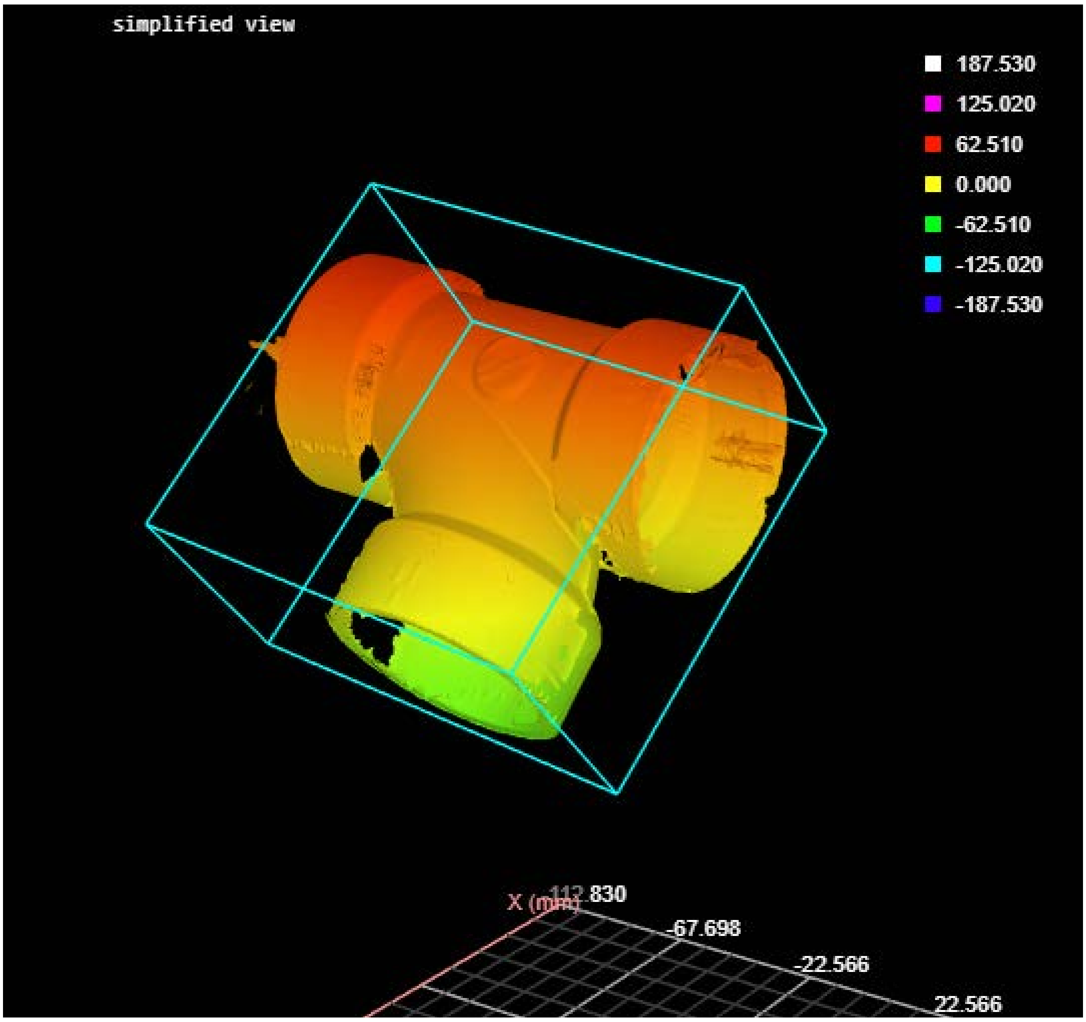
This section describes the Mesh tools available in SurfaceMeasure1008S sensors.

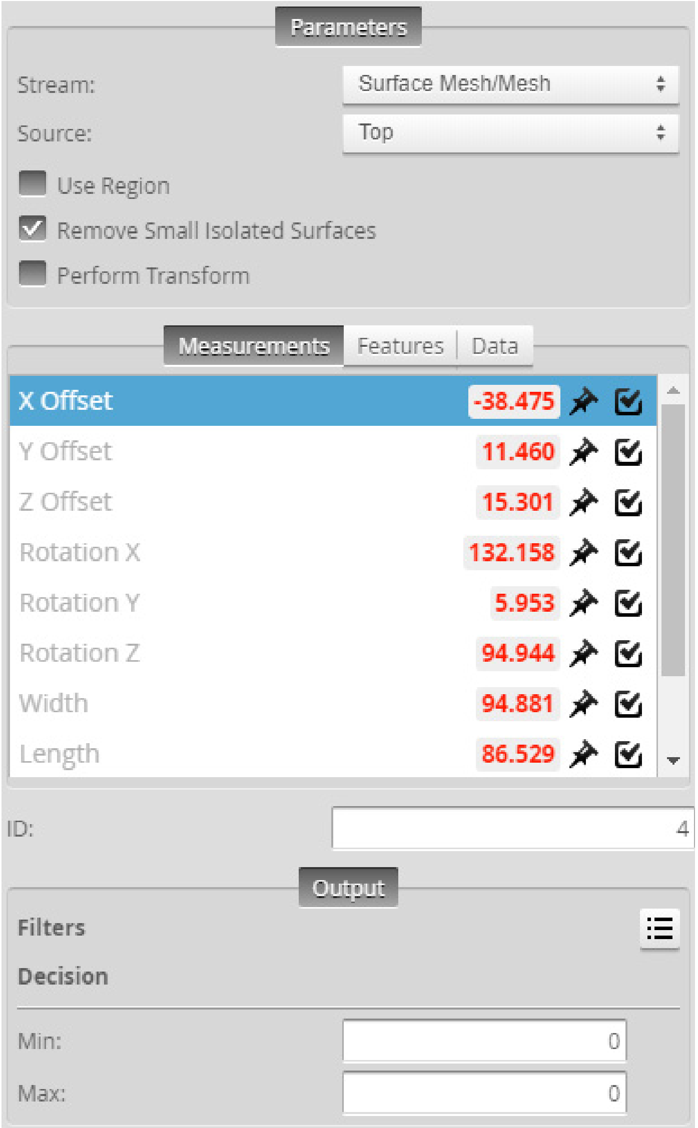
Mesh tools produce measurements on Mesh data output by the Surface Mesh tool (see "6.22 Mesh" on page 534), or the Mesh Bounding Box or Mesh Template Matching tools. The Mesh Projection tool lets the sensor extract a surface from any angle of the Mesh data (using a plane returned by the Mesh Plane tool), after which it can apply any of the built-in or custom GDK-based Surface measurement tools to the extracted surface.

■ Bounding Box

Tips
The tool is supported in emulator scenarios.

The Mesh Bounding Box tool takes in Mesh scan data (produced by the Surface Mesh tool and some other Mesh tools) and returns measurements related to the bounding box encapsulating the scan data in the region of interest, such as the rotation of the bounding box, the dimensions of the bounding box, and its location. In addition to a Point geometric feature, the tool returns the Mesh data in the bounding box. You can apply one of the other Mesh tools to this data, or after extracting Surface data using Mesh Projection or Mesh Plane, you can apply any built-in or custom GDK-based tool to the extracted surface data.





- Measurements, Features, and Settings

[Measurements]

Type	Description
[X Origin] [Y Origin] [Z Origin]	These measurements return the X, Y, and Z position of the center of the fitted bounding box, respectively.
[Rotation X] [Rotation Y] [Rotation Z]	The angle of the fitted bounding box around the X, Y, and Z axis, respecively.
[Width] [Length] [Height]	The width, length, and height of the fitted bounding box.
[Processing Time]	The time the tool takes to run.

[Features]

Type	Description
[Center Point]	A point representing the center of the fitted bounding box.

Tips

For more information on geometric features, see "●Geometric Features" on page 250.

[Data]

Type	Description
[Mesh]	The Mesh data contained in the bounding box.

[Parameters]

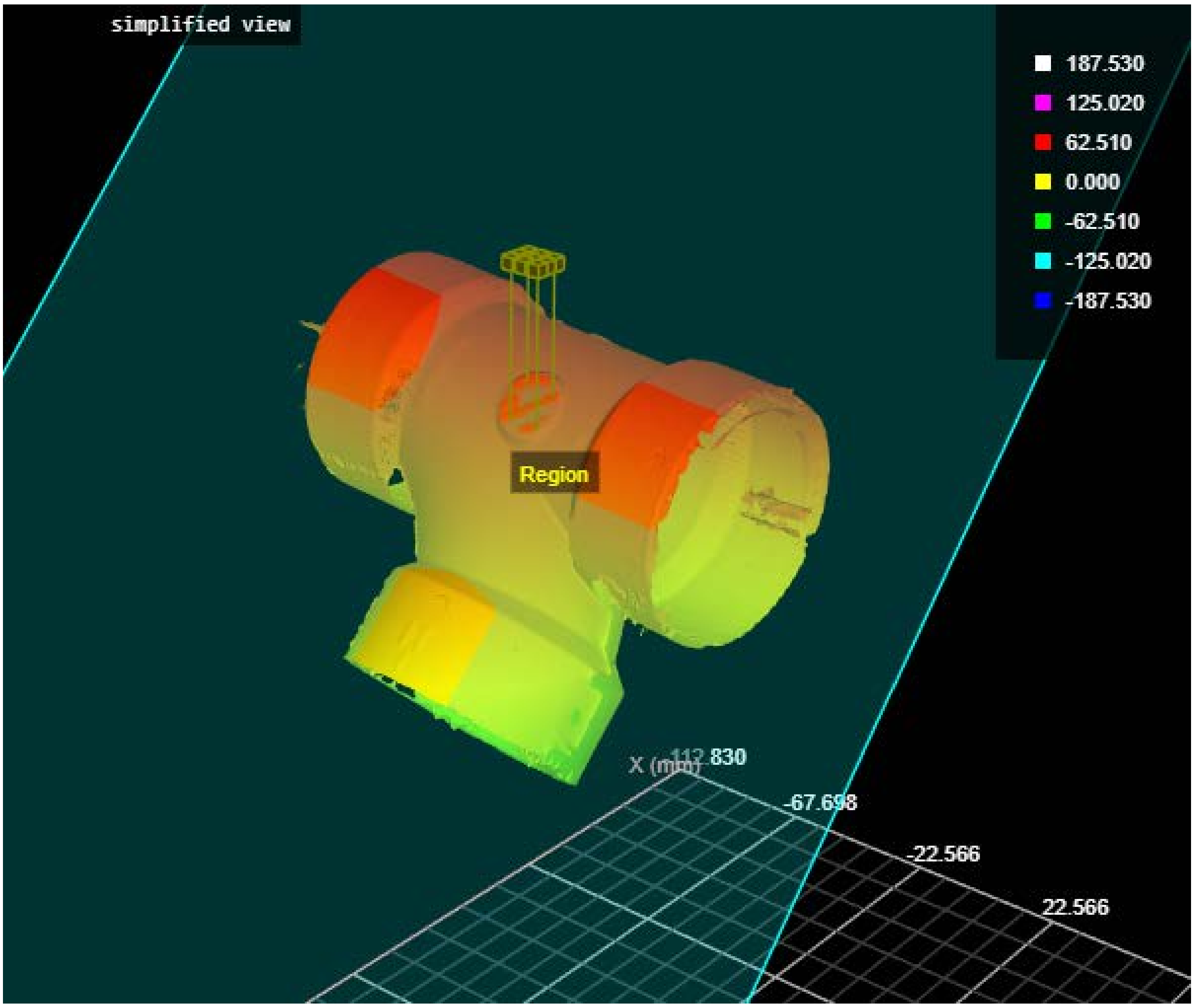
Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Use Region]	Determines whether the tool uses a user-defined region to fit a bounding box. Enabling this option displays parameters you use to define the size and position of the region.
[Remove Small Isolated Surfaces]	Excludes small, unconnected regions of data from the Mesh output.
[Perform Transform] [Transform Mode]	When [Perform Transform] is enabled, you can choose the which axes are the major, minor, and tertiary axes. The tool also centers the Mesh data at origin 0. This lets you align the part data however you want. [Transform Mode] is one of the following: • [Minimal Alignment]: The closest coordinate axes are arranged for alignment. • [X > Y > Z Order] • [X > Z > Y Order] • [Y > X > Z Order] • [Y > Z > X Order] • [Z > X > Y Order] • [Z > Y > X Order]
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

■ Plane

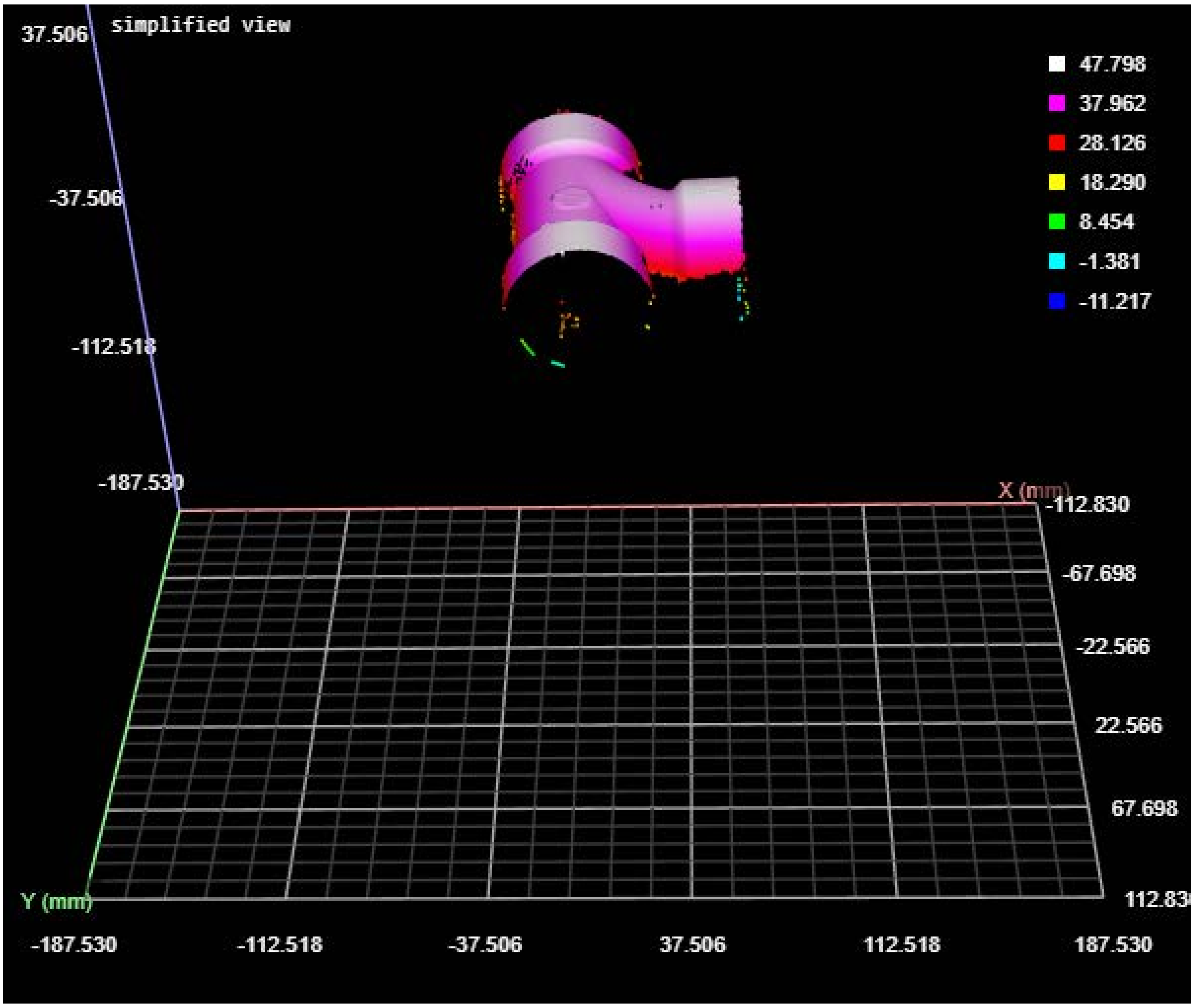
Tips

The tool is supported in emulator scenarios.

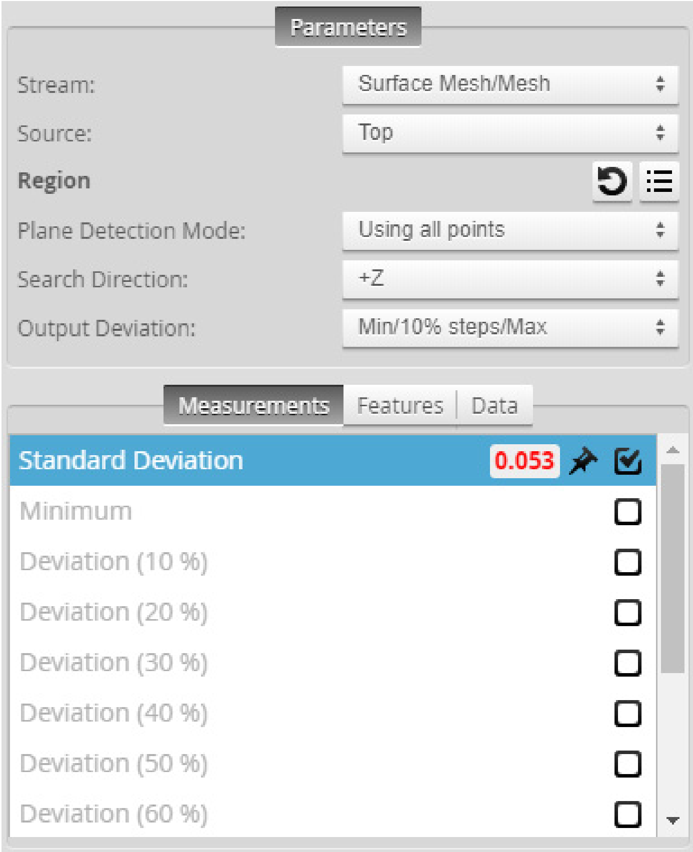
The Mesh Plane tool takes in Mesh scan data (produced by the Surface Mesh tool and some other Mesh tools) and returns measurements on the plane fitted within the region of interest, such as deviations of the data points relative to the plane. The tool also returns a Plane geometric feature that can be used as input by the Mesh Projection tool (see Projection on page 654). Finally, the tool returns front and back Surface data extracted from the plane: you can apply any built-in or custom GDK-based tools to the resulting data. This means that with 360-degree scan data, you can, for example, apply measurements to the sides or bottoms of your target, rather than just the top.



Mesh data with a region placed on a circular flat area.
The plane fitted to the data in this region is shown in cyan.



The Front Surface data output is rotated by the plane's X, Y, and Z rotation.



- Measurements, Features, and Settings

[Measurements]

	Measurement
[Standard Deviation]	The standard deviation of the data points from the fitted plane.
[Minimum] [Maximum]	The minimum and maximum error of the data points from the fitted plane, respectively.
[Deviation (x%)]	Deviations of the data points from the fitted plane, sorted into stepped percentiles. You set number of steps using the [Output Deviation] parameter.
[Processing Time]	The time the tool takes to run.

[Features]

Type	Description
[Plane]	A plane geometric feature.

Tips

For more information on geometric features, see "●Geometric Features" on page 250.

[Data]

Type	Description
[Front Surface]	Surface data representing the front of the meshed target.
[Back Surface]	Surface data representing the back of the meshed target.
[Difference Sur-face]	A Surface output that shows the fit error at each point in the height map.

[Parameters]

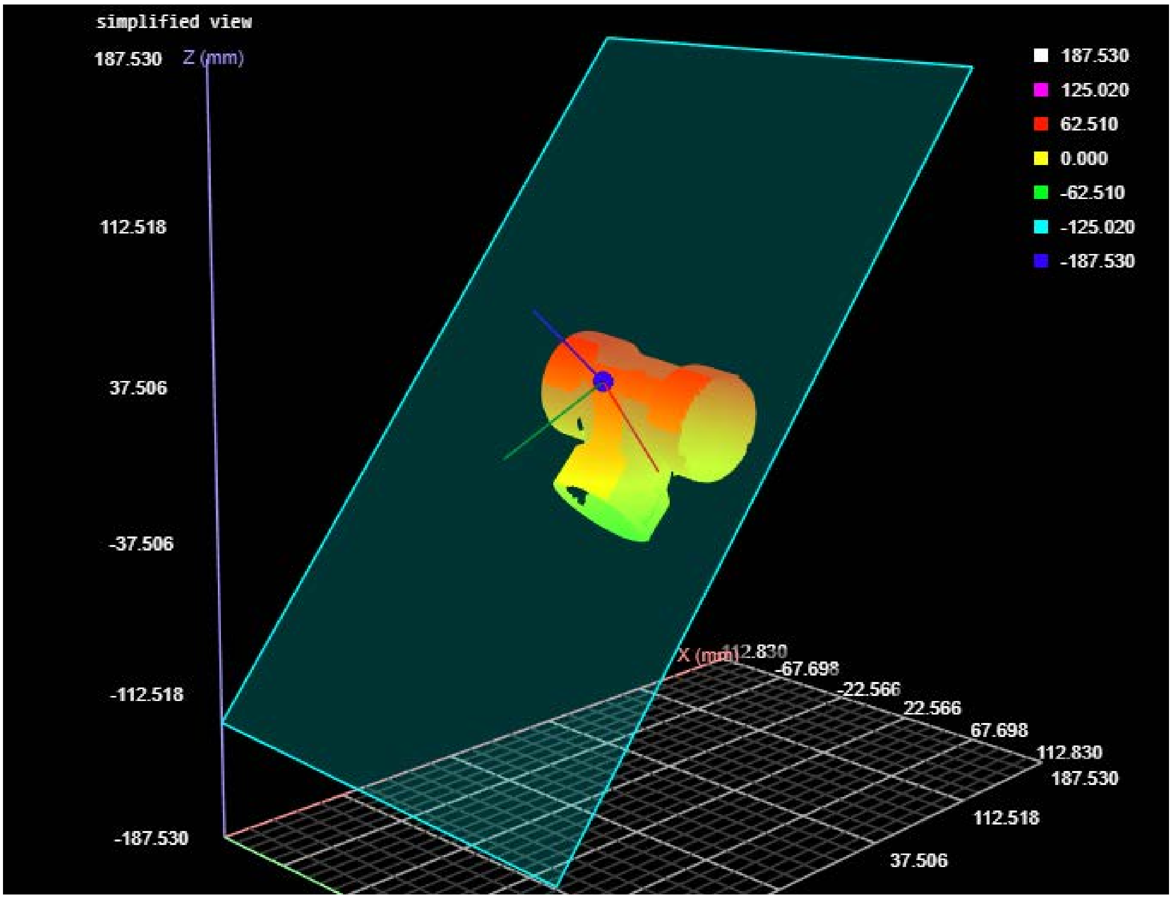
Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Plane Detection Mode]	The plane detection mode. One of the following: [With Largest Area] [With Maximum Distance] [With Minimum Distance] Chooses the plane at the maximum or minimum distance in the region, respectively, from the 0 origin. Use these options when more than one plane fit is possible in the region. Works in conjunction with [Search Direction]. [Eliminating outliers] Uses all data points of the scan data in the region, with 0.3% points with a maximum distance to the best-fit plane being considered as outliers, and excluded from the calculation. [Using all points] Uses all data points of the scan data in the region.
[Search Direction]	The search direction the tool will use to fit a plane. For example, when [Search Direction] is set to +Z, the tool starts searching from origin Z = 0 and moves along the positive Z axis. This parameter is only useful when [Plane Detection Mode] is set to one of the following: • [With Largest Area] • [With Maximum Distance] • [With Minimum Distance] The corresponding surface normals are taken into account in the processing so that the uninvolved points can be sorted out relatively quickly and safely. The fixed search angle is 45 degrees around the set direction. When [Search Direction] is set to [Input Direction], the tool displays additional parameters: [Tilt Angle] and [Direction Angle]. [Tilt Angle] - The angle between the Z axis and the vector. [Direction Angle] - The vector is projected onto the XY plane and then rotated around the X axis. Specifically: X = sin(TiltAngle) * cos(DirectionAngle) Y = sin(TiltAngle) * sin(DirectionAngle) Z = cos(TiltAngle)

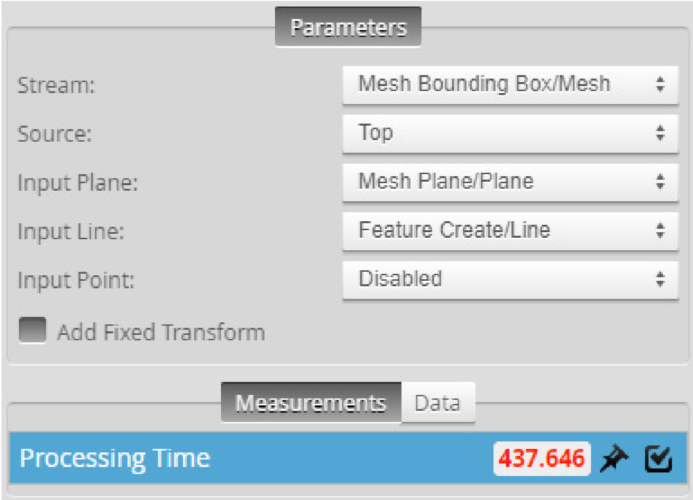
Parameter	Description
[Output Deviation]	Determines which deviations are output as measurements, which can be a combination of minimum and maximum, and a set of Deviation (x %) measurements (with the specified step between them). Can also be set so that no deviations are output. Use this to get a rough idea of the distribution of the deviation values (or a histogram of the deviations).
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

■ Projection

Tips
The tool is supported in emulator scenarios.

The Mesh Projection tool takes in Mesh scan data (produced by the Surface Mesh tool) and extracts Surface data. The tool can optionally take plane, line, or point geometric features produced by other Mesh tools to perform transformations on the output surface data (if no geometric features are used as inputs, the surface parallel to the XY plane is output), or you can manually apply fixed transformation. You can then apply any built-in or custom GDK-based Surface tool to the resulting Surface data. This means that with 360-degree scan data, you can, for example, apply measurements to the sides or bottoms of your target, rather than just the top.





- Measurements, Features, and Settings

[Measurements]

Measurement	Description
[Processing Time]	The time the tool takes to run.

Tips

For more information on geometric features, see "●Geometric Features" on page 250.

[Data]

Type	Description
[Front Surface]	Surface data representing the front of the meshed target.
[Back Surface]	Surface data representing the back of the meshed target.

[Parameters]

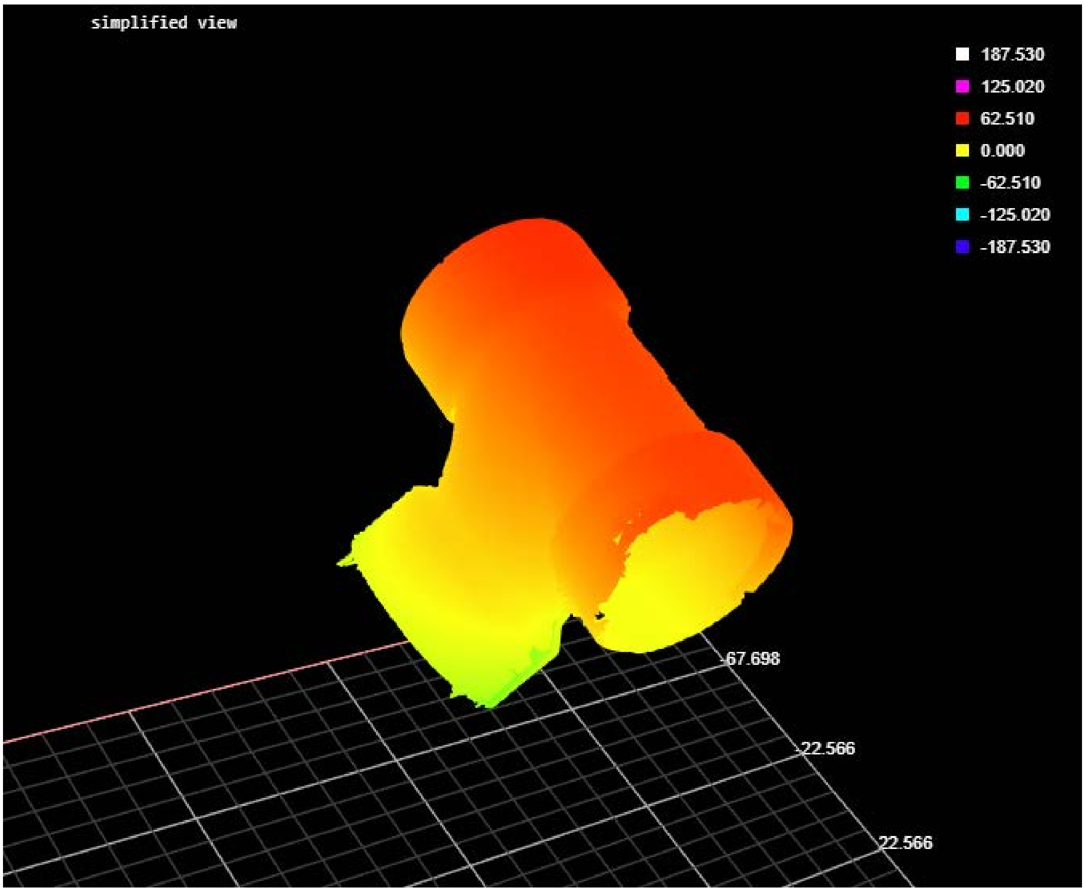
Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Input Plane]	The tool aligns the XY plane to the selected plane geometric feature in the output Surface data.
[Input Line]	The tool aligns the X axis to the selected line geometric feature in the output Surface data.
[Input Point]	The tool uses the selected point geometric feature the origin in the output Surface data.
[Add Fixed Transform]	When this parameter is enabled, you can provided fixed X, Y, and Z offsets, as well as X, Y, and Z angles, which the tool uses in the output Surface data.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

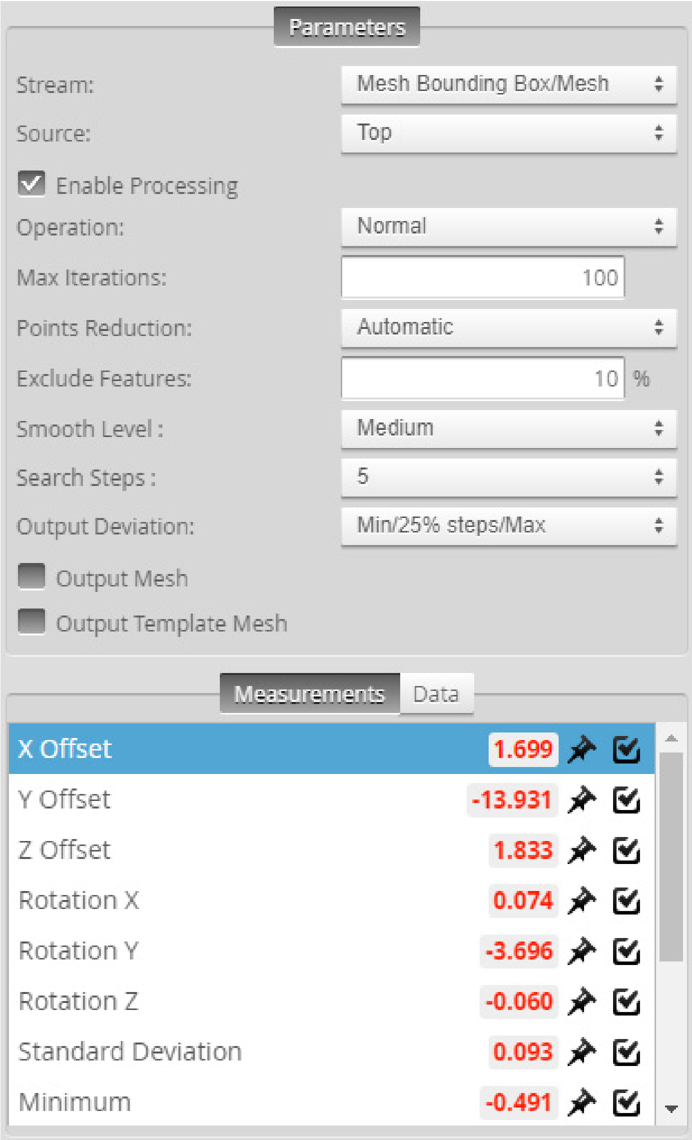
■ Template Matching

Tips

The tool is supported in emulator scenarios.

The Mesh Template Matching tool takes in Mesh scan data (produced by the Surface Mesh tool) and a template you previously defined based on a "golden part" (itself created using the Mesh Template Matching tool). The tool returns measurements related to the position and orientation of the scan data relative to the template, such as offsets and rotations, as well as standard deviations between the scan data and the template. The tool can also output Mesh scan data.





- Measurements, Features, and Settings

[Measurements]

Type	Description
[X Origin] [Y Origin] [Z Origin]	These measurements return the X, Y, and Z position of the center of the fitted bounding box, respectively.
[Rotation X] [Rotation Y] [Rotation Z]	The angle of the fitted bounding box around the X, Y, and Z axis, respecively.
[Standard Deviation]	The standard deviation of the data points from the fitted plane.
[Minimum] [Maximum]	The minimum and maximum error of the data points from the fitted plane, respectively.
[Deviation (x%)]	Deviations of the data points from the fitted plane, sorted into stepped percentiles. You set number of steps using the [Output Deviation] parameter.
[Processing Time]	The time the tool takes to run.

[Data]

Type	Description
[Mesh]	The transformed Mesh. Only listed if the [Output Mesh] parameter is enabled.
[Mesh Template]	The template Mesh. Only listed if the [Output Template Mesh] parameter is enabled.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Enable Processing]	When this option is enabled, the tool compares the Mesh data to the loaded template.
[Operation]	The tool's operation mode. One of the following: • [Normal]: When Enable Processing is enabled, the tool compares the Mesh scan data and the loaded template. • [Load]: Displays a list of Mesh template files (in the [Template File] drop-down) you can load. • [Save]: Saves the current frame of Mesh scan data as a template (in C:\GoTools\Mesh Template Matching\). Type the name of the template in the [File Name] field, and then press Enter or click anywhere outside of the field. • [Delete]: Deletes the initialization file you select in the [Template File] field.
[Max Iterations]	The maximum number of iterations the tool uses to perform match the Mesh scan data with the template. Typically, leave this at the default value.
[Points Reduction]	Controls the number of points used in the matching process, which can improve processing time.
[Exclude Features]	Use this when there are high or low features on the part that should not be included in the matching. For example, at 10%, the tool excludes 10% of the points with maximum or minimum deviation from the matching process.
[Smooth Level]	The amount of smoothing the tool applies. Mitutoyo recommends leaving this setting at its default.
[Search Steps]	Determines the neighborhood level in which to search for connection point pairs.
[Output Deviation]	Determines which deviations are output as measurements, which can be a combination of minimum and maximum, and a set of Deviation (x %) measurements (with the specified step between them). Can also be set so that no deviations are output. Use this to get a rough idea of the distribution of the deviation values (or a histogram of the deviations).
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

4.7.9 Feature Measurement

The following sections describe SurfaceMeasure1008S's Feature tools.

Feature tools produce measurements based on more complex geometry, letting you implement applications more quickly by reducing dependence on writing scripts to accomplish these kinds of measurements. Feature tools take geometric features generated by other tools as input and perform measurements on those features.

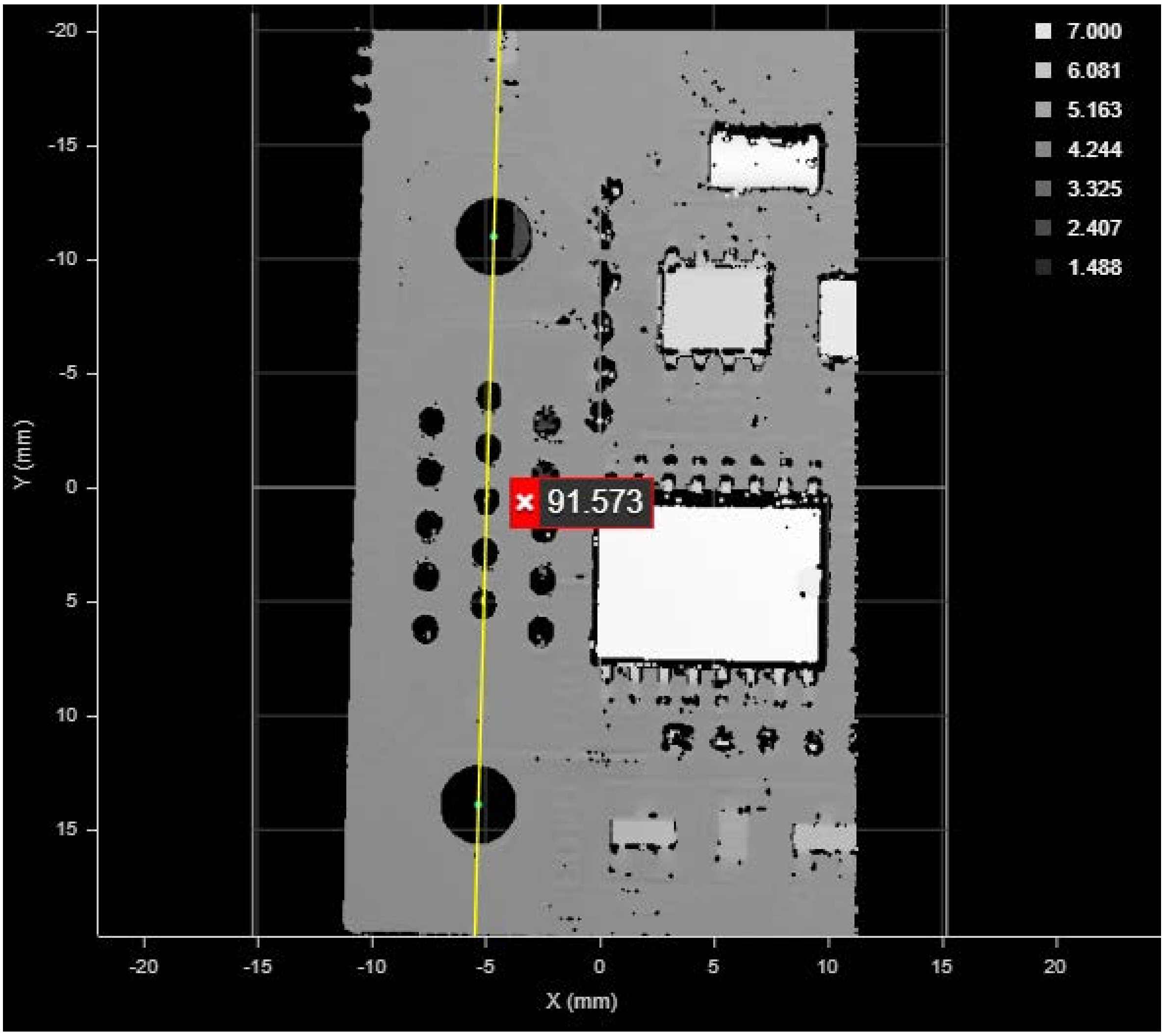
Feature tools are available in either Profile or Surface mode.

> **Tips**
> The Circle geometric feature currently cannot be used by any of the built-in Feature tools.

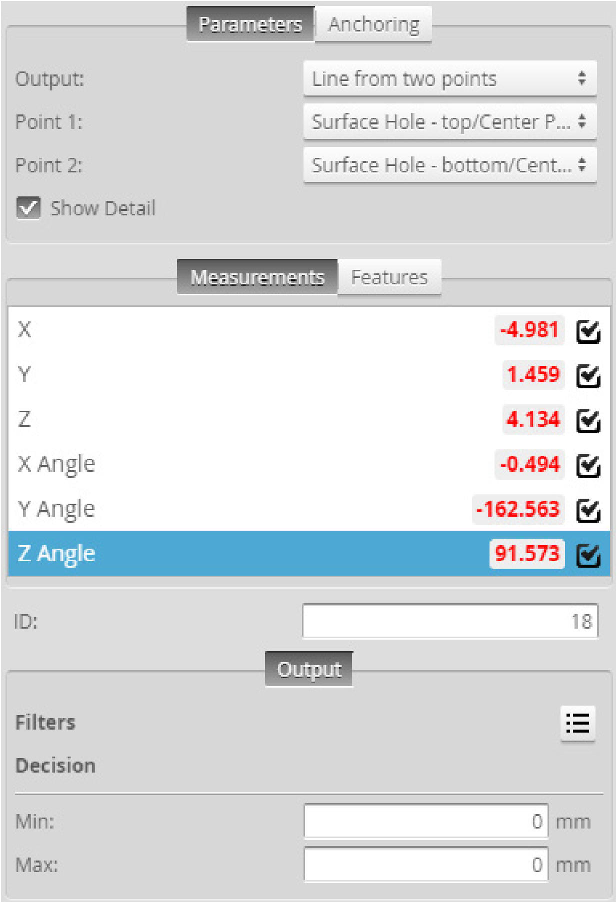
Create

The Feature Create tool lets you generate geometric features from other geometric features (ones generated by other tools). For example, you can create a line from two points, or create a plane from a point and a line. The tool can generate points, lines, circles, or planes. You can also extract measurement values from the geometric features generated by other tools; you can use these values as decisions or use them as anchors in other tools. The advantage of the Feature Create tool is that it means you need to rely less on Script tools or SDK/GDK applications to perform complex geometric operations.

For example, in the following, a Feature Create tool takes the hole geometric features output by two Surface Hole tools to generate a line geometric feature (near-vertical yellow line between the cyan hole center points).



You could perform measurements on the resulting line (X, Y, and Z positional measurements on the line's center point, and, more importantly, angle measurements on the line). You could also use the line's Z angle as an anchor in other tool's in order to increase repeatability.



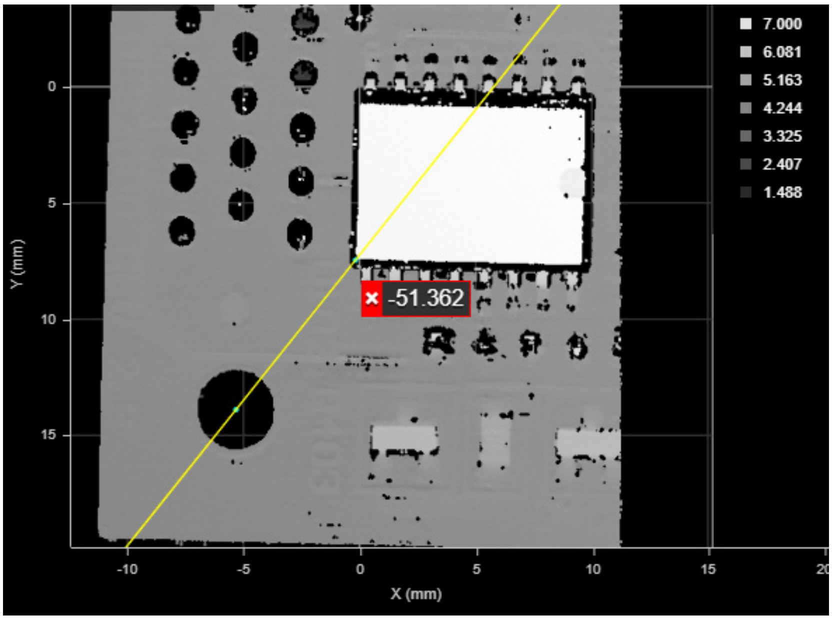
Measurement Panel

The following sections describe the output types available in the [Output] drop-down, the inputs required by each output, and the resulting output.

- Line from Two Points

The [Line from two points] type of output takes two point geometric features as input.

The resulting output is a line geometric feature connecting the two points.



A line between the center point of a hole and the corner of the chip.
(The corner is the intersect point resulting from the Feature Intersect tool,
taking the left vertical and lower horizontal line edges of the chip as input.)

The X, Y, and Z measurements return the midpoint of the line. The X, Y, and Z Angle measurements return the angle of the line.

- Perpendicular or Parallel Line from Point and Line

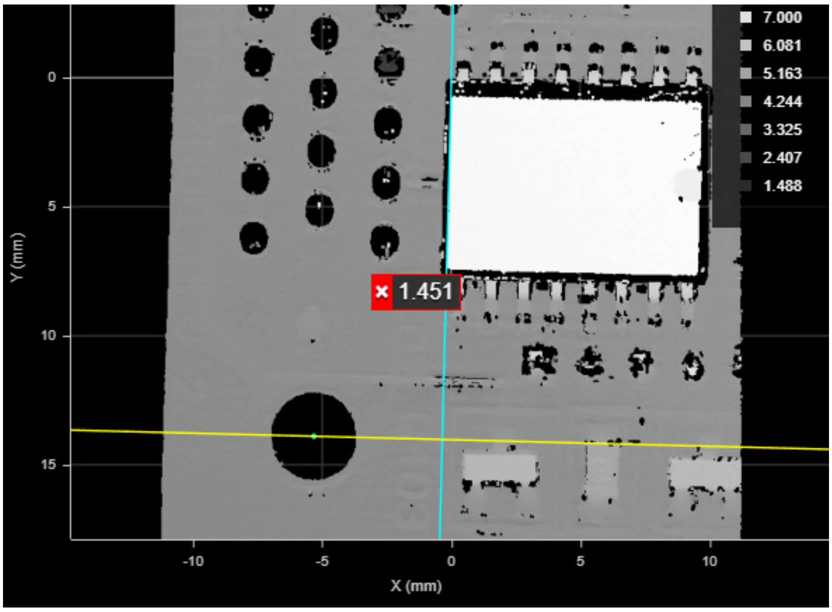
These types of output take a point and a line geometric feature as input to create another line.

For both of these types of line output, the X, Y, and Z measurements return the position of the point.

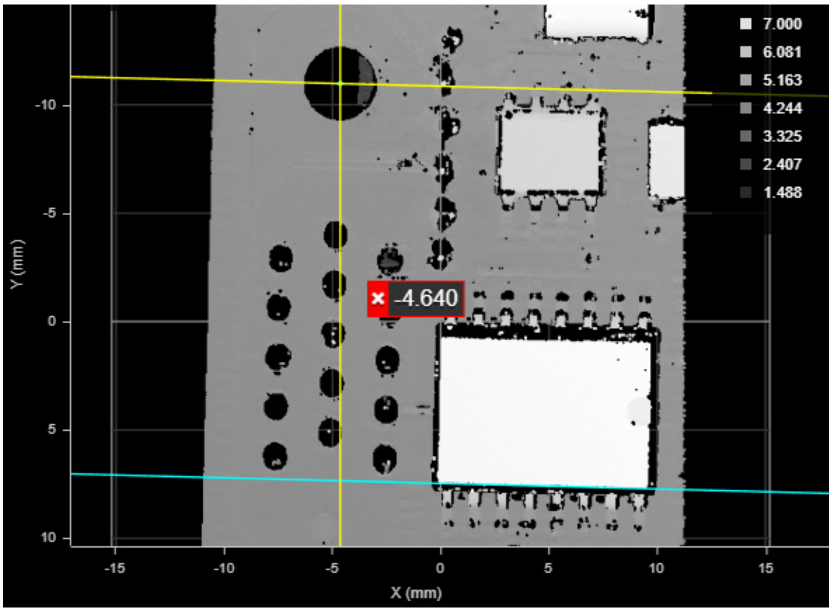
For perpendicular line output, the X, Y, and Z angle measurements return the angles of the line.

For parallel line output, the Z angle measurement returns the angle of the line; the X and Y angle measurements both return arbitrary values.

In the following, the tool generates a roughly vertical line (yellow) perpendicular to the input line (cyan line along the left edge of the large integrated circuit), passing through the input point (cyan dot at the center of the hole).



In the following, the tool generates a roughly horizontal line (yellow) parallel to the input line (cyan line along the bottom edge of the large integrated circuit), passing through the input point (cyan dot at the center of the hole).



- Perpendicular Line from Point to Plane

  Creates a perpendicular line from a point up to a plane.

- Projected Point on Plane

  Creates a point projected onto a plane.

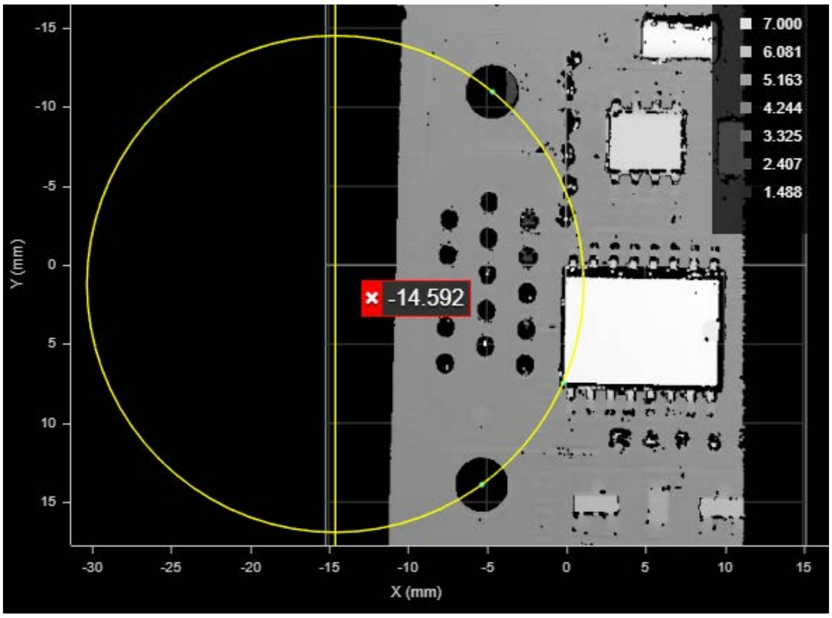
- Projected Line on Plane

  Creates a line projected onto a plane.

- Circle from Points

  The [Circle from points] output type takes three point geometric features and fits a circle to those points. The circle is always on the XY plane.

  The X, Y, and Z measurements return the center of the circle. The X, Y, and Z Angle measurements return arbitrary values.



Circle generated from the center points of the two holes and the corner of the chip (cyan points).
(The corner is the intersect point resulting from the Feature Intersect tool,
taking the left vertical and lower horizontal line edges of the chip as input.)

- Plane from Point and Normal

  Creates a plane from a point and a normal.

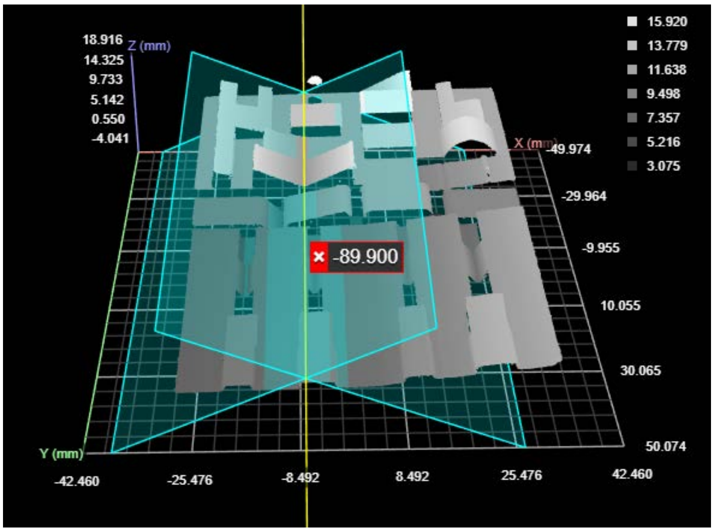
- Plane from Three Points

  Creates a plane from three points.

- Line from Two Planes

  The [Line from two planes] output type takes two plane geometric features as input and creates a line at their intersection.

  The X, Y, and Z measurements return the midpoint. The X, Y, and Z Angle measurements return the angle of the line.

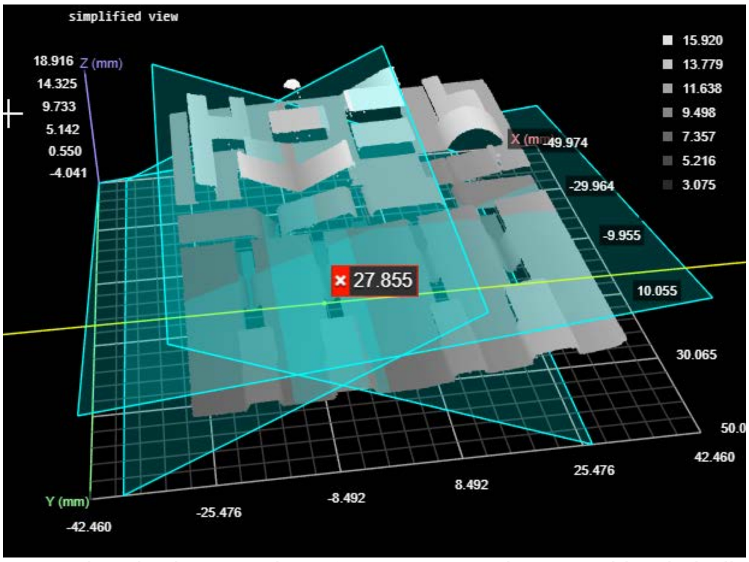


A line generated at the intersection of two planes. The Z angle is indicated.

- Point from Three Planes

The [Point from three planes] output type takes three plane geometric features as input and creates a point at their intersection.

The X, Y, and Z measurements return the position of the intersect point. The X, Y, and Z Angle measurements return arbitrary values.



A point generated at the intersection of two planes. The Y position is indicated here.

- Point from Line and Circle

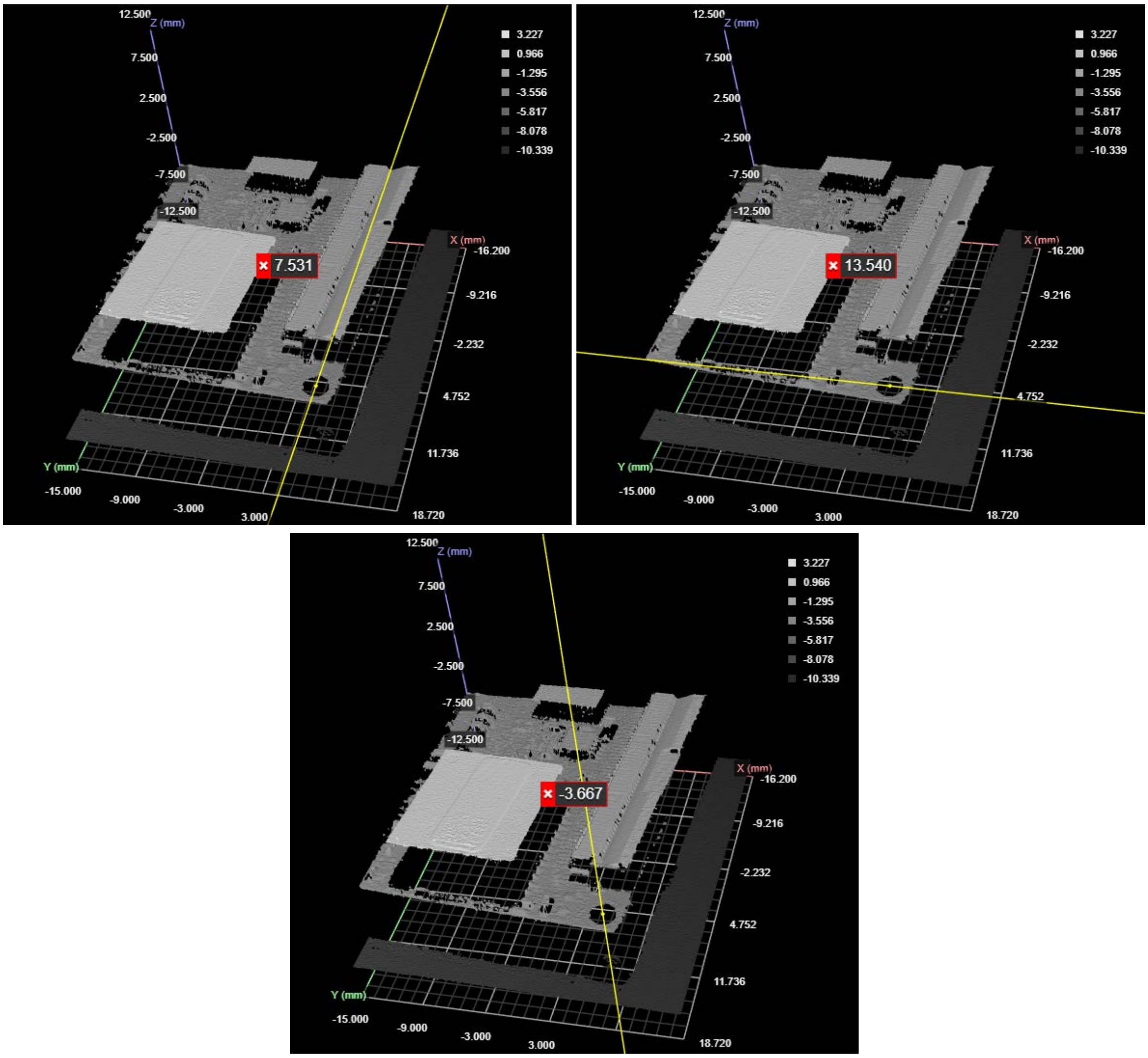
Creates a point from a line and a circle (their intersection).

- Point or Line

The [Point] and [Line] types of output take a point or a line geometric feature as input, respectively.

These outputs are useful if the tool takes features generated by another Feature Create tool as input, on which you want to perform measurements in the second Feature Create tool. Also, this can be useful if you have developed GDK tools that only generate geometric features (no measurements): you can use this tool to extract those measurements.

For point output, the X, Y, and Z measurements return the X, Y, and Z position of the point; the angle measurements all return arbitrary values.



Positional measurements of a point

For line output, the X, Y, and Z measurements return the midpoint of the line. The Z Angle measurement returns the angle of the line around the Z axis. The X angle and Y angle measurements return arbitrary values.

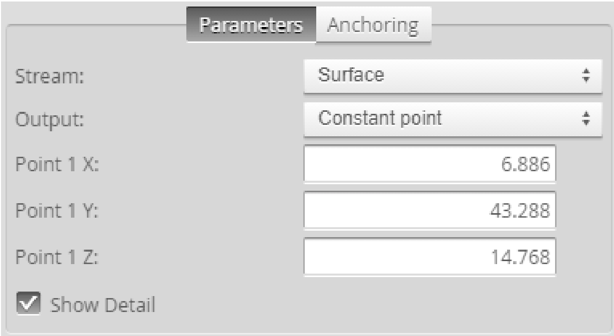
- Line Rotated around a Point

This output type lets you choose a Line geometric feature and a Point geometric feature around which the line is rotated by the value you set in [Rotation] angle.

If [Stream] is set to Profile data, the tool rotates the line around the Y axis of the input point (a valid XZ point). If [Stream] is set to Surface data, the tool rotates the line around the Z axis of the input point (a valid XYZ point).

- **Constant Point, Line, and Plane**

Choosing these output types displays parameters you can manually fill in to create geometric features. These output types are useful if scan data from frame to frame is reliably fixed and you want to measure from an arbitrary point, line, or plane to a feature.



See "■Adding and Configuring a Measurement Tool" on page 235 for instructions on how to add measurement tools.

[Measurements]

Type	Description
[X], [Y], [Z]	The X, Y, and Z positions of some aspect of the geometric feature. For more information, see the sections above.
[X Angle], [Y Angle], [Z Angle]	The X, Y, and Z angles of some aspect of the geometric feature. For more information, see the sections above.

Note that even when enabled on the [Features] tab, not all features are generated. (For example, with Line selected as the output type, only a line geometric feature can be generated: point, circle, and plane features are not generated.)

[Features]

Type	Description
[Point]	The generated point geometric feature.
[Line]	The generated line geometric feature.
[Circle]	The generated circle geometric feature.
[Plane]	The generated plane geometric feature.

[Parameters]

Parameter	Description
[Output]	The type of output the tool generates. Switching between the options changes the input types displayed in the tool.
[Show Detail]	Toggles the display of the input geometric features in the data viewer.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

■ Dimension

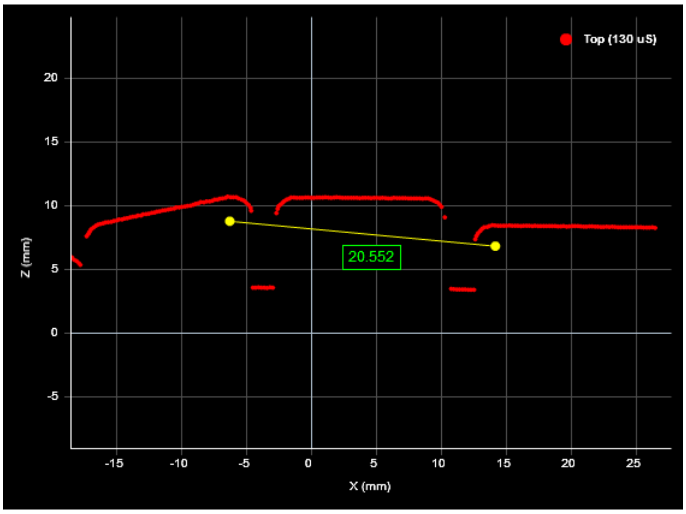
The Feature Dimension tool provides dimensional measurements from a point geometric feature to a reference point, line, or plane geometric feature.

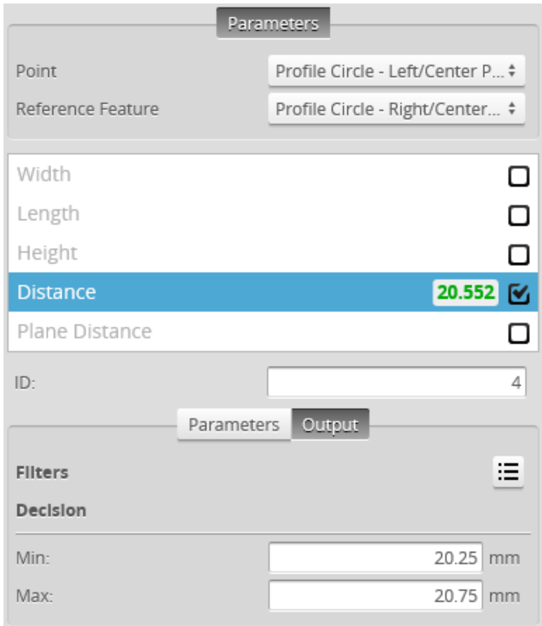
Some examples:

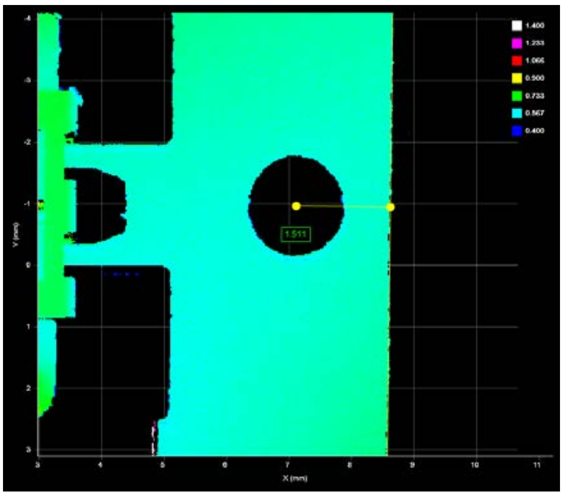
- Measuring the distance between the center of a hole and an edge.
- Measuring the distance between the centers of two holes.
- Measuring the distance between a point and a plane.
- Measuring the distance between a point and the closest point on a circle.
- Obtaining the length of a stud by measuring the distance between its tip and base.

The sensor compares the measurement value with the values in [Min] and [Max] to yield a decision. For more information on decisions, see 📖 "●Decisions" on page 251.

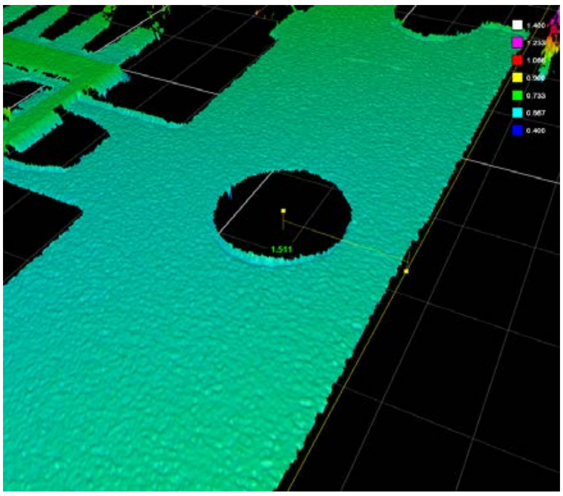
See 📖 "■Adding and Configuring a Measurement Tool" on page 235 for instructions on how to add measurement tools.



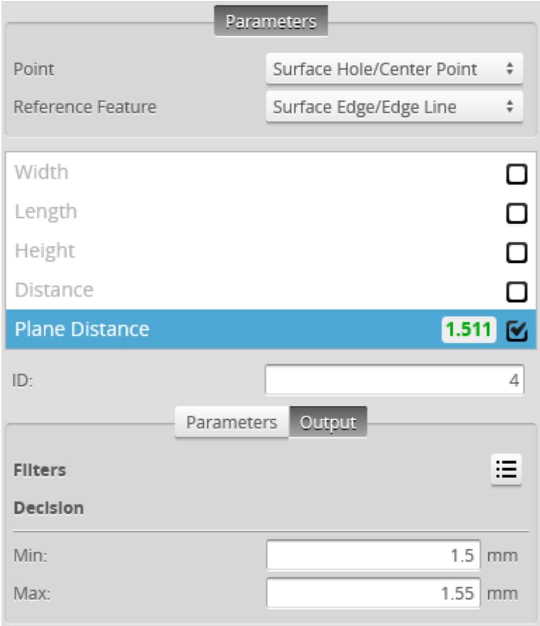




2D View



3D View

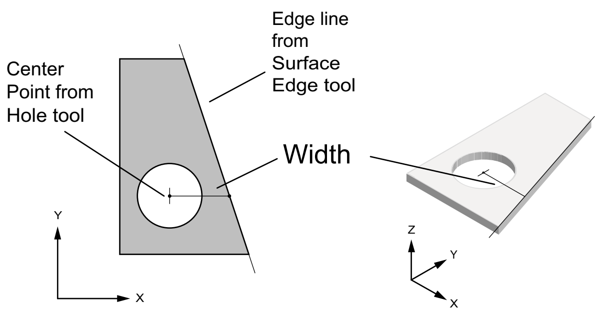


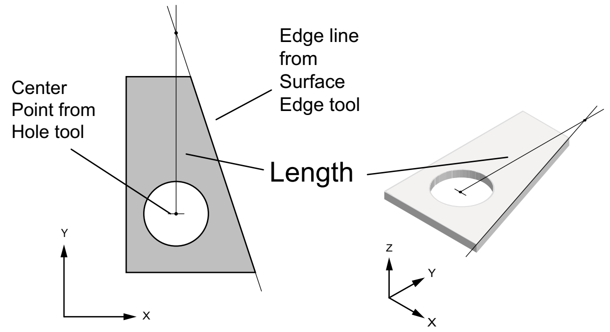
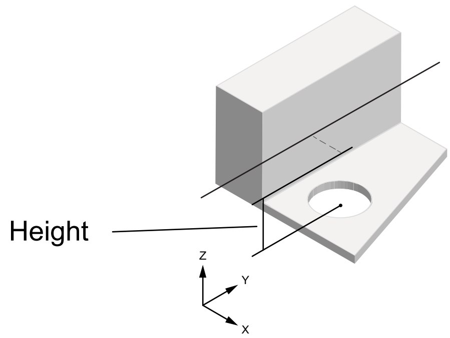
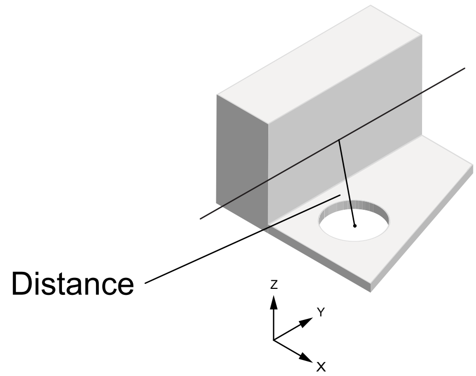
Measurement Panel

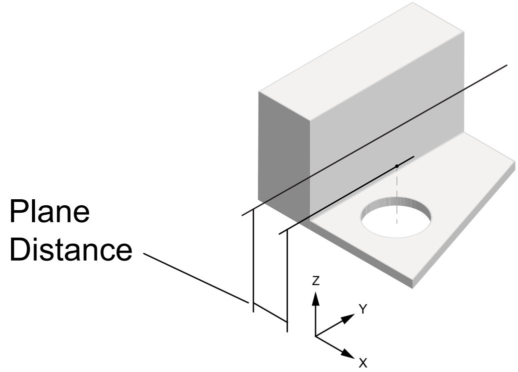
> **Tips**
> In the following measurement descriptions, the first geometric feature is set in the [Point] drop-down. The second geometric feature is set in the [Reference Feature] drop-down.

> **Tips**
> When [Reference Feature] is set to a feature other than a point, such as a circle or a line, measurements are between the point in [Point] and the nearest point on the reference feature (for example, the nearest point on a circle).

[Measurements]

Measurement	Illustration
[Width] Point-point: The difference on the X axis between the points. Point-line: The difference on the X axis between the point and a point on the line. For profiles, the point on the line is at the same Z position as the first point. For surface data, the point on the line is at the same Y position. Point-plane: The difference on the X axis between a point and a point on the plane with the same Y and Z coordinates as the first point (or the intersection of the plane and a line from the first point, parallel to the X axis).	

Measurement	Illustration
[Length] Point-point: The difference on the Y axis between the points. Point-line: The difference on the Y axis between the point and, for profiles, the nearest point on the line; currently, always zero. For surface data, the point on the line is at the same X position as the first point. Point-plane: The difference on the Y axis between the point and a point on the plane with the same X and Z coordinates as the first point (or the intersection of the plane and a line from the first point, parallel to the Y axis).	
[Height] Point-point: The difference on the Z axis between the points. Point-line: The difference on the Z axis between the point and, for profiles, a point on the line at the same X position as the first point. For surface data, the point on the line is the one nearest to the first point. Point-plane: The difference on the Z axis between the point and a point on the plane with the same X and Y coordinates as the first point (or the intersection of the plane and a line from the first point, parallel to the Z axis).	
[Distance] Point-point: The direct, Euclidean distance between two point geometric features. Point-line: The direct, Euclidean distance between a point and the nearest point on the line. Point-plane: The direct, Euclidean distance between a point and the nearest point on the plane.	

Measurement	Illustration
[Plane Distance] Point-point: The distance between two point geometric features. For profile data, the points are projected onto the XZ plane (always the same as the Distance measurement). For surface data, the points are projected onto the XY plane. Point-line: The distance between a point and a line. For profile data, projected onto the XZ plane (always the same as the Distance measurement). For surface data, the distance is projected onto the XY plane. Point-plane: The distance between a point and a plane. For profiles, the distance is projected onto the XZ plane (always the same as the Distance measurement). For surface data, the distance is projected onto the XY plane.	

[Parameters]

Parameter	Description
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool. If you switch from one type of data to another (for example, from section profile data to surface data), currently set input features will become invalid, and you will need to choose features of the correct data type.
[Point]	A point geometric feature generated by another tool.
[Reference Feature]	A feature generated by another tool. Dimensional measurements are calculated from the reference feature to the point in the [Point] setting.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

■ Intersect

The Feature Intersect tool returns the intersection of a line or plane geometric features and a second line or plane geometric feature. For line-line intersections, the lines are projected onto the Z = reference Z line plane for features extracted from a surface, and the intersection of the lines projected onto the Y = 0 plane for features extracted from a profile. The angle measurement between the two lines is also returned. The lines the tool takes as input are generated by other tools, such as Surface Edge or Surface Ellipse.

The Feature Intersect tool saves you from having to write complicated calculations in script tools to find intersect point between lines. Previously, calculating the intercept point of two lines was difficult and prone to bugs, involving finding lines in indirect ways.

The Feature Intersect tool's positional measurements are particularly useful as anchor sources. For example, you can easily find a corner point on a part from two edges (produced by two Surface Edge tools) and using the X and Y positions as anchor sources.

When you use these positional anchors in combination with a Z Angle anchor from tools such as Surface Edge, you can achieve extremely robust, repeatable measurements.

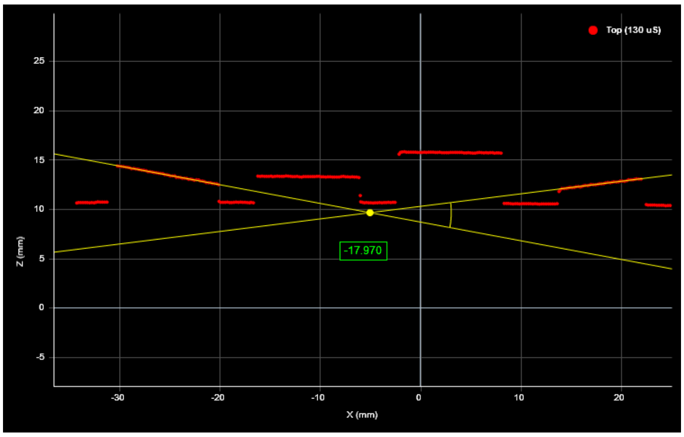
> **Tips**
> This tool's Angle measurement cannot be used as an angle anchor source. Only Z Angle measurements can be used as angle anchor sources.

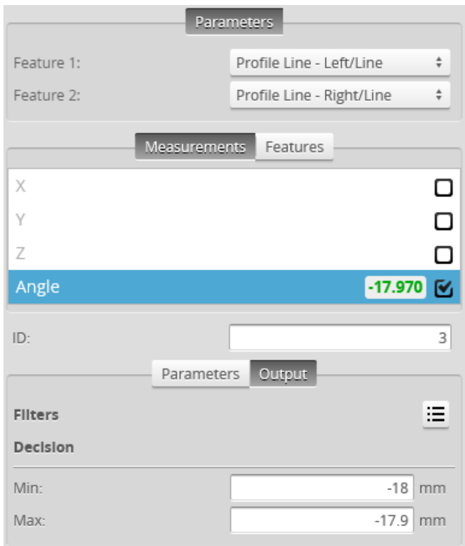
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

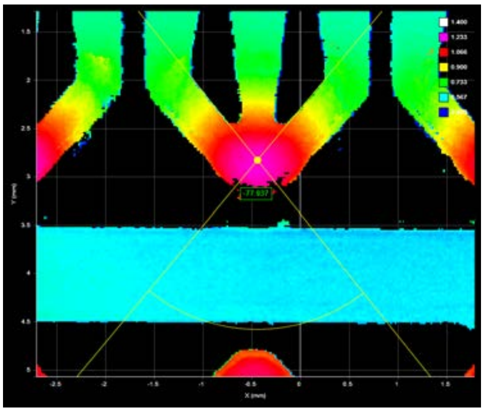
The Feature Intersect tool can also generate a point geometric feature representing the point of intersection of the lines that the Feature Dimension tool can use in measurements.

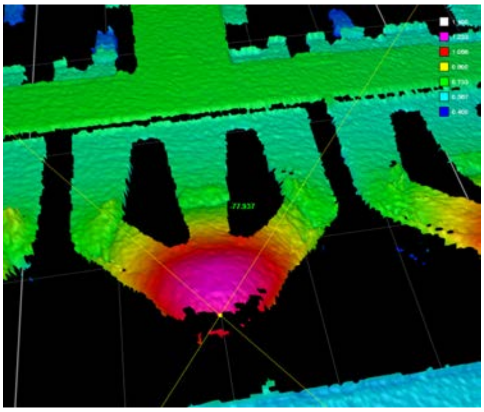
The sensor compares the measurement value with the values in [Min] and [Max] to yield a decision. For more information on decisions, see 📖 "●Decisions" on page 251.

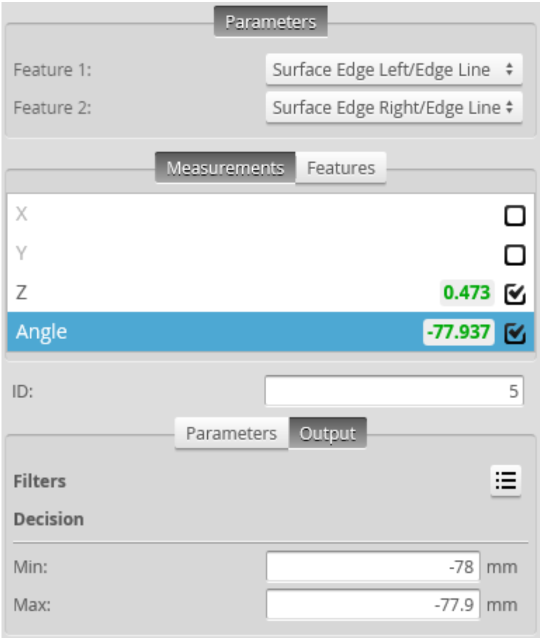
See 📖 "■Adding and Configuring a Measurement Tool" on page 235 for instructions on how to add measurement tools.





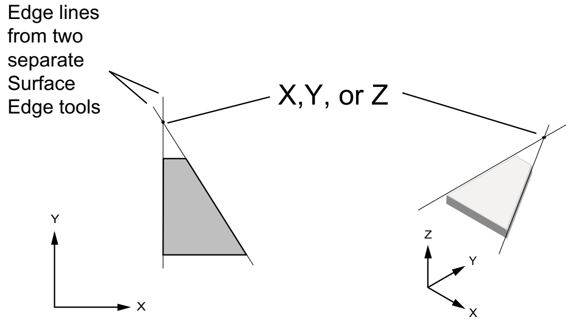
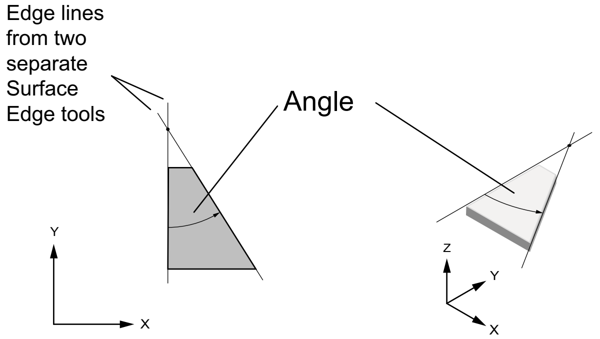
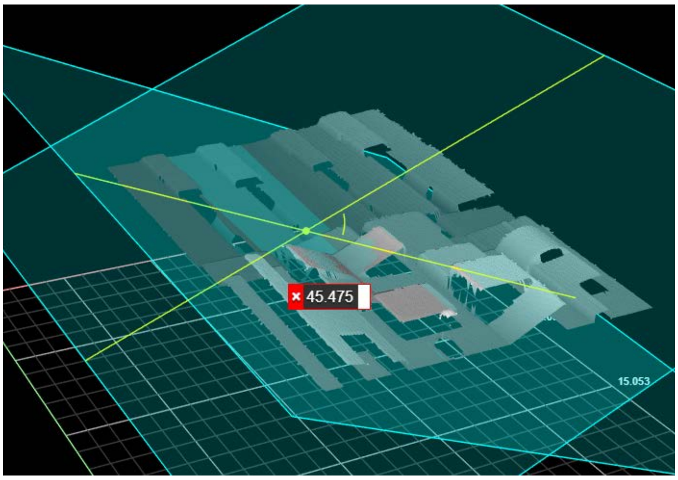

2D View


3D View



Measurement Panel

[Measurements]

Measurement	Illustration
[X] Line-Line: The X position of the intersect point between the lines. Line-Plane: The X position of the intersect point between the line and the plane. Plane-Plane: The X position of the center of the line intersecting the planes.	
[Y] Line-Line: The Y position of the intersect point between the lines. Line-Plane: The Y position of the intersect point between the line and the plane. Plane-Plane: The Y position of the center of the line intersecting the planes.	
[Z] Line-Line: The Z position of the intersect point between the lines. Line-Plane: The Z position of the intersect point between the line and the plane. Plane-Plane: The Z position of the center of the line intersecting the planes.	
[Angle] Line-Line: The angle between the lines, as measured from the line selected in [Reference Feature] to the line selected in [Line]. Line-Plane: The angle between the line and the perpendicular projection of the line onto the plane, as measured from the plane geometric feature selected in [Reference Feature] to the line selected in [Line]. Plane-Plane: The angle between the two planes, as measured from the plane geometric features selected in [Feature 1] and [Feature 2]. For line-line and line-plane angle measurements, the [Angle Range] setting determines how angles are expressed. (The setting does nothing with plane-plane angle measurements.)	 In the following image, the angle is measured between two planes (the small angled surfaces facing each other in the center of the image). 

[Features]

Type	Description
[Intersect Point]	The intersect point of the two features.

[Parameters]

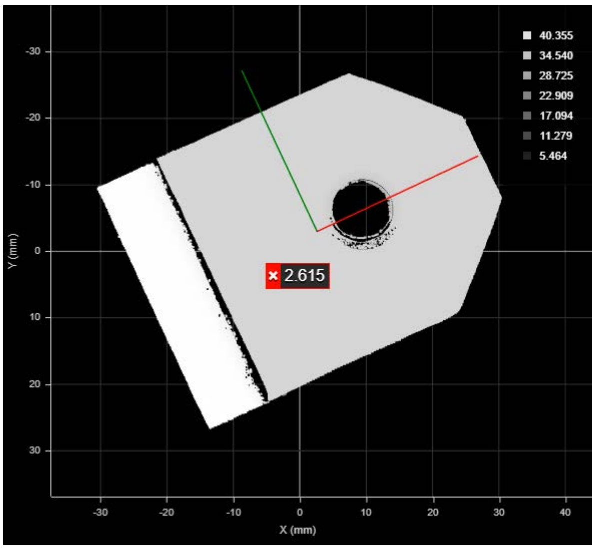
Parameter	Description
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool. If you switch from one type of data to another (for example, from section profile data to surface data), currently set input features will become invalid, and you will need to choose features of the correct data type.
[Feature 1]	A line or plane geometric feature generated by another tool.
[Feature 2]	A line or plane geometric feature generated by another tool. For the Angle measurement, the angle is measured from this feature.
[Angle Range] (Angle measurement only; does nothing with plane-plane measurements)	Determines the angle range.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

Robot Pose

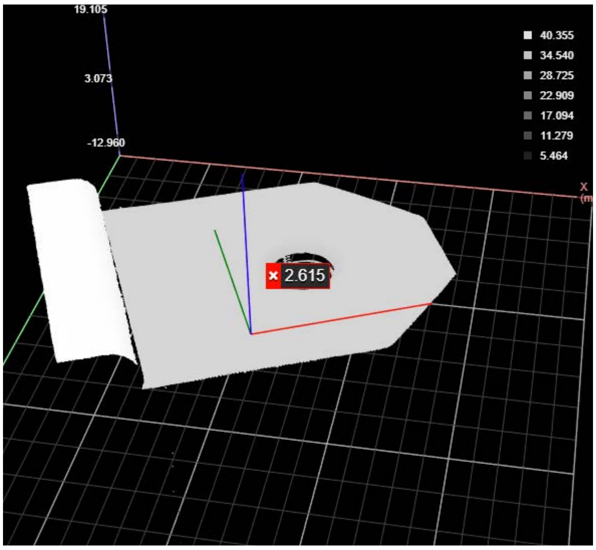
The tool is supported in emulator scenarios.

The Feature Robot Pose tool takes geometric features as input and outputs positional and rotational values. You can use these values in a robot system to control the robot.

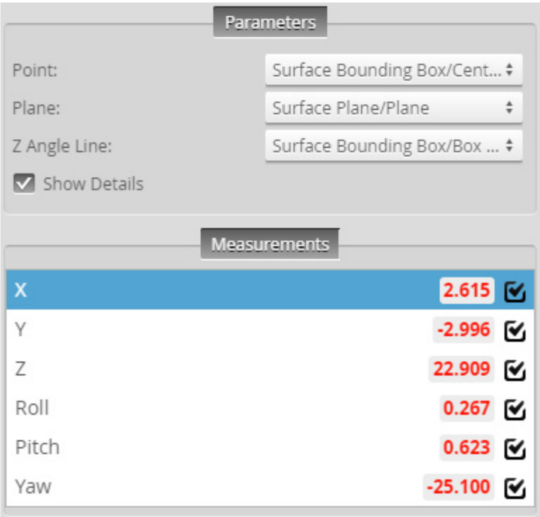
In the following images, the Robot Pose tool has returned positional (X, Y, and Z) and rotational (roll, pitch, and yaw) information on a part.



2D View



3D View

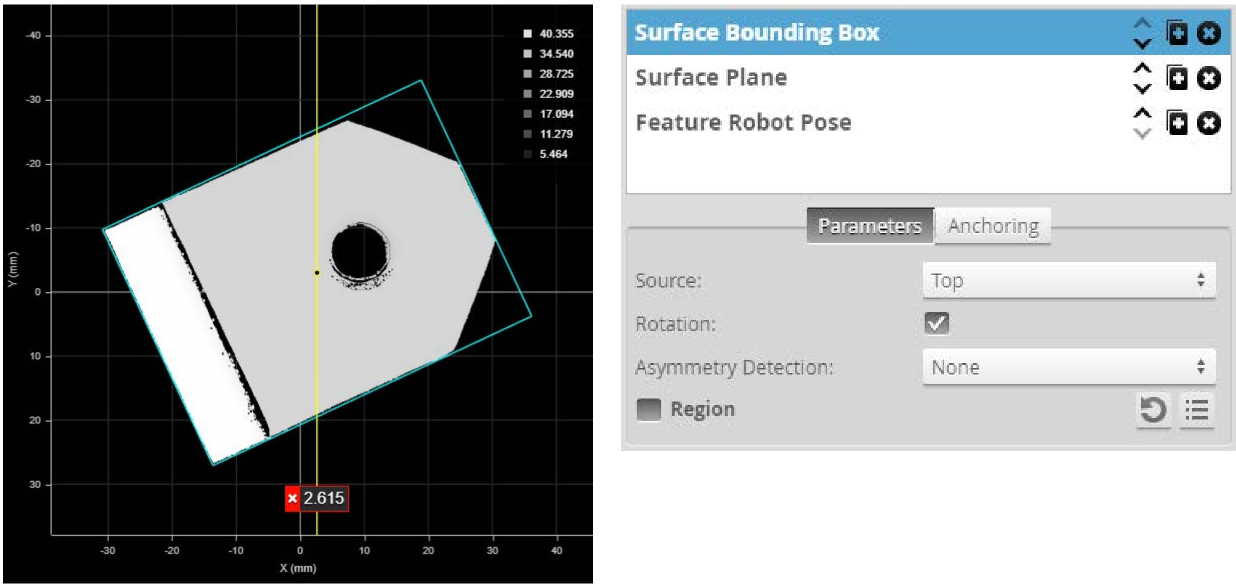


Measurement Panel

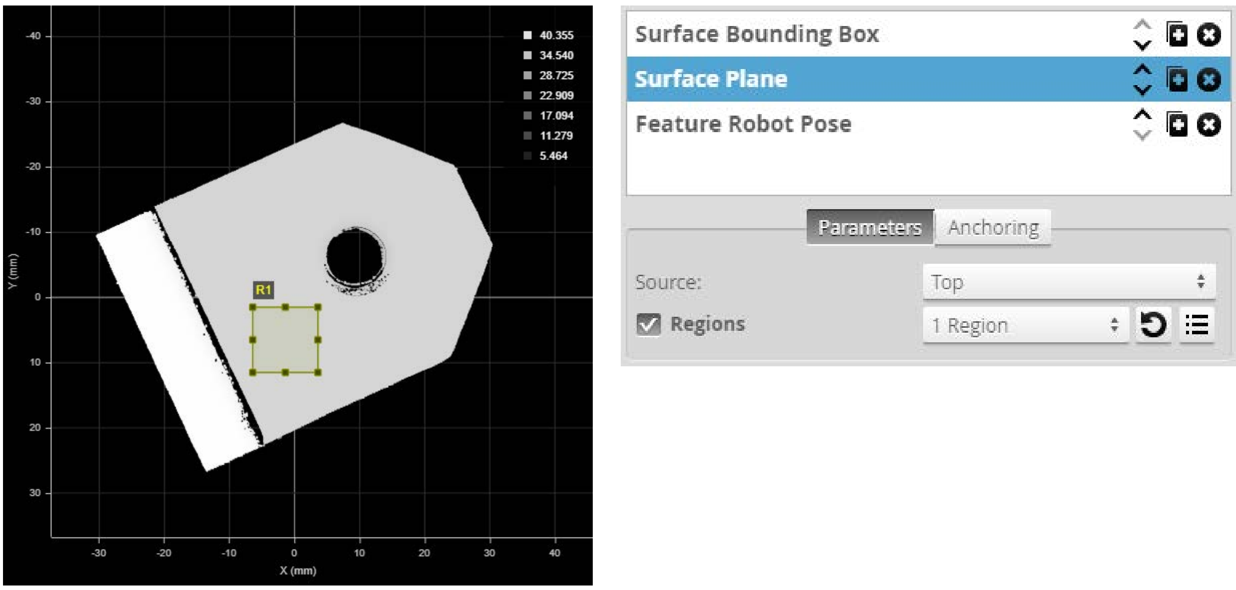
At a minimum, the Robot Pose tool needs the following input:

- A Point geometric feature to determine XYZ information
- A Plane geometric feature to determine roll and pitch (rotation around the X and Y axes)

Including a Line geometric feature lets the tool also return yaw (Z rotational information). For example, to get pose information for the part shown below, you could first configure a Surface Bounding Box tool and a Surface Plane tool.



Bounding Box tool. The tool is configured to rotate to accommodate the orientation of the part.

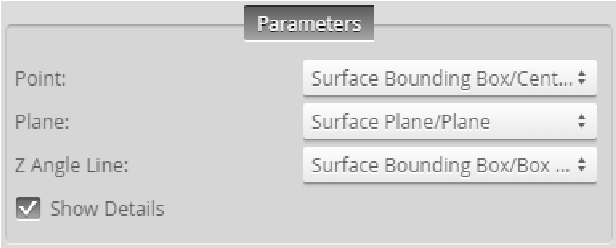


Surface Plane tool on flat area of part.

With both tools, you must enable the required feature outputs on the Feature tabs:

Enabled geometric features in Features tabs of Bounding Box and Plane tools, respectively.

Then select the features as input (the first three parameters) in the Robot Pose tool:



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

● Measurements and Settings

[Measurements]

Type	Description
[X], [Y], [Z]	The X, Y, and Z positions of the Point geometric feature.
[Roll], [Pitch], [Yaw]	The rotational angles of the Plane and Line geometric feature.

[Data]

Type	Description
[Matrix]	Data containing a matrix representing the same pose as the tool's measurements. It can be deserialized into a GoRobotMatrix structure using the GoRobot library.

[Parameters]

Parameter	Description
[Point]	The Point geometric feature the tool extracts the X, Y, and Z measurements from. This input is required.
[Plane]	The Plane geometric feature the tool extracts the Roll and Pitch measurements from. This input is required.
[Z Angle Line]	The Line geometric feature the tool extracts the Yaw measurement from. This input is optional. If you omit it, the X and Y axes will be parallel to the sensor's X and Y axes.
[Show Details]	Toggles the display of additional visualizations in the data viewer.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

4.7.10 Scripts

Script tools use outputs from other measurement tools to produce custom measurements.
Similar to other measurement tools, a script tool can output multiple measurement values and decisions. Scripts are added, configured, and removed much like other measurement tools; for more information on this, see Script under 📖 "5 Profile Measurement" on page 343 or
📖 "4 SurfaceMeasure1008S Web Interface" on page 75.

Tips
Scripts are limited to 1 megabyte of memory. As a general guideline, calculate the combined memory used by the script given its length in characters and the number and types of variables, structures, and arrays the script uses.

Script tools use a simplified C-based syntax. The following elements of the C language are supported:

Supported Elements

Elements	Supported
Control operators	if, while, do, for, switch and return.
Data types	char, int, unsigned int, float, double, long long (64-bit integer).
Arithmetic and logical Operator	Standard C arithmetic operators, except ternary operator (i.e., "condition?trueValue:falseValue"). Explicit casting (e.g., int a = (int) a_float) is not supported.
Function declarations	Standard C function declarations with argument passed by values. Pointers are not supported.
Array declarations	Standard C array declarations. For example: float measurements[5].
Standard arithmetic functions	+ , −, *, /, %, ++, --

■ Built-in Script Functions

The script engine provides the following types of functions:

- Measurement
- Output
- Memory
- Runtime variable
- Stamp
- Math

Measurement Functions

Function	Description
int Measurement_Exists(int id)	Determines if a measurement exists by ID. Parameters: id – Measurement ID Returns: 0 – measurement does not exist 1 – measurement exists

Function	Description
int Measurement_Valid(int id)	Determines if a measurement value is valid by its ID. Parameters: id - Measurement ID Returns 0 - Measurement is invalid 1 - Measurement is valid
double Measurement_Value (int id)	Gets the value of a measurement by its ID. Parameters: id - Measurement ID Returns: Value of the measurement 0 – if measurement does not exist 1 – if measurement exists
int Measurement_Decision (int id)	Gets the decision of a measurement by its ID. Parameters: ID - Measurement ID Returns: Decision of the measurement 0 – if measurement decision is false 1 – If measurement decision is true
int Measurement_NameExists(char* toolName, char* measurementName)	Determines if a measurement exist by name. Parameter: toolName – Tool name measurementName – Measurement name Returns: 0 – measurement does not exist 1 – measurement exists
int Measurement_Id (char* toolName, char* measurementName)	Gets the measurement ID by the measurement name. Parameters: toolName – Tool name measurementName – Measurement name Returns: -1 – measurement does not exist Other value – Measurement ID

Output Functions

Function	Description
void Output_Set (double value, int decision)	Sets the output value and decision on Output index 0. Only the last output value / decision in a script run is kept and passed to the SurfaceMeasure1008S output. To output an invalid value, the constant INVALID_VALUE can be used (e.g., Output_SetAt(0, INVALID_VALUE, 0)) Parameters: value - value output by the script decision - decision value output by the script. Can only be 0 or 1
void Output_SetAt(unsigned int index, double value, int decision)	Sets the output value and decision at the specified output index. To output an invalid value, the constant INVALID_VALUE can be used (e.g., Output_SetAt(0, INVALID_VALUE, 0)) Parameters: index – Script output index value – value output by the script decision – decision value output by the script. Can only be 0 or 1
void Output_SetId(int id, double value, int decision)	Sets the output value and decision at the specified script output ID. To output an invalid value, the constant INVALID_VALUE can be used (e.g., Output_SetId(0, INVALID_VALUE, 0)) Parameters: id – Script output ID

Memory Functions

Function	Description
void Memory_Set64s (int id, long long value)	Stores a 64-bit signed integer in persistent memory. Parameters: id - ID of the value value - Value to store
long long Memory_Get64s (int id)	Loads a 64-bit signed integer from persistent memory. Parameters: id - ID of the value Returns: value - Value stored in persistent memory
void Memory_Set64u (int id, unsigned long long value)	Stores a 64-bit unsigned integer in the persistent memory Parameters: id - ID of the value value - Value to store
unsigned long long Memory_Get64u (int id)	Loads a 64-bit unsigned integer from persistent memory. Parameters: id - ID of the value Returns: value - Value stored in persistent memory

Function	Description
void Memory_Set64f (int id, double value)	Stores a 64-bit double into persistent memory. Parameters: id - ID of the value value - Value to store
double Memory_Get64f (int id)	Loads a 64-bit double from persistent memory. All persistent memory values are set to 0 when the sensor starts. Parameters: id - ID of the value Returns: value - Value stored in persistent memory
int Memory_Exists (int id)	Tests for the existence of a value by ID. Parameters: id – Value ID Returns: 0 – value does not exist 1 – value exists
void Memory_Clear (int id)	Erases a value associated with an ID. Parameters: id – Value ID
void Memory_ClearAll()	Erases all values from persistent memory

Runtime Variable Functions

Function	Description
int RuntimeVariable_Count()	Returns the number of runtime variables that can be accessed. Returns: The count of runtime variables.
int RuntimeVariable_Get32s(int id)	Returns the value of the runtime variable at the given index. Parameters: Id – ID of the runtime variable Returns: Runtime variable value

Stamp Functions

Function	Description
long long Stamp_Frame()	Gets the frame number of the last frame.
long long Stamp_Time()	Gets the time stamp of the last frame.
long long Stamp_Encoder()	Gets the encoder position of the last frame when the image data was scanned/taken.
long long Stamp_EncoderZ()	Gets the encoder position at the time of the last index pulse of the last frame.
unsigned int Stamp_Inputs()	Gets the digital input state of the last frame. Returns a bit field representing digital input states.

Math Functions

Function	Description
float sqrt(float x)	Calculates square root of x
float sin(float x)	Calculates sin(x) (x in radians)
float cos(float x)	Calculates cos(x) (x in radians)
float tan(float x)	Calculates tan(x) (x in radians)
float asin(float x)	Calculates asin(x)
float acos(float x)	Calculates acos(x)
float atan(float x)	Calculates atan(x)
float pow (float x, float y)	Calculates the exponential value. x is the base, y is the exponent
float fabs(float x)	Calculates the absolute value of x

Example: Accumulated Volume

The following example shows how to create a custom measurement that is based on the values from other measurements and persistent values. The example calculates the volume of the target using a series of box area measurement values.

```
/* Calculate the volume of an object by accumulating the boxArea measurements*/
/* Encoder Resolution is 0.5mm. */
/* BoxArea Measurement ID is set to 1*/

long long encoder_res = 500;

int id = 1;

long long boxArea = Measurement_Value(id);
long long Volume = Memory_Get64s(0) + boxArea;

Memory_Set64s(0, Volume);

if (Volume > 1000000)
{
Output_Set(Volume, 1);
}
else
{
Output_Set(Volume, 0);
}
```

4.8 Output

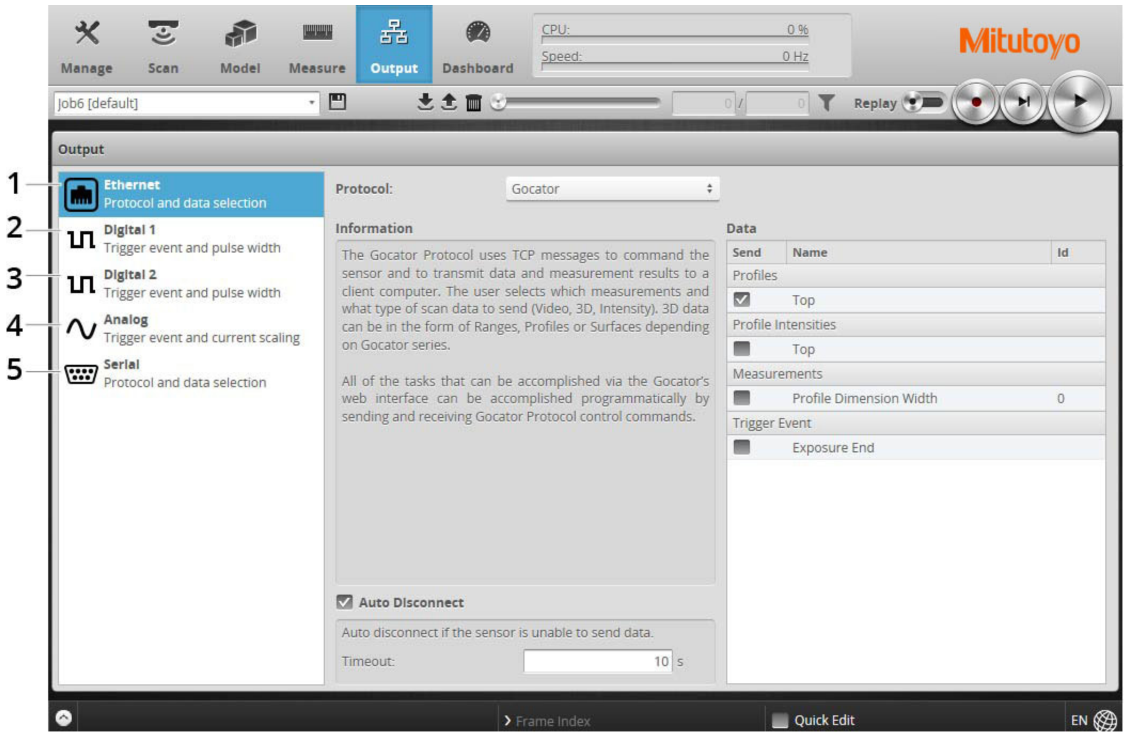
The following sections describe the [Output] page.

4.8.1 Output Page Overview

Output configuration tasks are performed using the [Output] page. SurfaceMeasure1008S sensors can transmit data and measurement results to various external devices using several output interface options.

Tips

Up to two outputs can have scheduling enabled with ASCII as the Serial output protocol. When Selcom is the current Serial output protocol, only one other output can have scheduling enabled.



	Category	Description
1	[Ethernet]	Used to select the data sources that will transmit data via Ethernet. See 📖 "4.8.2 Ethernet Output" on page 327.
2	[Digital Output 1]	Used to select the data sources that will be combined to produce a digital output pulse on Output 1. See 📖 "4.8.3 Digital Output" on page 332.
3	[Digital Output 2]	Used to select the data sources that will be combined to produce a digital output pulse on Output 2. See 📖 "4.8.3 Digital Output" on page 332.
4	[Analog Panel]	Used to convert a measurement value or decision into an analog output signal. See Analog Output on page 655.
5	[Serial Panel]	Used to select the measurements that will be transmitted via RS-485 serial output. See Serial Output on page 659.

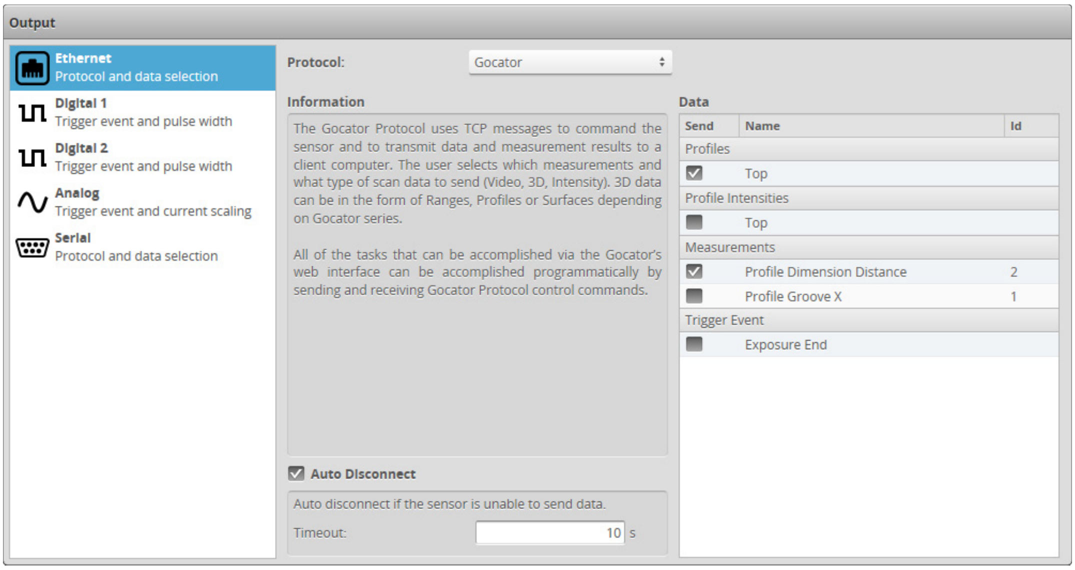
4.8.2 Ethernet Output

A sensor uses TCP messages (SurfaceMeasure1008S protocol) to receive commands from client computers, and to send video, laser profile, intensity, and measurement results to client computers. The sensor can also receive commands from and send measurement results to a PLC using ASCII, Modbus TCP, PROFINET, or EtherNet/IP protocol.

See 📖 "10.1 Protocols" on page 747 for the specification of these protocols.

The specific protocols used with Ethernet output are selected and configured within the panel.

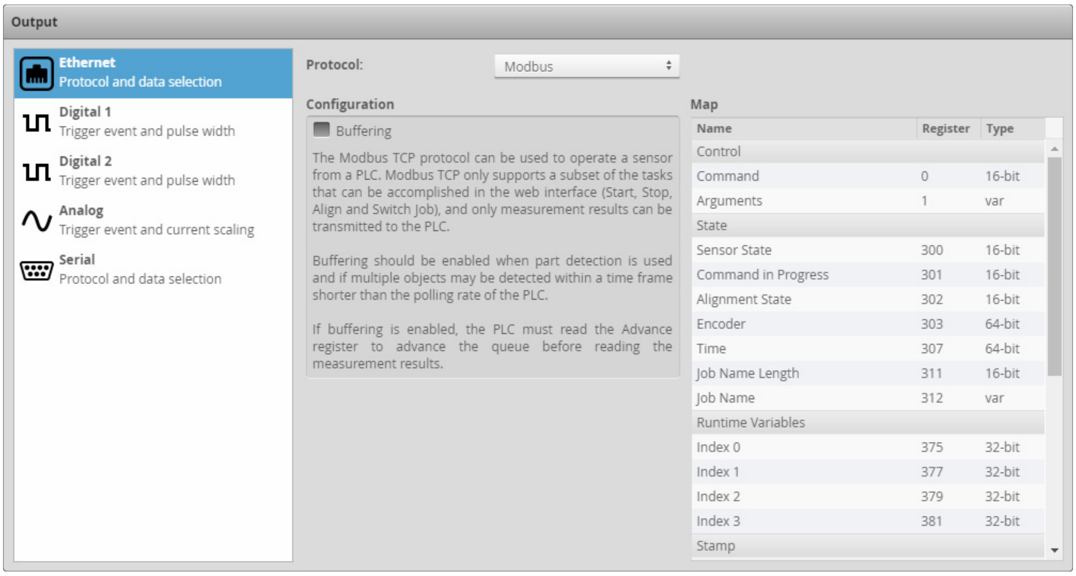
> **Tips**
> The SurfaceMeasure1008S protocol is always on and its output is always available, regardless of the output you choose. This allows simultaneous connections via an SDK application and a PLC, letting you for example archive or display scan data on a PC while controlling equipment with a PLC.



To receive commands and send results using SurfaceMeasure1008S Protocol messages:

1. **Go to the [Output] page.**
2. **Click on the [Ethernet] category in the [Output] panel.**
3. **Select [SurfaceMeasure1008S] as the protocol in the [Protocol] drop-down.**
4. **Check the video, profile, intensity, or measurement items to send.**
5. **(Optional) Uncheck the Auto Disconnect setting.**
   By default, this setting is checked, and the timeout is set to 10 seconds.

All of the tasks that can be accomplished with the SurfaceMeasure1008S's web interface (creating jobs, performing alignment, sending data and health information, and software triggering, etc.) can be accomplished programmatically by sending SurfaceMeasure1008S protocol control commands.



To receive commands and send results using Modbus TCP messages:

1 **Go to the [Output] page.**

2 **Click on [Ethernet] in the [Output] panel.**

3 **Select [Modbus] as the protocol in the [Protocol] drop-down.**

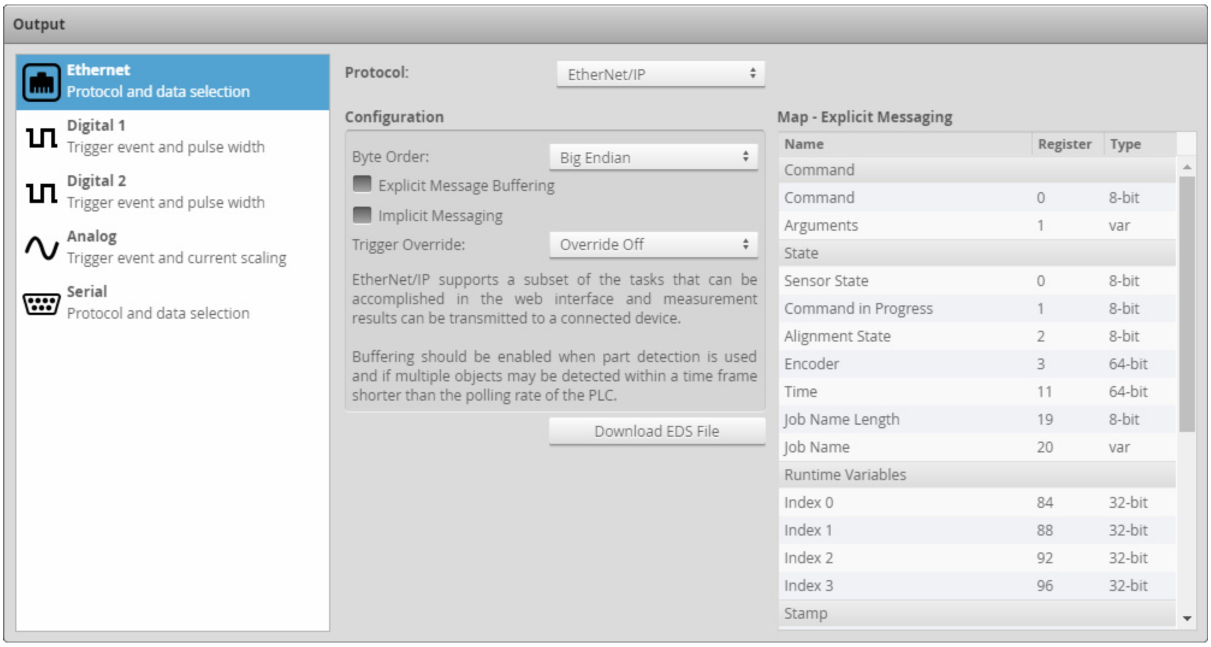
Unlike the SurfaceMeasure1008S Protocol, you do not select which measurement items to output. The Ethernet panel will list the register addresses that are used for Modbus TCP communication.

The Modbus TCP protocol can be used to operate a sensor. Modbus TCP only supports a subset of the tasks that can be performed in the web interface. A sensor can only process Modbus TCP commands when Modbus is selected in the [Protocol] drop-down.

4 **Check the [Buffering] checkbox, if needed.**

Buffering is needed, for example, in Surface mode if multiple objects are detected within a time frame shorter than the polling rate of the PLC.

If buffering is enabled with the Modbus protocol, the PLC must read the Advance register to advance the queue before reading the measurement results.



To receive commands and send results using EtherNet/IP messages:

1 Go to the [Output] page.

2 Click on [Ethernet] in the [Output] panel.

3 Select [EtherNet/IP] in the [Protocol] option.

Unlike using the SurfaceMeasure1008S Protocol, you don't select which measurement items to output. The [Ethernet] panel will list the register addresses that are used for EtherNet/IP messages communication.

The EtherNet/IP protocol can be used to operate a sensor. EtherNet/IP only supports a subset of the tasks that can be accomplished in the web interface. A sensor can only process EtherNet/IP commands when the EtherNet/IP is selected in the [Protocol] option.

4 Check the [Explicit Message Buffering] option, if needed.

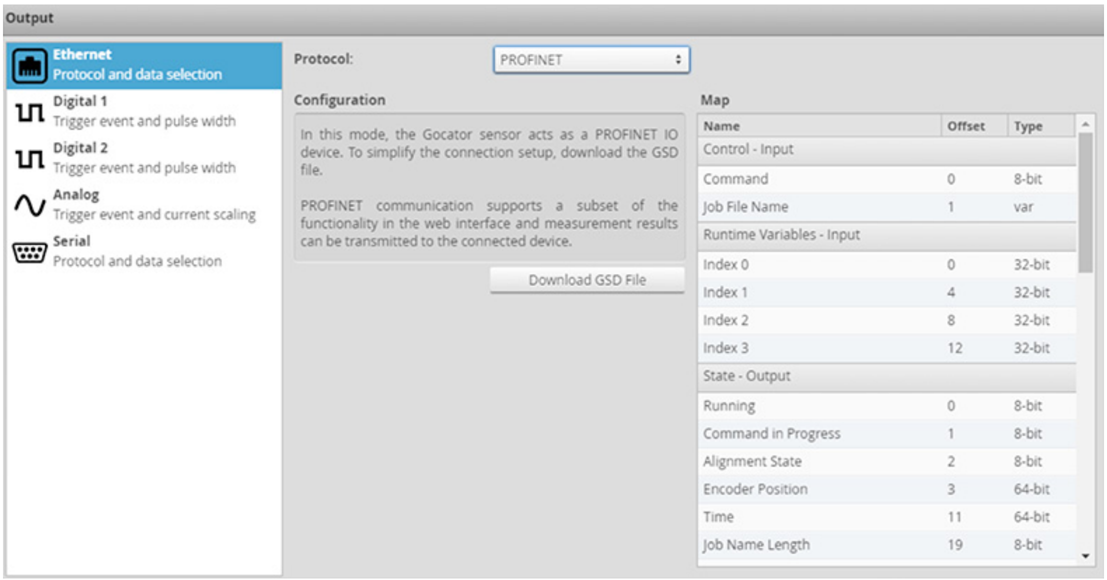
Buffering is needed, for example, in Surface mode if multiple objects are detected within a time frame shorter than the polling rate of the PLC. If buffering is enabled with the EtherNet/IP protocol, the buffer is automatically advanced when the Sample State Assembly Object is read (📖 "•Sample State Assembly" on page 828).

5 Check the [Implicit Messaging] option, if needed.

Implicit messaging uses UDP and is faster than explicit messaging, so it is intended for time-critical applications. However, implicit messaging is layered on top of UDP. UDP is connectionless and data delivery is not guaranteed. For this reason, implicit messaging is only suitable for applications where occasional data loss is acceptable.

For more information on setting up implicit messaging, access the website at https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/ and download the appropriate document.

6 **Choose the byte order in the [Byte Order] dropdown.**



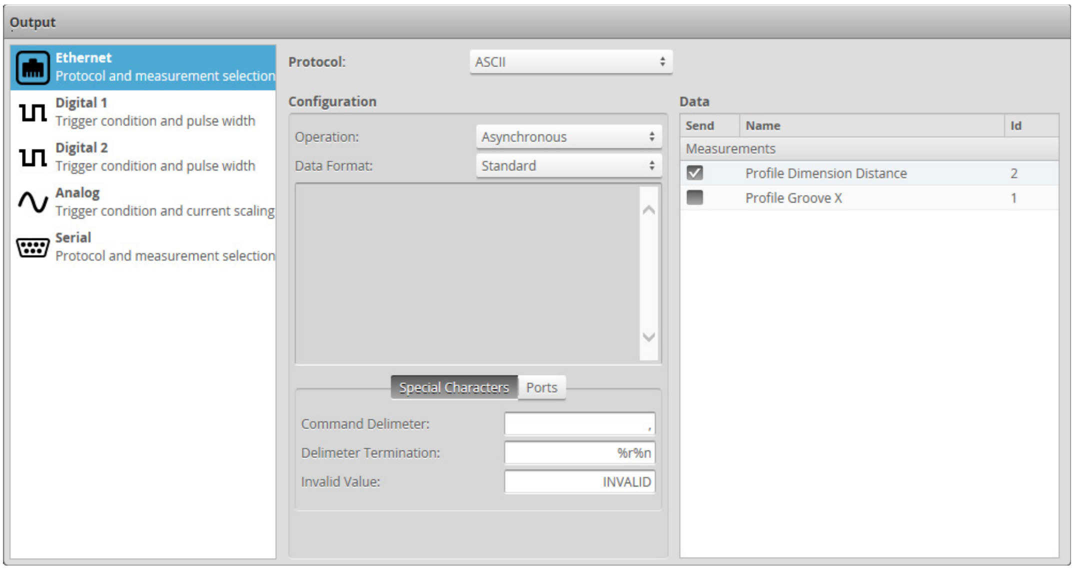
To receive commands and send results using PROFINET messages:

1 **Go to the [Output] page.**

2 **Click on [Ethernet] in the [Output] panel.**

3 **Select [PROFINET] in the [Protocol] option.**

4 **Click the [Download GSD File] button to download a GSD file for use with your IDE.**



To receive commands and send results using ASCII messages:

1 **Go to the [Output] page.**

2 **Click on [Ethernet] in the [Output] panel.**

3 **Select [ASCII] as the protocol in the [Protocol] drop-down.**

4 **Set the operation mode in the [Operation] drop-down.**

» In asynchronous mode, the data results are transmitted when they are available.

» In polling mode, users send commands on the data channel to request the latest result.

See 📖 "■Polling Operation Commands (Ethernet Only)" on page 918 for an explanation of the operation modes.

5 **Select the data format from the [Data Format] drop-down.**

Data Format	Description
[Standard]	**The default result format of the ASCII protocol. Select the measurement to send by placing a check in the corresponding checkbox. See 📖 "■Standard Result Format" on page 926 for an explanation of the standard result mode.**
[Standard with Stamp]	**Select the measurement to send by placing a check in the corresponding checkbox. See 📖 "■Standard Result Format" on page 926 for an explanation of the standard result mode.**
[Custom]	**Enables the custom format editor. Use the replacement patterns listed in [Replacement Patterns] to create a custom format in the editor. C language printf-style formatting is also supported: for example, %sprintf[%09d, %value[0]]. This allows fixed length formatting for easier input parsing in PLC and robot controller logic.**

6 **Set the special characters in the [Special Characters] tab.**

Set the command delimiter, delimiter termination, and invalid value characters. Special characters are used in commands and standard-format data results.

7 **Set the TCP ports in the [Ports] tab.**

Select the TCP ports for the control, data, and health channels. If the port numbers of two channels are the same, the messages for both channels are transmitted on the same port.

4.8.3 Digital Output

Sensors can convert measurement decisions or software commands to digital output pulses, which can then be used to output to a PLC or to control external devices, such as indicator lights or air ejectors.

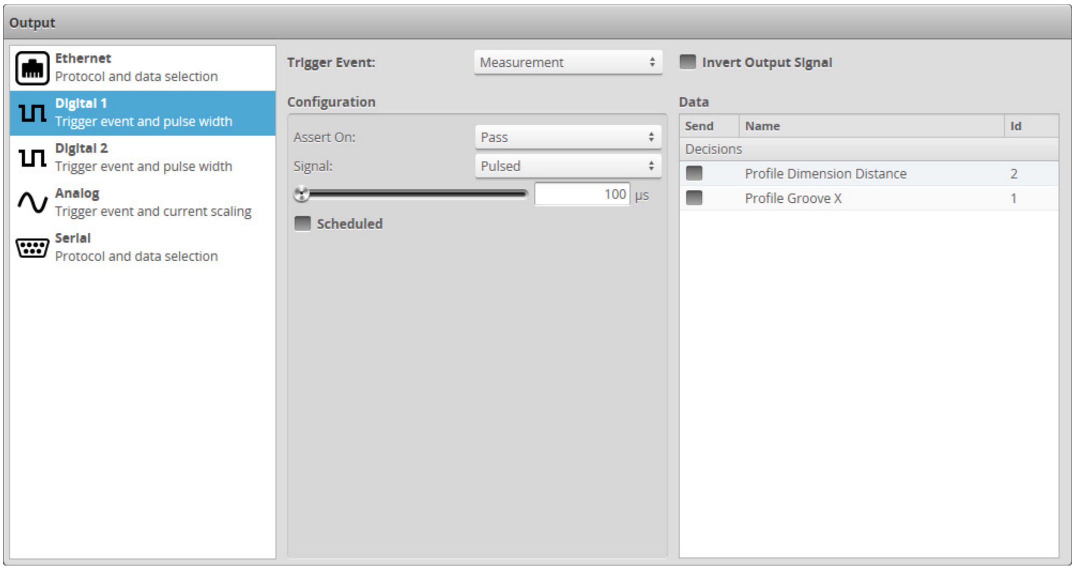
> **Tips**
> Digital outputs cannot be used when taking scans using the Snapshot button, which takes a single scan and is typically used to test measurement tool settings. Digital outputs can only be used when a sensor is running, taking a continuous series of scans.

A digital output can act as a measurement valid signal to allow external devices to synchronize to the timing at which measurement results are output. In this mode, the sensor outputs a digital pulse when a measurement result is ready.

A digital output can also act as a strobe signal to allow external devices to synchronize to the timing at which the sensor exposes. In this mode, the sensor outputs a digital pulse when the sensor exposes.

Each sensor supports two digital output channels. See "■Digital Outputs" on page 1009 for information on wiring digital outputs to external devices.

Trigger conditions and pulse width are then configured within the panel.



To output measurement decisions:

1. **Go to the [Output] page.**

2. **Click [Digital 1] or [Digital 2] in the [Output] panel.**

3. **Set [Trigger Event] to [Measurement].**

4. **In [Configuration], set [Assert On] and select the measurements that should be combined to determine the output.**

   If multiple measurement decisions are selected and [Assert On] is set to [Pass], the output is activated when all selected measurements pass.

   If [Assert On] is set to [Fail], the output is activated when any one of the selected measurements fails.

5 **Set the [Signal] option.**

The signal type specifies whether the digital output is a continuous signal or a pulsed signal. If [Signal] is set to [Continuous], the signal state is maintained until the next transition occurs. If [Signal is set to is [Pulsed], you must specify the pulse width and how it is scheduled.

6 **Specify a pulse width using the slider.**

The pulse width is the duration of the digital output pulse, in microseconds.

7 **Check the [Scheduled] option if the output needs to be scheduled; otherwise, leave it unchecked for immediate output.**

A scheduled output becomes active after the delay from the start of SurfaceMeasure1008S exposure. A scheduled output can be used to track the decisions for multiple objects as these objects travel from the sensor to the eject gates.

The [Delay] setting specifies the distance from the sensor to the eject gates.

An immediate output becomes active as soon as measurement results are available. The output activates after the sensor finishes processing the data. As a result, the time between the start of sensor exposure and output activates can vary and is dependent on the processing latency. The latency is reported in the dashboard and in the health messages.

8 **If you checked [Scheduled], specify a delay and a delay domain.**

The [Delay] specifies the time or encoder distance between the start of sensor exposure and when the output becomes active. The delay should be larger than the time needed to process the data inside the sensor. It should be set to a value that is larger than the processing latency reported in the dashboard or in the health messages.

The unit of the delay is configured with the [Delay Domain] setting.

9 **If you want to invert the output signal, check [Invert Output Signal].**

To output a measurement valid signal:

1 **Go to the [Output] page.**

2 **Click on [Digital 1] or [Digital 2] in the [Output] panel.**

3 **Set [Trigger Event] to [Measurement].**

4 **In [Configuration], set [Assert On] to [Always].**

5 **Select the measurements.**

» The output activates when the selected decisions produce results. The output activates only once for each frame even if multiple decision sources are selected.

6 **Specify a pulse width using the slider.**

» The pulse width determines the duration of the digital output pulse, in microseconds.

To respond to software scheduled commands:

1 **Go to the [Output] page.**

2 **Click [Digital 1] or [Digital 2] in the [Output] panel.**

3 **Set [Trigger Event] to [Software].**

4 **Specify a [Signal] type.**

The signal type specifies whether the digital output is a continuous signal or a pulsed signal. If the signal is continuous, its state is maintained until the next transition occurs. If the signal is pulsed, user specifies the pulse width and the delay.

5 **Specify a [Pulse Width].**

» The pulse width determines the duration of the digital output pulse, in microseconds.

6 **Specify if the output is immediate or scheduled.**

A pulsed signal can become active immediately or be scheduled. A continuous signal always becomes active immediately.

Immediate output becomes active as soon as a scheduled digital output (📖 "•Schedule Digital Output" on page 777) is received.

Scheduled output becomes active at a specific target time or position, given by the Scheduled Digital Output command. Commands that schedule an event in the past will be ignored. An encoder value is in the future if the value will be reached by moving in the forward direction (the direction that encoder calibration was performed in).

To output an exposure signal:

1 **Go to the [Output] page.**

2 **Click [Digital 1] or [Digital 2] in the [Output] panel.**

3 **Set [Trigger Event] to [Exposure Begin] or [Exposure End].**

4 **Set the [Pulse Width] option.**

» The pulse width determines the duration of the digital output pulse, in microseconds.

To output an alignment signal:

1 **Go to the [Output] page.**

2 **Click [Digital 1] or [Digital 2] in the [Output] panel.**

3 **Set [Trigger Event] to [Alignment].**

The digital output state is High if the sensor is aligned, and Low if not aligned. Whether the sensor is running does not affect the output.

To respond to exposure begin/end:

1 **Go to the [Output] page.**

2 **Click [Digital 1] or [Digital 2] in the [Output] panel.**

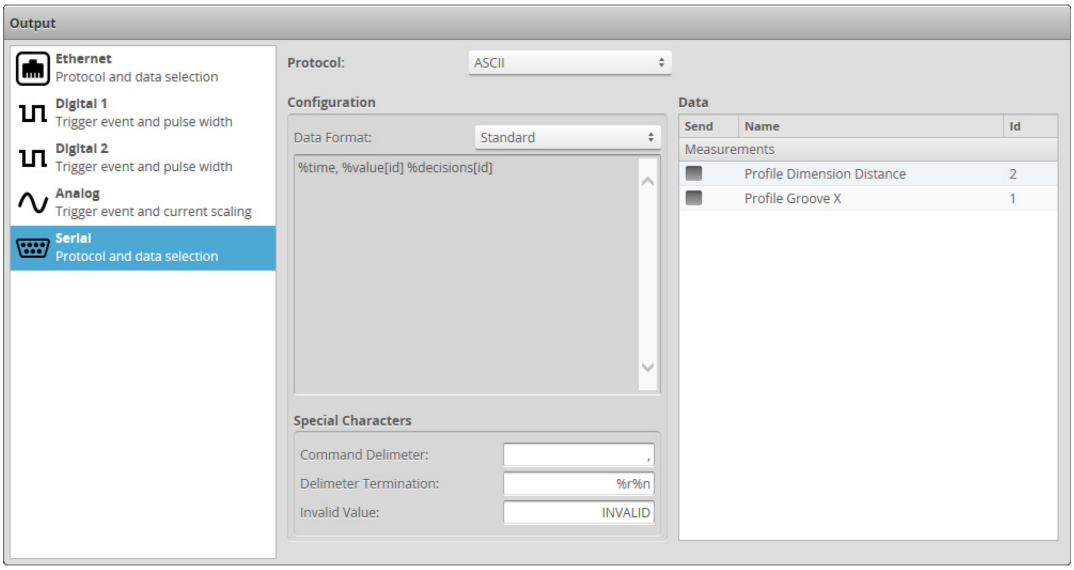
3 **Set [Trigger Event] to [Exposure Begin] or [Exposure End].**

4.8.4 Serial Output

SurfaceMeasure1008S's web interface can be used to select measurements to be transmitted via RS-485 serial output. Each sensor has one serial output channel. ASCII Protocol is supported.

The ASCII protocol outputs data asynchronously using a single serial port. For information on the ASCII Protocol parameters and data formats, see "10.1.5 ASCII Protocol" on page 917.

For information on wiring serial output to an external device, see "■Serial Output" on page 1011.



To configure ASCII output:

1 **Go to the [Output] page.**

2 **Click on [Serial] in the [Output] panel.**

3 **Select [ASCII] in the [Protocol] option.**

4 **Select the [Data Format].**

Select [Standard] to use the default result format of the ASCII protocol. Select value and decision to send by placing a check in the corresponding check box. See 📖 "■Standard Result Format" on page 926 for an explanation of the standard result mode.

Select [Custom] to customize the output result. A data format box will appear in which you can type the format string. See 📖 "■Custom Result Format" on page 927 for the supported format string syntax.

5 **Select the measurments to send.**

Select measurements by placing a check in the corresponding check box.

6 **Set the [Special Characters].**

Select the delimiter, termination and invalid value characters. Special characters are used in commands and standard-format data results.

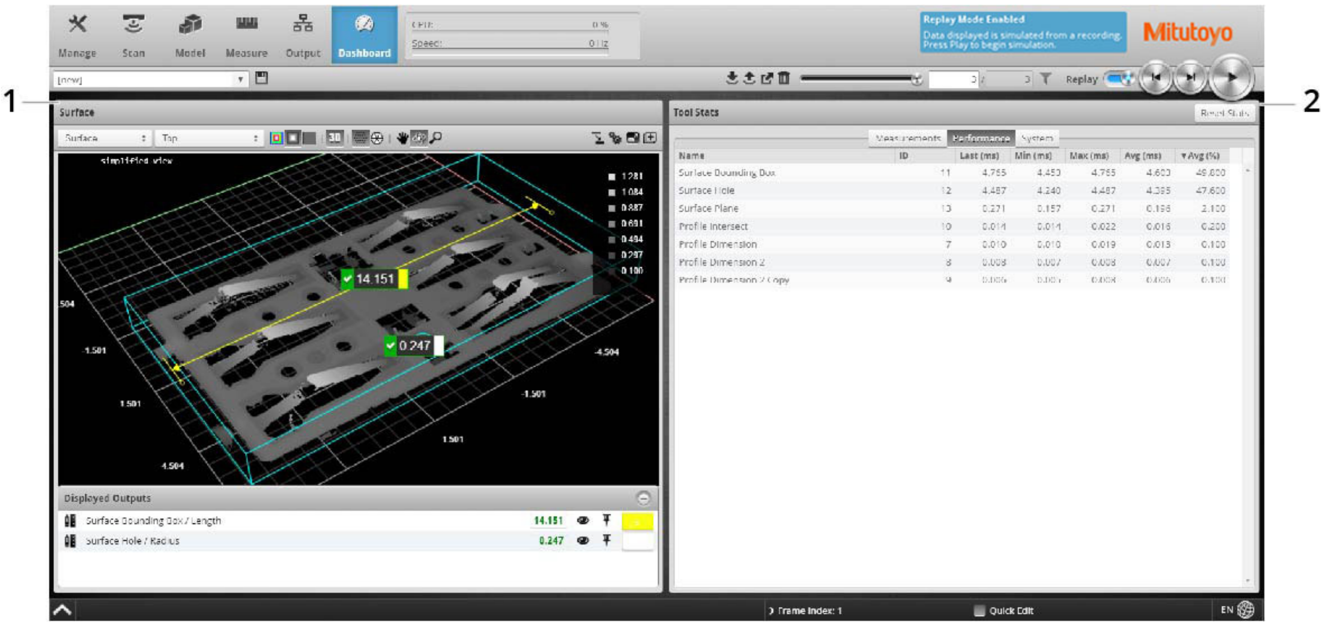
4.9 Dashboard

The following sections describe the [Dashboard] page.

4.9.1 Dashboard Page Overview

The [Dashboard] page summarizes sensor and system health information and provides tool and measurement statistics. It also provides tool performance statistics. The data viewer is available on the Dashboard page. This is especially useful for users accessing sensors via Technician accounts (which provide a simplified user interface, namely, with only the Scan and Dashboard pages). This lets any user monitor one or more measurements visually, on scan data, during troubleshooting and monitoring.

You can also pin multiple tool outputs such as measurements and geometric features so that they are displayed on the data viewer at the same time. Note however that pinned outputs in the data viewers on the Measure page and the Dashboard page are not independent: pinning or unpinning on either page affects the pinned outputs in both.



	Element	Description
1	Data viewer	Displays scan data and, if they are pinned to the main view, measurements and geometric features. For general information on the data viewer, see "4.4.8 Data Viewer" on page 156. For more information on pinning, see "4.7.5 Pinning Measurements and Features" on page 281.
2	Tool Stats	Displays measurement and tool performance statistics. See "4.9.2 Statistics" on page 338. Also displays sensor state and health information. See "4.9.3 State and Health Information" on page 339.

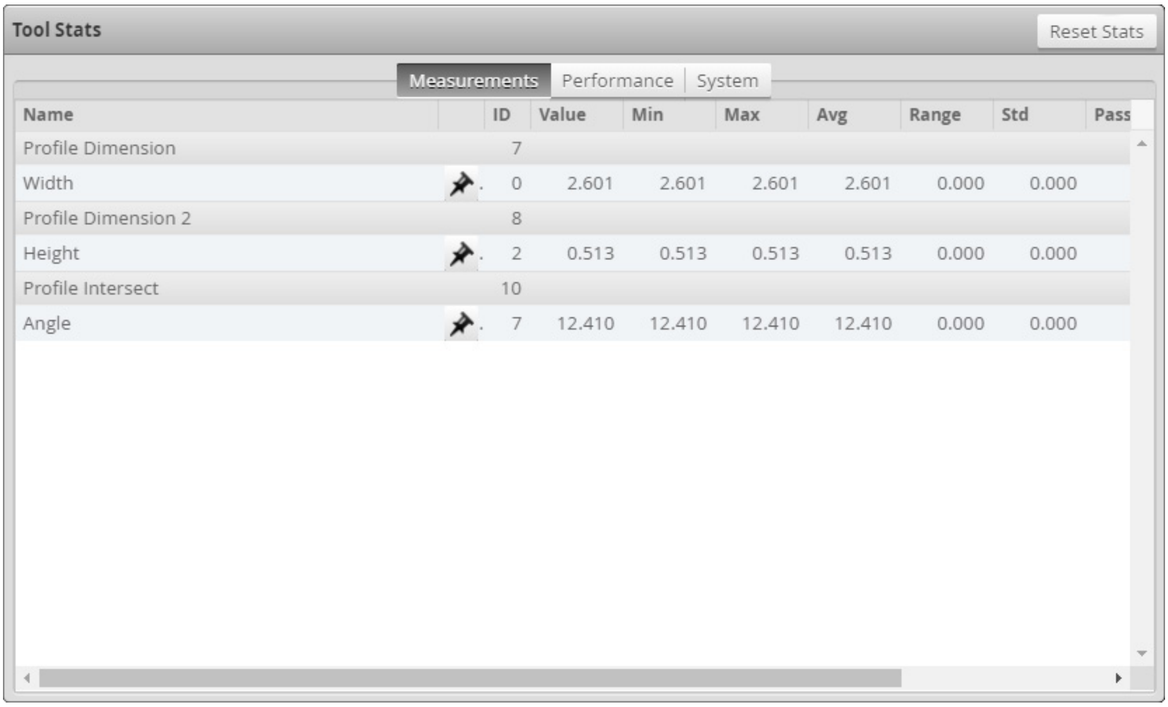
4.9.2 Statistics

In the [Tool Stats] panel, you can examine measurement and tool statistics in two tabs: [Measurements] and [Performance].

To reset statistics in both tabs, use the [Reset Stats] button.

■ Measurements

The [Measurements] tab displays statistics for each measurement enabled in the [Measure] page, grouped by the tool that contains the measurement.



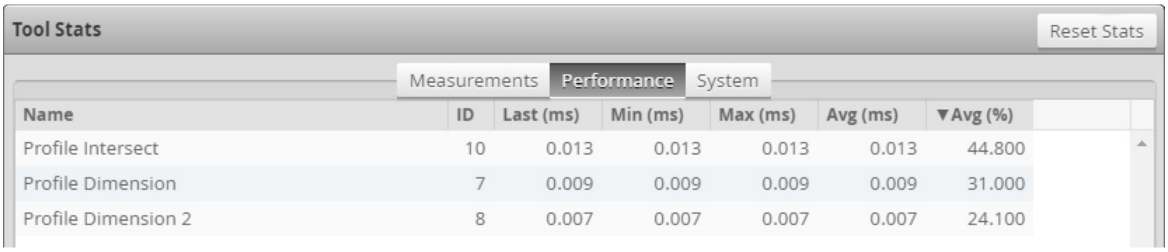
For each measurement, SurfaceMeasure1008S displays the following information:

Measurement Statistics

Name	Description
[ID]	The measurement ID as set in the measurement's ID field on the Measure page.
[Value]	The most recent measurement value.
[Min]	The minimum measurement value that has been observed.
[Max]	The maximum measurement value that has been observed.
[Avg]	The average of all measurement values collected since the sensor was started.
[Range]	The difference between Max and Min.
[Std]	The standard deviation of all measurement values collected since the sensor was started.
[Pass]	The number of pass decisions the measurement has generated.
[Fail]	The number of fail decisions the measurement has generated.
[Invalid]	The number of frames that returned no valid measurement value.
[Overflow]	The number of frames that returned an overflow.

■ Performance

The [Performance] tab displays performance statistics (execution time) for each tool added in the [Measure] page.



For each tool, SurfaceMeasure1008S displays the following information:

Performance Statistics

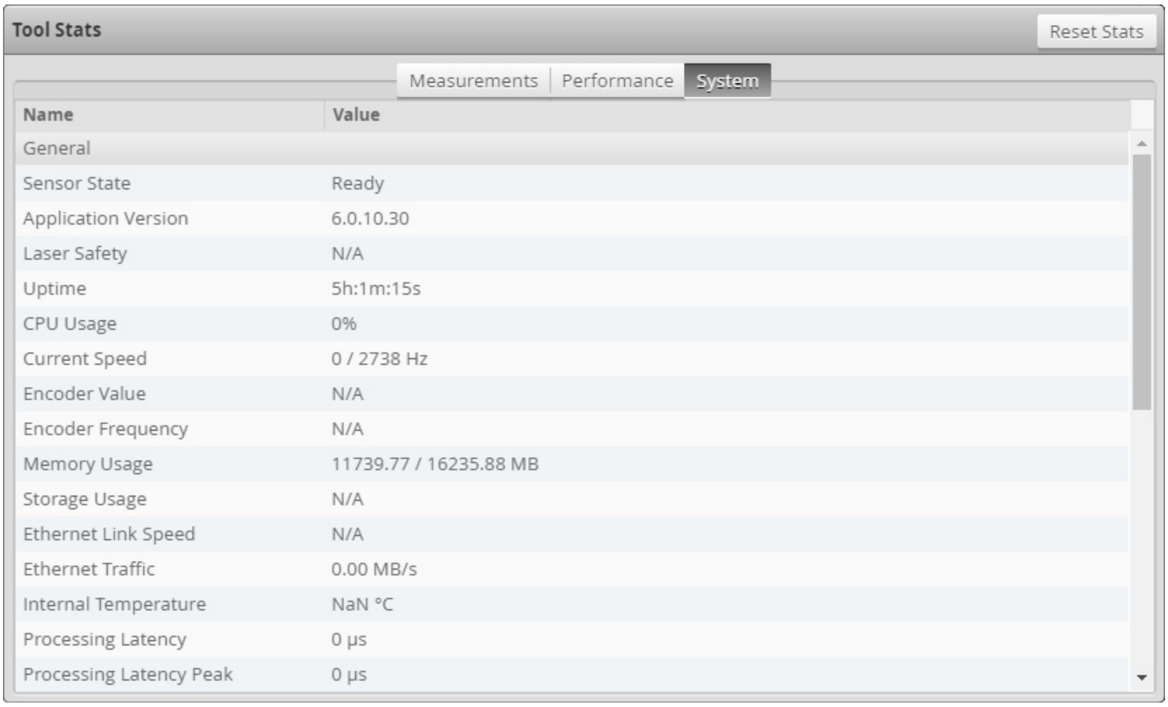
Name	Description
[Last (ms)]	The last execution time of the tool.
[Min (ms)]	The minimum execution time of the tool.
[Max (ms)]	The maximum execution time of the tool.
[Avg (ms)]	The average execution time of the tool.
[Avg (%)]	The average percentage the CPU the tool uses.

Tips

Tools are sorted by the Avg (%) column in descending order.

4.9.3 State and Health Information

In the [Tool Stats] pane, you can examine state and health information.



The following information is available in the [System] tab on the [Dashboard] page:

Dashboard General System Values

Name	Description
[Sensor State]*	Current sensor state (Conflict, Ready, or Running).
[Application Version]	Sensor firmware version.
[Laser Safety]	Whether Laser Safety is enabled. With laser-based sensors, laser safety must be enabled in order to scan.
[Uptime]	Length of time since the sensor was power-cycled or reset.
[CPU Usage]	Sensor CPU utilization.
[Current Speed]*	Current speed of the sensor.
[Encoder Value]	Current encoder value (ticks).
[Encoder Frequency]	Current encoder frequency (Hz).
[Memory Usage]	Sensor memory utilization (MB used / MB total available).
[Storage Usage]	Sensor flash storage utilization (MB used / MB total available).
[Ethernet Link Speed]	Speed of the Ethernet link (Mbps).
[Ethernet Traffic]	Network output utilization (MB/sec).
[Internal Temperature]	Internal sensor temperature.
[Processing Latency]	Last delay from camera exposure start to when the results are ready for output.
[Processing Latency Peak]	Peak delay from camera exposure start to when the results are ready for output.
[Alignment State]	Whether the sensor or sensor system has been aligned.

Dashboard History Values

Name	Description
[Scan Count]*	Number of scans performed since sensor state last changed to Running.
[Trigger Drop]**	Count of camera frames dropped due to excessive trigger speed.
[Processing Drop]**	The sum of various indicators related to processing drop including drops due to insufficient CPU and buffer overflows.
[Ethernet Output Drop]**	Count of frame drops due to slow Ethernet link.
[Analog Output Drop]**	Count of analog output drops because last output has not been completed.
[Serial Output Drop]**	Count of serial output drops because last output has not been completed.
[Digital Output 1 Drop]**	Count of digital output drops because last output has not been completed.
[Digital Output 2 Drop]**	Count of digital output drops because last output has not been completed.
[Digital Output 1 High Count]	Count of high states on digital output.

Name	Description
[Digital Output 2 High Count]	Count of high states on digital output.
[Digital Output 1 Low Count]	Count of low states on digital output.
[Digital Output 2 Low Count]	Count of low states on digital output.
[Anchor Invalid Count]**	Count of invalid anchors.
[Valid Spot Count]	Count of valid spots detected in the last frame.
[Max Spot Count]*	Maximum number of spots detected since sensor was started.
[Camera Search Count]	Count of camera frames where laser tracking is lost. Only applicable when tracking window is enabled.

* When the sensor is accelerated, the indicator's value is reported from the accelerating PC.

** When the sensor is accelerated, the indicator's value is the sum of the values reported from the sensor and the accelerating PC.

MEMO

5 Profile Measurement

This section describes the profile measurement tools available in SurfaceMeasure1008S sensors.

When SurfaceMeasure1008S is in Surface mode and you have defined a section, a [Stream] option displays in Profile tools. Choosing a section in the [Stream] option lets you apply profile measurements to the section.

A subset of the Profile tools is available when [Uniform Spacing] is disabled, that is, when tools are applied to point cloud data.

For more information on the [Uniform Spacing] setting and resampled data, see 📖 "3.2.2 Uniform Data and Raw Data" on page 61.

Profile measurement tools can be used on sections. For more information on sections, see 📖 "4.6.3 Sections" on page 224.

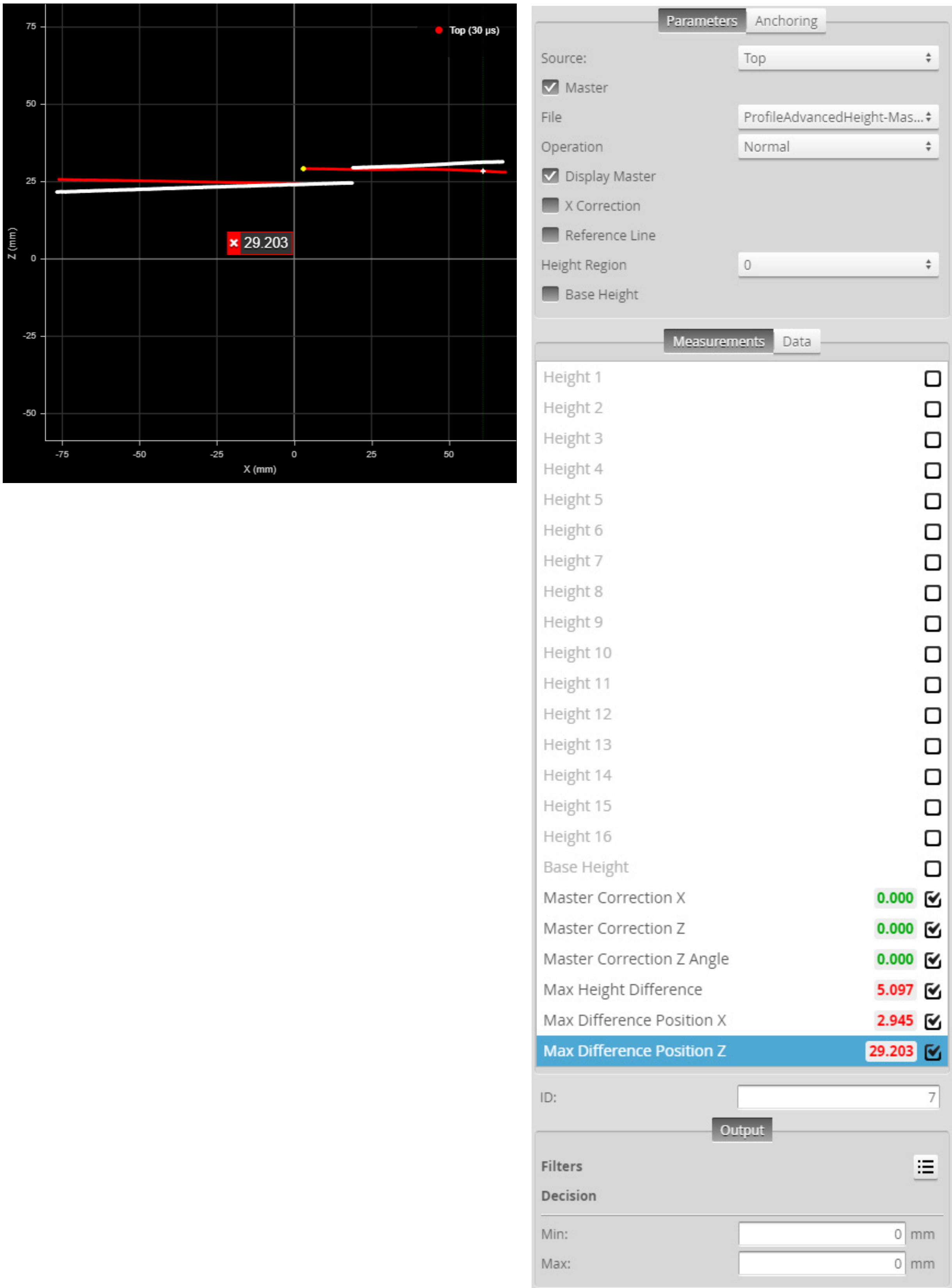
5.1 Advanced Height

The Advanced Height tool provides highly accurate and repeatable master (template) comparison and step height measurements (up to 16 in a tool instance).

Tips

All instances of the Advanced Height tool share the same template file set in File. For this reason, you must be careful when editing or removing template files shared by another instance of the tool.

Height measurements can be made relative to a reference line. Reference line sets the measurement direction (perpendicular to the reference line). A separate base line can also be set so that height measurements are between the base line and a profile feature, rather than the reference line (which in this case is used for angle correction).



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

5.1.1 Measurements, Data, and Settings

[Measurements]

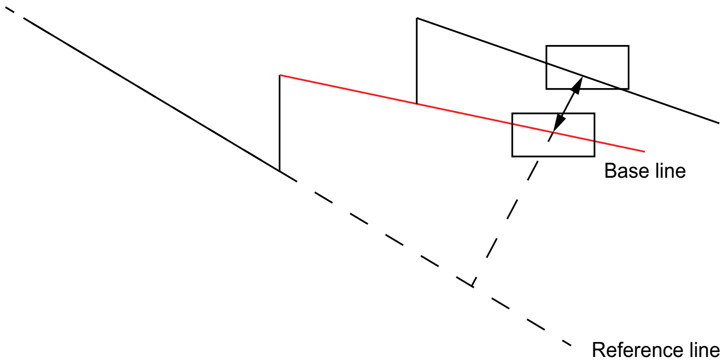
Type	Description
[Height {n}]	The height measured in height region {n}. Height is measured perpendicular Will be Invalid if the appropriate number of height regions has not been set in [Height Region].
[Master Correction X] [Master Correction Z] [Master Correction Z Angle]	The amount of correction applied to the profile with respect to the master.
[Max Height Difference]	The maximum height difference.
[Max Difference Position X] [Max Difference Position Z]	The X and Z positions of the maximum height difference.

[Data]

Type	Description
[Difference Profile]	A profile representing the difference between the master and the current frame's profile, available for use as input in the [Stream] drop-down in other tools.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Master]	Toggles a set of settings related to master comparison. For more information, see "5.1.2 Master Comparison" on page 347.
[Reference Line]	Toggles a set of settings related to the reference line. For more information, see "5.1.3 Reference Line" on page 348.
[Height Region]	Sets the number of height region measurements the tools returns. For each height region, the tool displays an [Edit Height Region] checkbox that you use to edit the height region's location and size. The tool also displays a [Height{n} Feature] drop-down that lets you select the type of feature for that height region.

Parameter	Description
[Base Height]	Use base height to "set" the Z axis: when enabled height values are offset from the base. This is useful if you need to measure between two features, rather than between a feature and the reference line.  When enabled, the tool displays settings related to the base height: size and position of the base height's region ([Base Height] section) and the base height's feature.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

5.1.2 Master Comparison

When you check the [Master] option, the tool displays several additional settings and disables measurement anchoring from other tools.

[Master Parameters]

Parameter	Description
[File]	The file containing the master (template) profile, created by choosing Save from the Operation drop-down.
[Operation]	Contains operations related to the master file. One of the following: • [Normal]: Selected by the tool after you perform another file operation. • [Create]: Saves the current profile as the master. • [Delete]: Deletes the master file selected in [File].
[Display Master]	Overlays the master profile, in white, on the current profile.
X Correction	Enables settings related to X correction (left or right movement) of the profile compared to the master profile. For more information, see "X Correction" on page 348

X Correction

When you check the [Master] option and enable [X Correction], the tool displays several additional settings.

[X Correction Parameters]

Parameter	Description
[Edit Edge Region]	Enables an edge region section letting you configure the region. You can also edit this region in the data viewer.
[Edge Direction]	Determines the direction of the edge. One of the following: [Falling] or [Rising].
[Count Direction]	Indicates how edges are counted. One of the following: [Left to Right] or [Right to Left].
[Edge Index]	Indicates which edge the tool uses.

5.1.3 Reference Line

When you check the [Master] option and enable [Reference Line], the tool displays several additional settings. The reference line is used to set the measurement direction (perpendicular to the reference line).

[Reference Line Parameters]

Parameter	Description
[Line Region]	The number of line regions the tool uses.
[Edit Line Region]	Enables settings that let you edit the size and position of the line's region.
[Fitting Method]	Indicates the fitting method the tool uses. One of the following: [Simple] or [Robust].

5.1.4 Anchoring

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

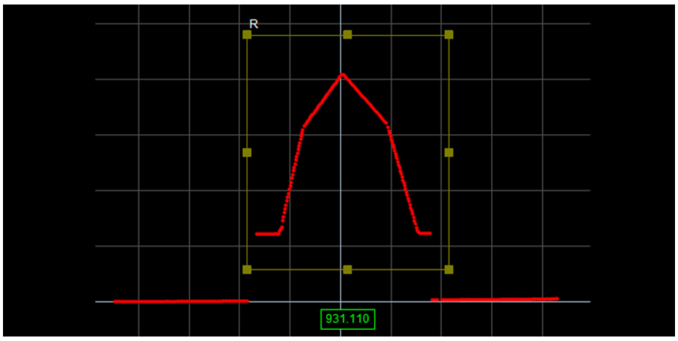
Tips

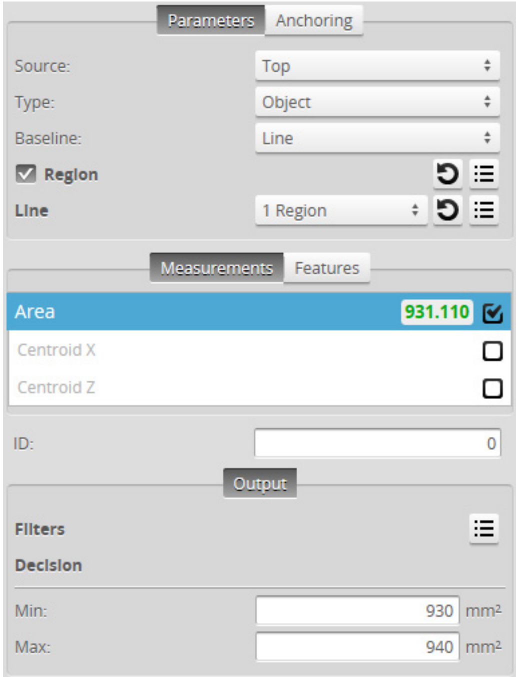
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

5.2 Area

The Area tool determines the cross-sectional area within a region.



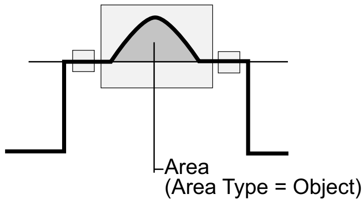
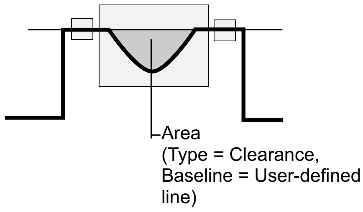
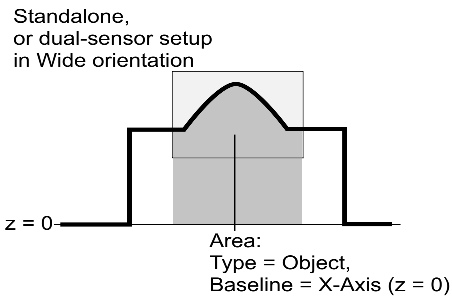
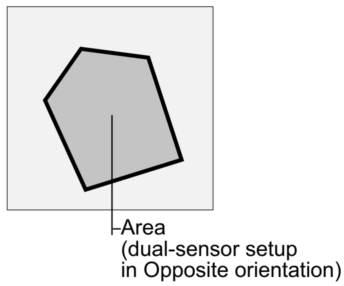
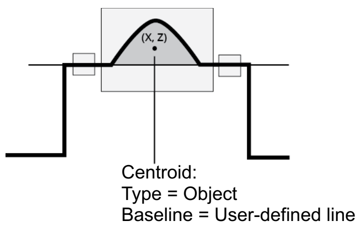


Areas are positive in regions where the profile is above the X axis. In contrast, areas are negative in regions where the profile is below the X axis.

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.2.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Area] Measures the cross-sectional area within a region that is above or below a fitted baseline.	   
[Centroid X] Determines the X position of the centroid of the area.	
[Centroid Z] Determines the Z position of the centroid of the area.	

[Features]

Type	Description
[Center Point]	The center point of the area.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Type]	[Object] area type is for convex shapes above the baseline. Regions below the baseline are ignored. [Clearance] area type is for concave shapes below the baseline. Regions above the baseline are ignored.
[Baseline]	Baseline is the fit line that represents the line above which (Object clearance type) or below which (Clearance area type) the cross-sectional area is measured. When this parameter is set to Line, you must define a line in the Line parameter. See 📖 "●Fit Lines" on page 251 for more information on fit lines. When this parameter is set to [X-Axis], the baseline is set to z = 0.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Line]	When [Baseline] (see above) is set to [Line], set this to one of the following: [1 Region] or [2 Regions]: Lets you set one or two regions whose data the tool will use to fit a line. [All Data]: The tool uses all of the data in the active area. For more information on regions, see 📖 "●Regions" on page 238). For more information on fit lines, see 📖 "●Fit Lines" on page 251.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

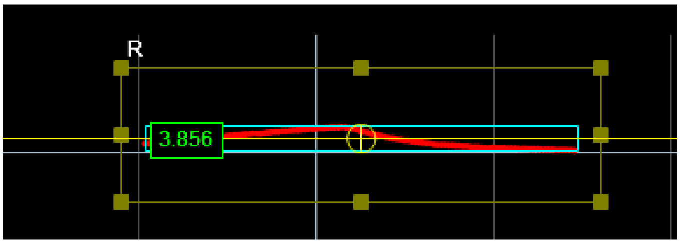
5.3 Bounding Box

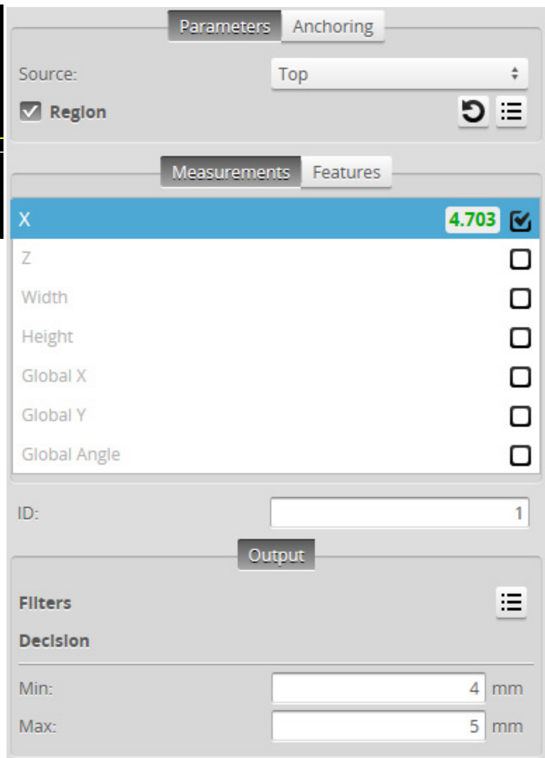
The Bounding Box tool provides measurements related to the smallest box that contains the profile (for example, X position, Z position, width, etc.).

The bounding box provides the absolute position from which the Position centroids tools are referenced.

Tips

When you use measurement tools on parts or sections, the coordinates returned are relative to the part or section. You can use the values returned by the Bounding Box tool's "Global" (see below) measurements as an offset in a SurfaceMeasure1008S script to convert the positional (X, Y, or Z) measurements of other measurement tools to sensor or system coordinates (depending on whether the sensor is aligned). For more information on SurfaceMeasure1008S scripts, see 📖 "4.7.10 Scripts" on page 321.



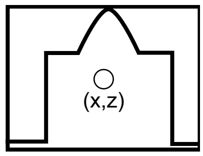
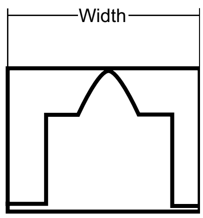
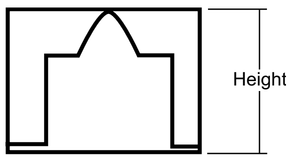


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.3.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Determines the X position of the center of the bounding box that contains the profile. The value returned is relative to the profile.	
[Z] Determines the Z position of the center of the bounding box that contains the profile. The value returned is relative to the profile.	
[Width] Determines the width of the bounding box that contains the profile. The width reports the dimension of the box in the direction of the minor axis.	
[Height] Determines the height (thickness) of the bounding box that contains the profile.	
[Global X]* Determines the X position of the center of the bounding box that contains the profile relative to the surface from which the profile is extracted.	
[Global Y]* Determines the Y position of the center of the bounding box that contains the profile relative to the surface from which the profile is extracted.	
[Global Angle]* Determines the angle around Z of the section used to create the profile, relative to the surface from which it is extracted, where a line parallel to the X axis is 0 degrees. Angles of sections pointing to the bottom of the data viewer are positive. Angles of sections pointing to the top of the data viewer are negative.	

*The Global X, Global Y, and Global Angle measurements are intended to be used with profiles extracted from a surface using a section.

When used with profiles not generated from a section, the Global X measurement returns the same value as the X measurement, and the Global Y and Global Angle measurements return 0.000.

[Features]

Type	Description
[Center Point]	The center point of the bounding box.
[Corner Point]	The lower left corner of the bounding box.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

5.4 Bridge Value

The Bridge Value tool calculates the "bridge value" and angle of a scanned surface. A bridge value is a single, processed range that is an average of a laser line profile that has been filtered to exclude user-definable portions of highs and lows in the profile. The resulting value represents a "roughness calculation." A bridge value is typically used to measure road roughness, but can be used to measure the roughness of any target.

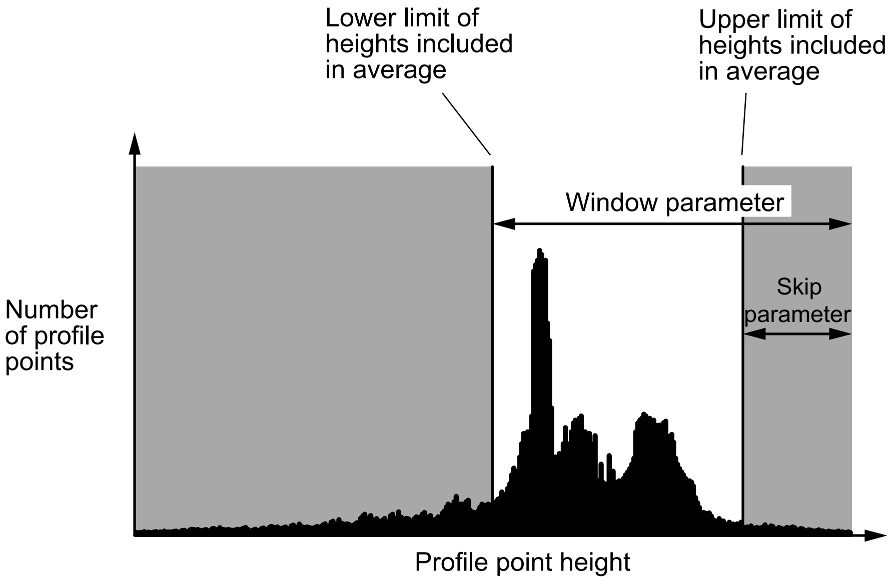
The tool provides two additional measurements (Window and StdDev) that can help determine whether the scanned data is valid; for more information, see 📖 "■Measurements" on page 338.

Tips

The Bridge value tool is only available when [Uniform Spacing] (in the [Scan Mode] panel on the [Scan] page) is unchecked, as the tool only works with unresampled data. For more information, see 📖 "3.2.2 Uniform Data and Raw Data" on page 61.

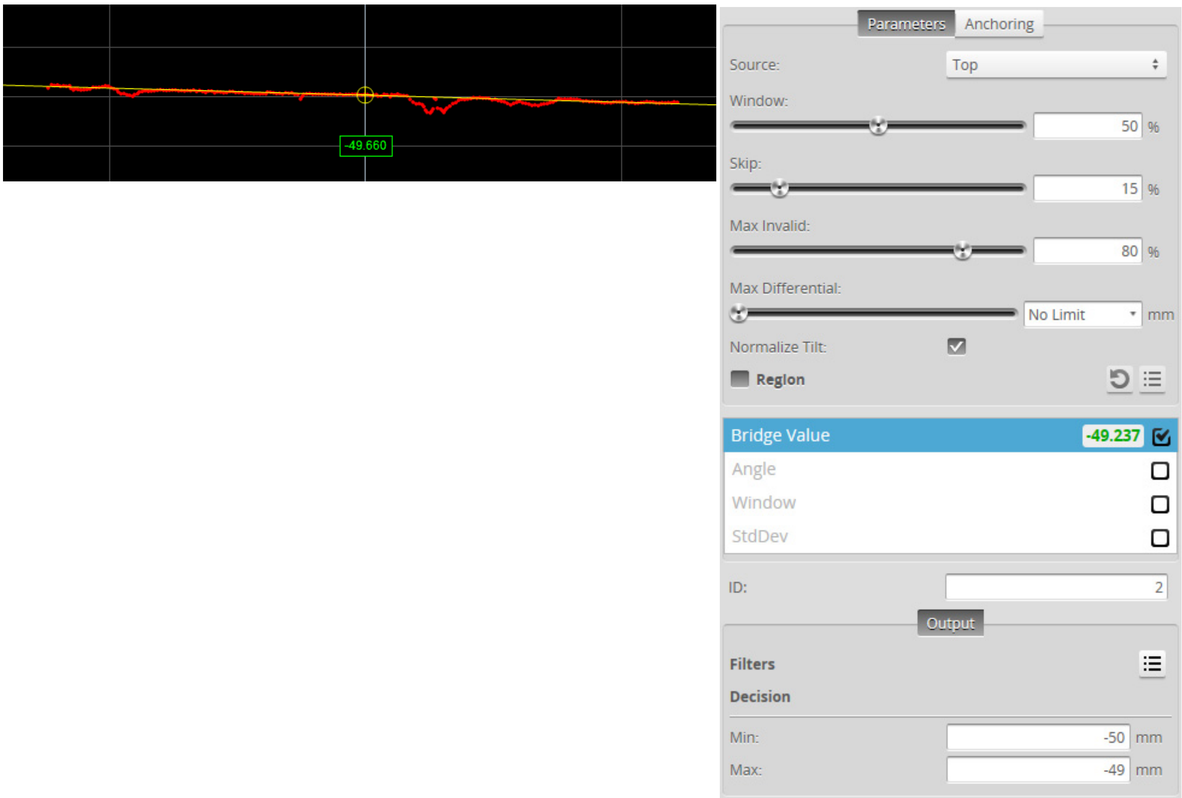
5.4.1 Understanding the Window and Skip Settings

The Bridge Value tool measurements work on a histogram of the ranges that make up the profile. The [Window] and [Skip] parameters together determine what segment of the heights in the histogram is used to calculate the bridge value. The following diagram illustrates the portion of the points of a histogram that would be included for calculating the bridge value, where [Window] is roughly 85% of the total points of the histogram, and [Skip] is roughly 15% of the points.



Profile point heights in the white area are included in the calculation of the average. Profile point heights in the grey area are excluded. By adjusting the [Window] and [Skip] parameters, you can exclude profile point heights that correspond to unwanted features on the target. In road roughness applications, for example, you could exclude rocks (profile points higher than the road surface), cracks or tining valleys (profile points lower than the road surface), and so on, to get an accurate representation of the tire-to-road interface.

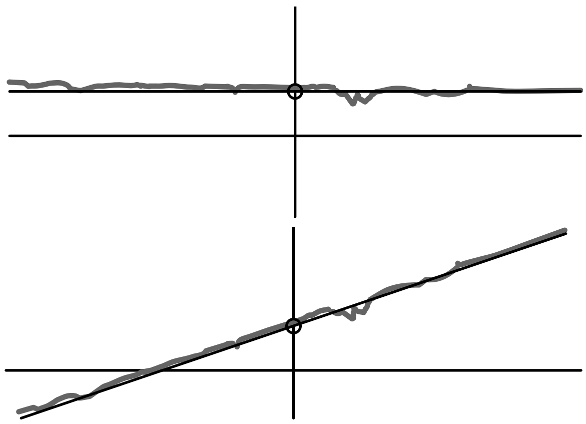
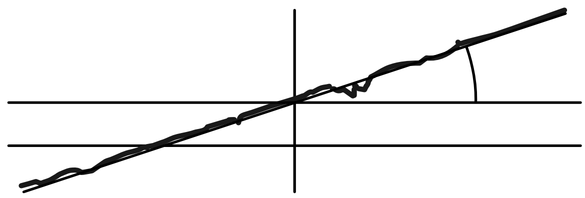
For more information on parameters, see the Parameters table below.



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

5.4.2 Measurements and Settings

[Measurements]

Measurement	Illustration
[Bridge Value] Determines the bridge value of the profile.	
[Angle] Determines the angle of the line fitted to the profile. When [Normalize] Tilt is unchecked, the measurement always returns 0.	

Measurement	Illustration
[Window] Returns the height of the area on the profile resulting from the Window and Skip settings.	
[StdDev] Returns the standard deviation of the data in the area on the profile resulting from the Window and Skip settings.	

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Window]	A percentage of the profile point heights in the histogram, starting from the highest point, to include in the average. For example, a setting of 50% would include the highest 50% of the heights. The [Skip] parameter then determines the actual portion of the profile point heights used to calculate the average. The [Window] setting in effect sets the lower limit of the profile point heights in the histogram to be used in the average. Use the setting to exclude lower parts of a profile that you do not want to include in the measurement.
[Skip]	A percentage of the profile point heights in the histogram, starting from the highest points, to exclude from the average. The [Skip] setting basically sets the upper limit of the profile point heights in the histogram to be used in the average. Use the setting to exclude higher parts of a profile that you do not want to include in the measurement. If [Skip] is greater than [Window], an invalid value is returned.
[Max Invalid]	The maximum percentage of invalid points allowed before an invalid result is returned.
[Max Differential]	The maximum difference between the maximum and minimum histogram values before an invalid measurement value is produced.
[Normalize Tilt]	Fits a line to the profile and shears the points in the Z direction by the angle between the fitted line and the X axis. The [Window] and [Skip] settings are applied to the histogram of the transformed data. Useful for surfaces that are tilted.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

Tips
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

5.4.3 Using Window and StdDev as Metrics Measurements

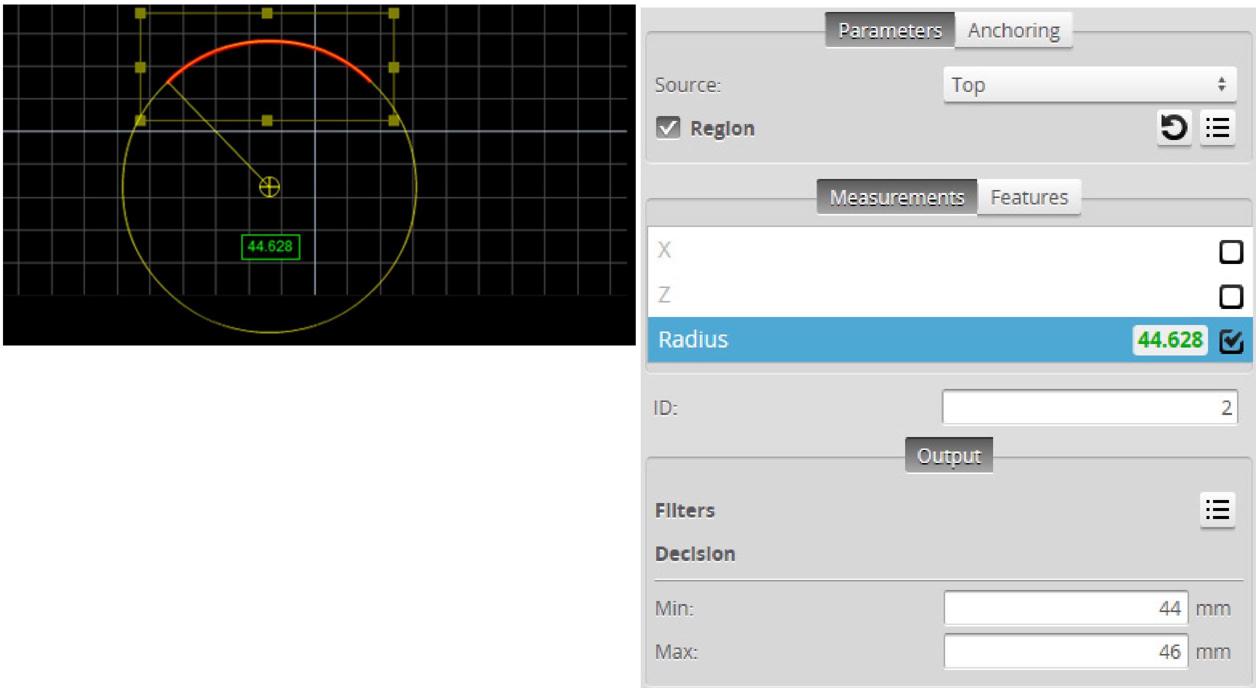
When a tracking window is defined, if the profile moves too quickly out of the tracking window and there is excessive noise in the scan data (caused for example by ambient light), the tracking window may track the noise instead of switching to search mode to find the actual profile. As a result, the Bridge Value tool receives bad data and returns incorrect or invalid measurements.

Tips
If the Window or StdDev measurements consistently return fail decisions or invalid measurements, the exposure may be set too high, creating excessive noise. Adjust the exposure to reduce the noise.

5.5 Circle

The Circle tool provides measurements that find the best-fitted circle to a profile and measure various characteristics of the circle.

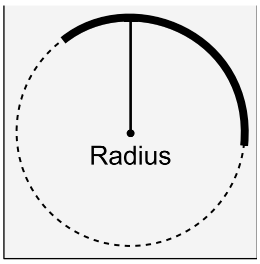
Tips
The tool may be unable to fit a circle to the profile when attempting the fit on a small number of relatively collinear data points.

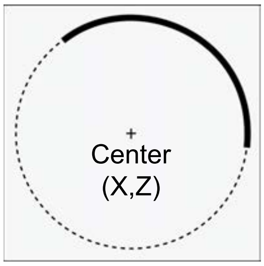


For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

5.5.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Radius] Measures the radius of the circle.	

Measurement	Illustration
[X] Finds the circle center position in the X axis.	
[Z] Finds the circle center position in the Z axis.	
[Standard Deviation] Returns the standard deviation of the data points with respect to the fitted circle.	
[Min Error] [Max Error] The minimum and maximum error among the data points with respect to the fitted circle.	
[Min Error X] [Min Error Z] The X and Z position of the minimum error.	
[Max Error X] [Max Error Z] The X and Z position of the maximum error.	

[Features]

Type	Description
[Center Point]	The center point of the fitted circle.

Tips

For more information on geometric features, see "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

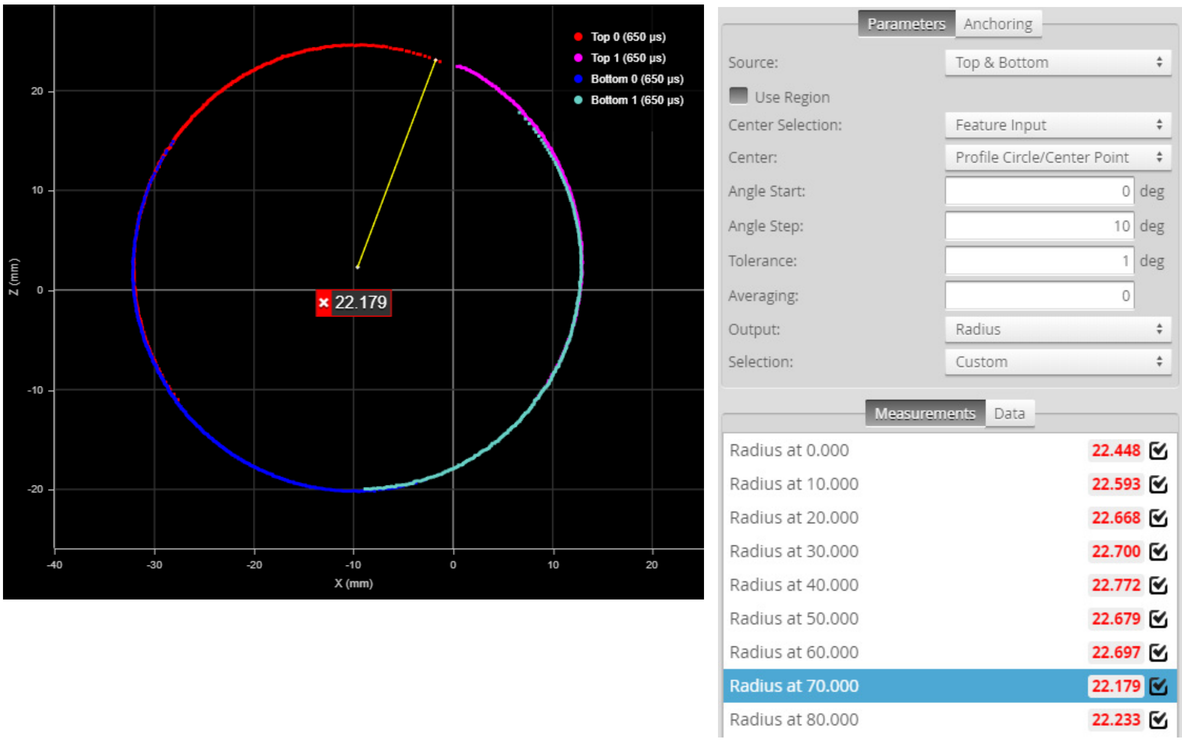
5.6 Circle Radii

Tips

The tool is supported in emulator scenarios.

The Profile Circle Radii tool lets you measure radii and diameters at specified angle steps, given a specified center point. The tool draws rays from the center point and returns radii or diameter measurements for each ray.

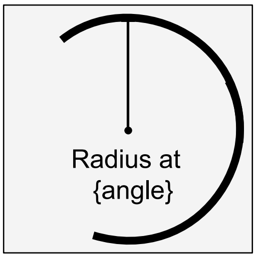
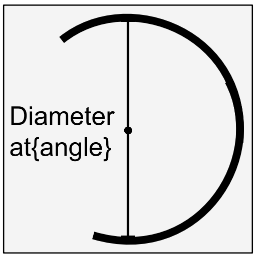
For example, in the following scan of an exhaust pipe by a four-sensor system, the tool is showing a radius measurement at 70 degrees that indicates a dent in the pipe. The tool also provides settings to compensate for missing data and for rough surfaces or noise.



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.6.1 Measurements, Features, and Settings

[Measurements]

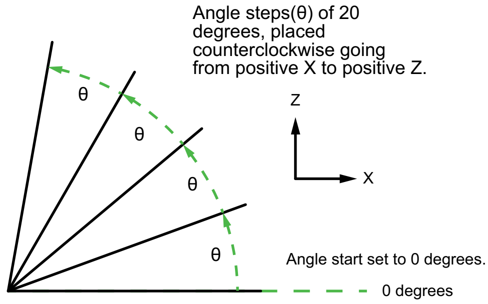
Measurement	Illustration
[Radius at {angle}] Returns the radius at {angle}.	
[Diameter at {angle}] Returns the diameter at {angle}.	

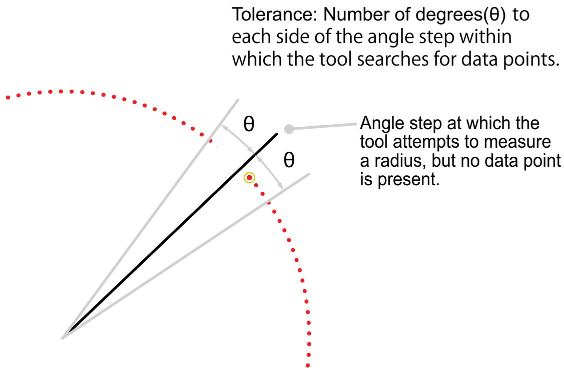
[Data]

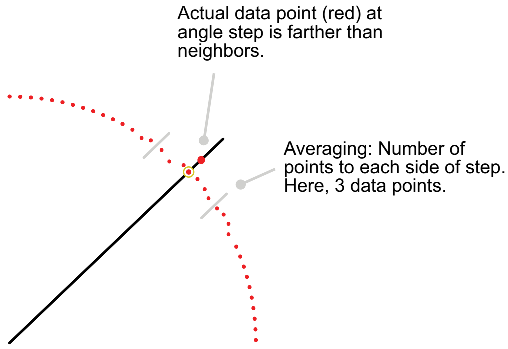
Type	Description
[Points]	An array of the points at the end of the rays.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Use Region]	Indicates whether the tool uses a user-defined region. If this option is not checked, the tool uses data from the entire active area.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Center Selection]	The source for the point geometric feature the tool uses as a center point. One of the following: [Bounding Box] – Uses the center of the bounding box that encloses the scan data selected in [Source]. If [Use Region] is enabled, the tool places a bounding box only around the data in the region. If [Use Region] is disabled, the tool places a bounding box around all scan data; this will include any outliers in the bounding box, which could produce an undesired center point. [Feature Input] – A point geometric feature provided by another tool, such as the center point from a Circle tool.
[Center]	The point geometric feature coming from another tool that the Circle Radii tool uses as the center point from which rays are drawn to search for data points. The parameter is only available when [Center Selection] is set to [Feature Input].

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Angle Start]
[Angle Step]</td><td>[Angle Start]: The angle at which ray steps start.
[Angle Step]: The angle step in degrees.
The following shows how these settings work together:


The tool searches for a data point at each angle step and returns the radius from the center point or the diameter.</td></tr>
<tr><td>[Tolerance]</td><td>If no data point is found at the angle step, the tool searches within the specified number of degrees to each side of the step to find a data point. Useful to compensate for gaps in the data.


The graphic above shows how the tool searches to each side of the angle step until it finds a data point (circled and in yellow).</td></tr>
<tr><td>[Averaging]</td><td>The number of data points to each side of the point the tool uses to average. Use this to compensate for noise or rough surfaces.


The graphic above shows how the tool averages the data point at the angle step with the number of data points specified in [Averaging] to each side of the angle step, replacing the original data point with the average (circled and in yellow).</td></tr>
<tr><td>[Output]</td><td>Selects whether to output radius, diameter, or both at each step.</td></tr>
<tr><td>[Selection]</td><td>Lets you quickly enable or disable all measurements.</td></tr>
<tr><td>[Filters]</td><td>The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.</td></tr>
</table>

Parameter	Description
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X]or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

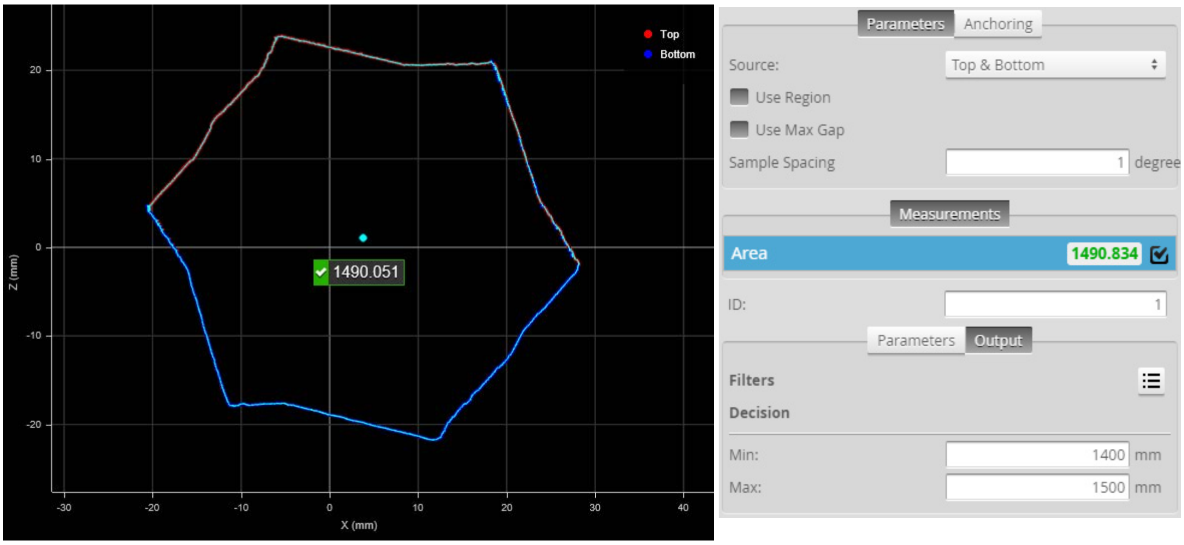
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

5.7 Closed Area

The Closed Area tool determines the cross-sectional area within a region using point cloud data from a dual- or multi-sensor system.

The tool is intended for use with roughly circular shaped profiles, or profiles that do not contain excessive concavity. The tool renders a polygon corresponding to the profile in the data viewer. Use this polygon to decide whether the tool can correctly calculate an acceptable representation of the profile. Minor gaps in the profile are permitted; the size of these gaps is configurable.

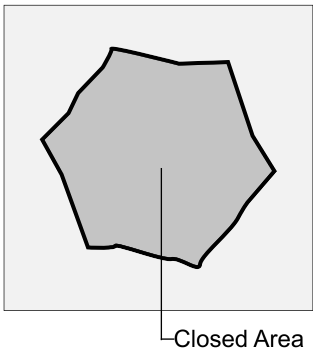
When the tool is used in conjunction with a script tool, you can calculate the volume of a target; for more information on the Script tool, see 📖 "5.22 Script" on page 418.



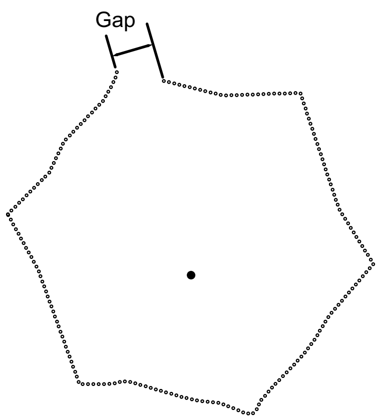
For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

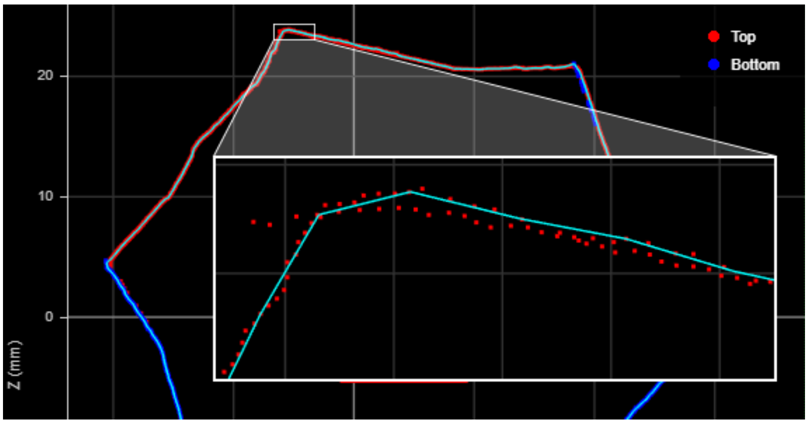
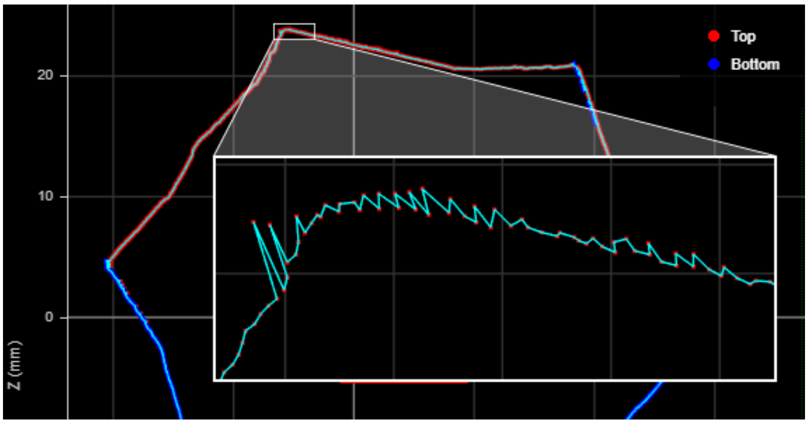
5.7.1 Measurements and Settings

[Measurements]

Measurement	Illustration
[Closed Area] Measures the cross-sectional area within a region using data from a dual- or multi-sensor system.	

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238. For this tool, you should set this parameter to [Top and Bottom].
[Use Region]	Indicates whether the tool uses a user-defined region. If this option is not checked, the tool uses data from the entire active area.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Center Selection]	The origin of the rays used to create the polygon (which in turn is used to calculate the area). One of the following: [Bounding Box] (default) Sets the center to the center of a bounding box that contains the tool data or the data in the region. [Feature Input] Lets you set the center to a point geometric feature output from another tool. When you choose this option, a [Center] dropdown lets you choose the center point. For more information on geometric features, see 📖 "●Geometric Features" on page 250.
[Use Max Gap]	Indicates whether the tool uses the [Max Gap] setting (see below).
[Max Gap]	The maximum gap allowed between any two profile points on the contour of the target, in millimeters. In the following illustration of a profile, if the gap were greater than the value set in [Max Gap], the tool would return an invalid value. 

Parameter	Description
[Sample Spacing]	The angle interval around the center of the profile the tool uses to calculate area. Enabling this setting and setting a value can increase the tool's performance. In the following image, the spacing is set to 1 degree. The polygon calculated from the profile points, which is then used to calculate the area, is simplified, increasing performance but reducing accuracy.  In the following image, [Sampling Spacing] is set to 0. Accuracy is increased, but performance is reduced.  If you set the value to 0, the tool uses the smallest angle permitted internally by the sampling engine.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

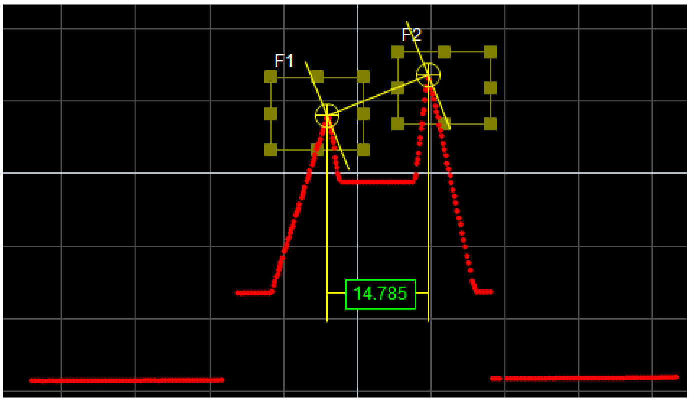
Tips

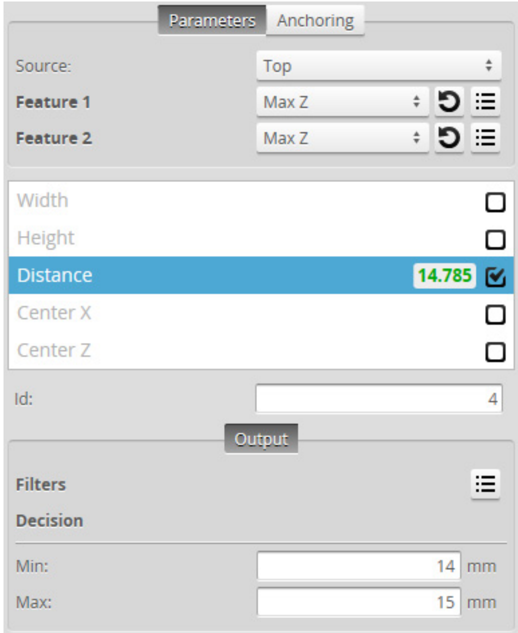
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

5.8 Dimension

The Dimension tool provides Width, Height, Distance, Center X, and Center Z measurements.

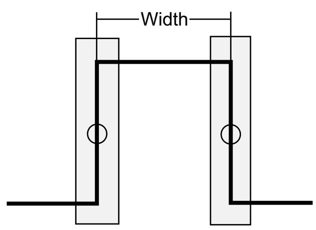
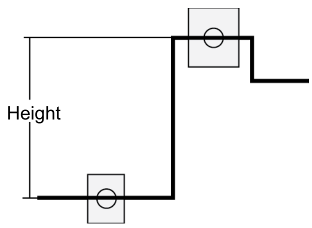


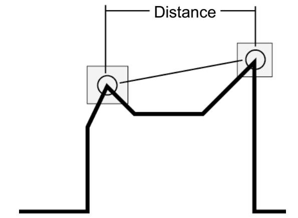
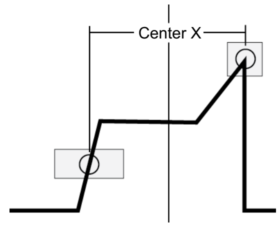
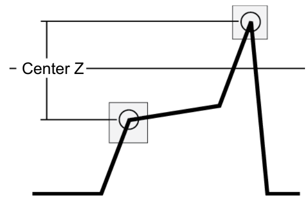


For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

5.8.1 Measurements and Settings

[Measurements]

Measurement	Illustration
[Width] Determines the difference along the X axis between two feature points. The difference can be calculated as an absolute or signed result. The difference is calculated by: Width = Feature 2X position – Feature 1X position	
[Height] Determines the difference along the Z axis between two feature points. The difference can be expressed as an absolute or signed result. The difference is calculated by: Height = Feature 2Z position – Feature 1Z position	

Measurement	Illustration
[Distance] Determines the direct, Euclidean distance between two feature points.	
[Center X] Finds the average location of two features and measures the X axis position of the average location	
[Center Z] Finds the average location of two features and measures the Z axis position of the average location.	

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Feature 1] [Feature 2]	The [Feature 1] and [Feature 2] settings represent the two features the tool uses to perform measurements. For each, one of the following: • [Max Z] • [Min Z] • [Max X] • [Min X] • [Corner]* • [Average]* • [Rising Edge]* • [Falling Edge]* • [Any Edge]* • [Top Corner]* • [Bottom Corner]* • [Left Corner]* • [Right Corner]* • [Median] To set the region of a feature, adjust it graphically in the data viewer, or expand the feature using the expand button (☰) and enter the values in the fields. For more information on regions, see "Regions" on page 238.

Parameter	Description
[Absolute] (Width and Height measurements only)	Determines if the result will be expressed as an absolute or a signed value.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

* These elements are not shown when [Uniform Spacing] (in the [Scan Mode] panel on the [Scan] page) is unchecked.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

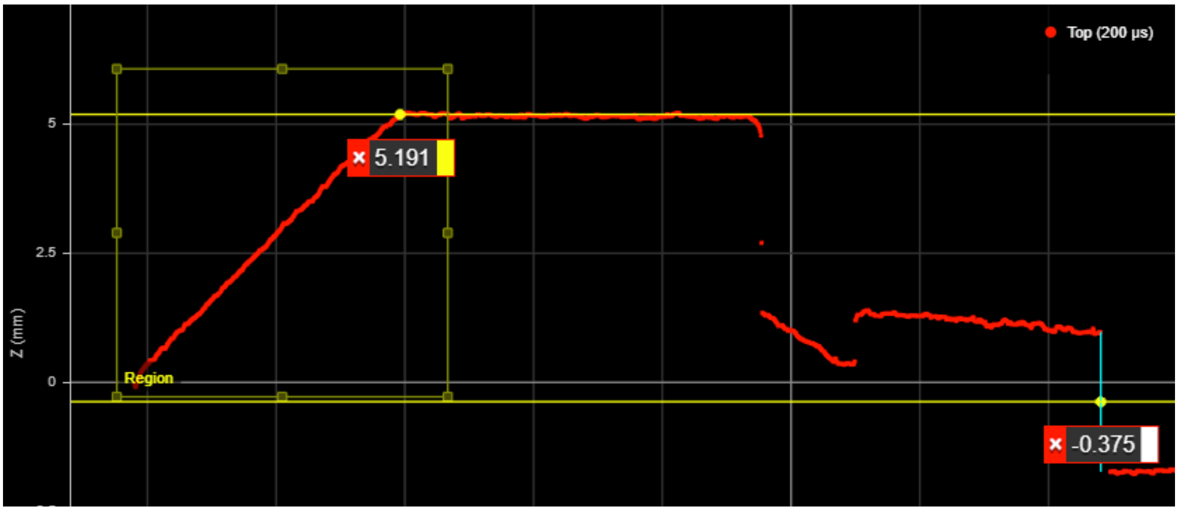
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

5.9 Edge

The Profile Edge tool finds an edge on a profile, searching from left to right. The tool's settings help fit the edge point when multiple potential edges are in the region of interest.

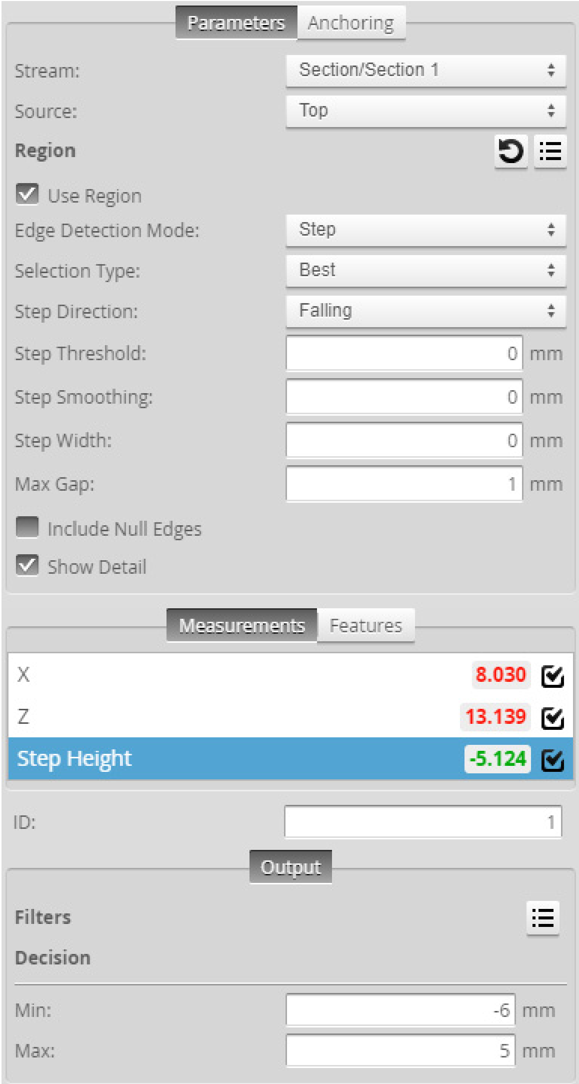
You can configure the tool to locate steps or corners (that is, for cases where there is no clear step in the profile but instead a smooth slope). In the following, one instance of the tool detects the corner on the left, and another detects the step on the right.



Z positions of the corner (left) and the center of a step (right)

After the tool locates an edge, it returns the position (X and Z) of the edge. For steps, it also returns the step height.

The tool can also generate a point geometric feature corresponding to the center of the step that Feature tools can take as input for measurement. For more information on Feature tools, see 📖 "4.7.9 Feature Measurement" on page 301.



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

5.9.1 Measurements, Features, and Settings

[Measurements]

Measurement	Description
[X] [Z]	These measurements return the X and Z position of the edge point, respectively. The edge point is located half-way between the upper and lower data points of the step.
[Step Height]	Returns the height of the step on the profile. Only available if [Edge Detection Mode] is set to Step.

[Features]

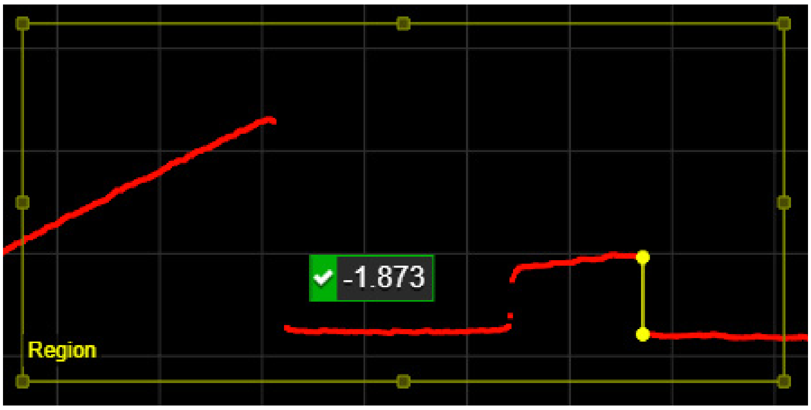
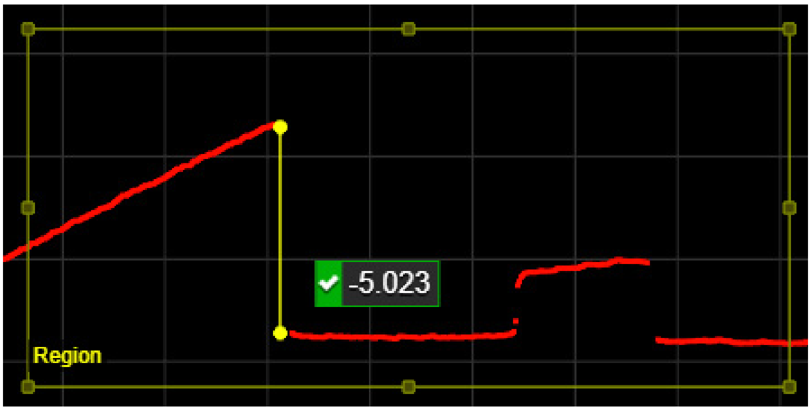
Type	Description
[Edge Center Point]	The edge point.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

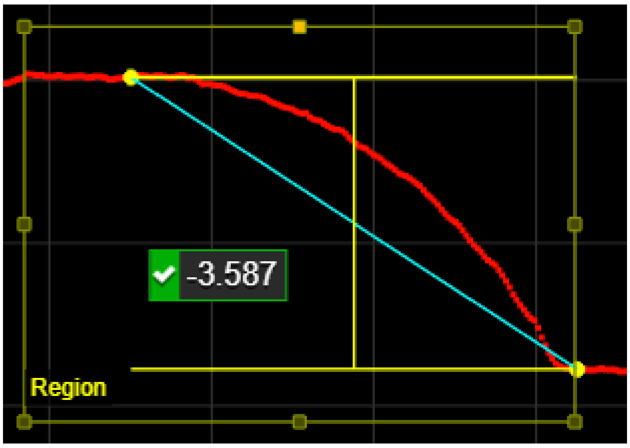
[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Edge Detection Mode]	One of the following: Step or Corner. [Step]: Searches for steps on each path profile. [Corner]: Searches for slopes on each path profile. When you choose this mode, several of the tool's parameters are hidden.
[Selection Type]	Determines which step the tool uses when there are multiple steps in the profile. An edge point is placed the chosen step. Steps must satisfy the tool's [Step Threshold] and [Step Direction] settings. [Best]: Selects the greatest step on the profile. [First]: Selects the first step on the profile. [Last]: Selects the last step on the profile.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Step Threshold]</td><td>The minimum step accepted as an edge candidate. Steps on the profile are treated as absolute values when compared to this setting.
In the following profile, with [Step Threshold] set to 1.7 (and [Selection Type] set to Last), the tool accepts the step to the right, with a step of -1.873 mm, because it is above the step threshold.

In the following, when [Step Threshold] is increased to 1.9, the tool excludes the falling step to the right, because it is no longer above the step threshold, and instead uses the step to the left.
</td></tr>
<tr><td>[Step Direction]</td><td>Determines whether the expected step rises or falls, moving left to right, along the profile. Either [Rising], [Falling], or [Rising or Falling].</td></tr>
<tr><td>[Step Smoothing]</td><td>The size of the (moving) window along the profile used to calculate an average for each data point on the profile. The setting is useful for averaging out noise.
If [Step Smoothing] is set to 0, no averaging is performed.</td></tr>
</table>

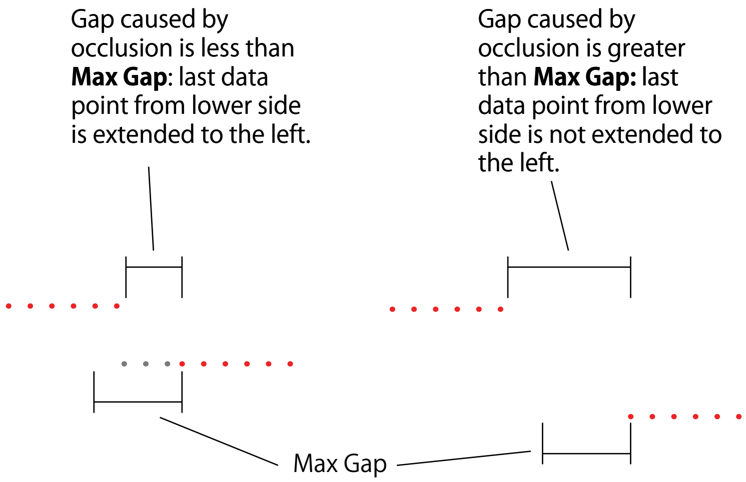
<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Step Width]</td><td>The distance, along a path profile, separating the points the tool uses to find steps on a profile.

In the following, a step width of 5.5 mm causes the tool to consider profile points that distance apart as steps. Consequently, the curved portion of the profile is not used to measure the step.



The setting is useful when you must detect a slope as an edge, rather than a sharply defined edge: setting [Step Width] to a value greater than the width of the edge ensures that the tool measures the height difference between the flat regions on either side of the edge. As a result, the height of the step is accurately measured, and the edge is correctly located.

Tips
Setting [Step Width] wider than necessary can reduce the precision of edge location.</td></tr>
<tr><td>[Max Gap]</td><td>Fills in regions of missing data caused by an occlusion near the desired edge. Use this setting when continuity on the target is expected. When [Max Gap] is set to a non-zero value, the tool holds and extends the last data point on the low side next to an edge across a gap of null points, up to the distance specified in [Max Gap].



The tool uses data points "filled in" by [Max Gap] before data points filled in by [Null Fill Value] (see below).</td></tr>
</table>

Parameter	Description
[Include Null Edges]	Indicates whether null points (points where no height value is available, due to drop-outs or regions outside of the measurement range) are filled with the value in [Null Fill Value] as a general “background level.” **Tips** To find an edges next null points, you must use either this option and an appropriate value in [Null Fill Value] or [Max Gap]. Otherwise, only edges within areas of contiguous data will be detected.
[Null Fill Value]	The height value (in mm) used to replace null points when Include Null Edges is enabled. If both [Null Fill Value] and [Max Gap] fill in null points at the same position, the tool uses the value extended by [Max Gap], regardless of the value of [Null Fill Value].
[Show Detail]	When disabled, reduces what is indicated in the data viewer.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

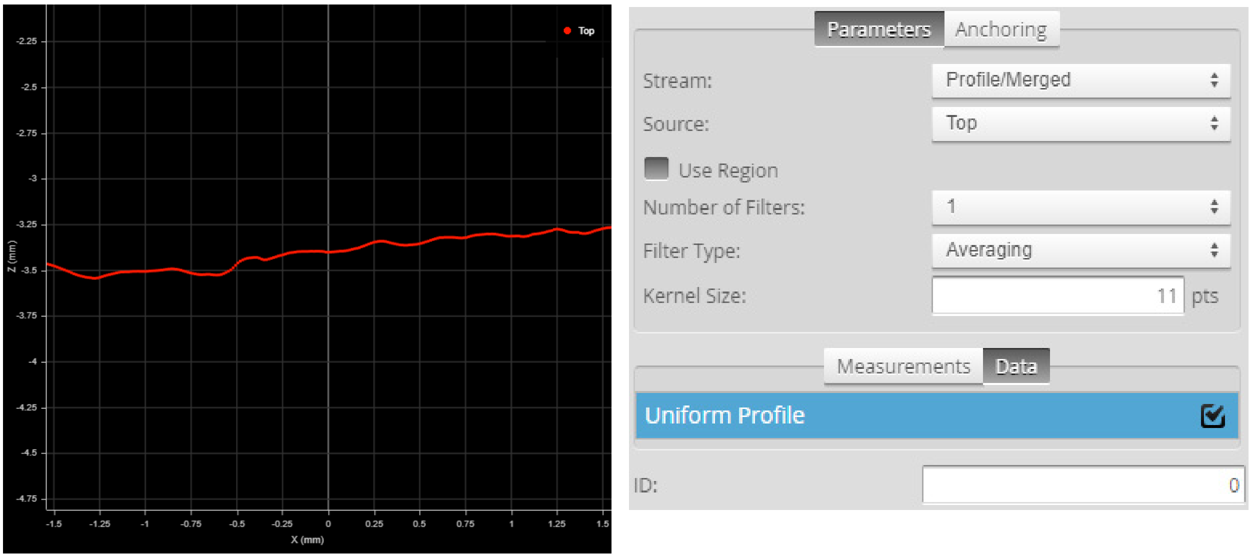
5.10 Filter

> **Tips**
> The tool is supported in emulator scenarios.

The Profile Filter tool provides processing filters that you can apply to a uniform profile, letting you process scan data to get more repeatable measurements. You can enable up to seven of the filters at once, in any order. Filters in the tool are chained together. Any Profile tool can use the resulting filtered profile as input, via the tool's [Stream] drop-down.

For a list of the filters, see 📖 "[Filters]" on page 378.

The Filter tool provides no measurements or decisions, as its only purpose is to output processed profile data.



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.10.1 Settings and Available Filters

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238. Can only accept Profile scan data (that is, cannot accept data from other tools).
[Use Region]	When enabled, displays additional settings to let you set a region (see below).
Number of Regions [Region {n}]	Lets you set the number of regions, and for each region, the position and dimensions.
Number of Filters	Specifies the number of filters you want to chain together. You can specify up to seven filters.

[Filter Type]	For each filter you have activated using [Number of Filters], specifies the type of filter. For more information on the available filters, see "[Filters]" on page 378.
[Sigma]	The Gaussian curve's sigma value. (Only displayed with the Gaussian filter.)
[Kernel Size]	The kernel size that the filter uses. (Not available on all filters.)
[Max Gap]	The maximum gap between data points allowed when interpolating.

The following filters are available in the Profile Filter tool.

[Filters]

Name	Description
[Averaging]	An averaging filter applied over the kernel.
[Gaussian]	A Gaussian filter applied over the specified kernel using the provided sigma. Enables a [Sigma] parameter.
[Median]	A median filter applied over the specified kernel. The filter supports a kernel size ranging from 3 to 99999 data points.
[Interpolation]	Fills in missing data points between two valid data points using interpolation up to the value specified in [Max Gap].

[Data]

Type	Description
[Uniform Profile]	The filtered uniform profile, available for use as input in the [Stream] drop-down in other tools.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

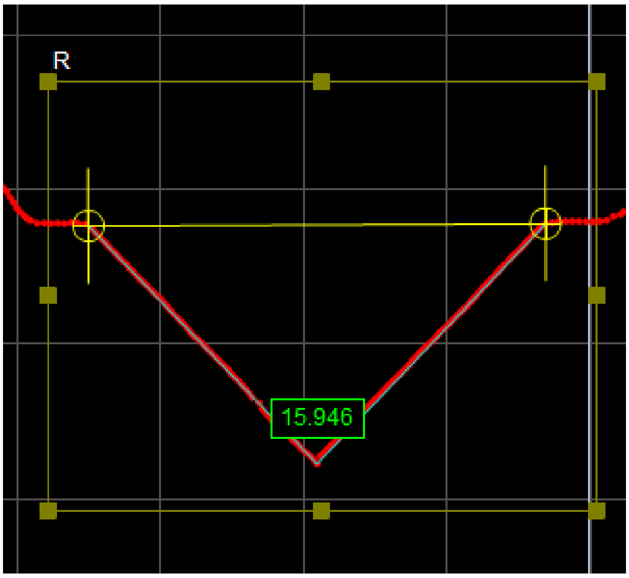
Tips

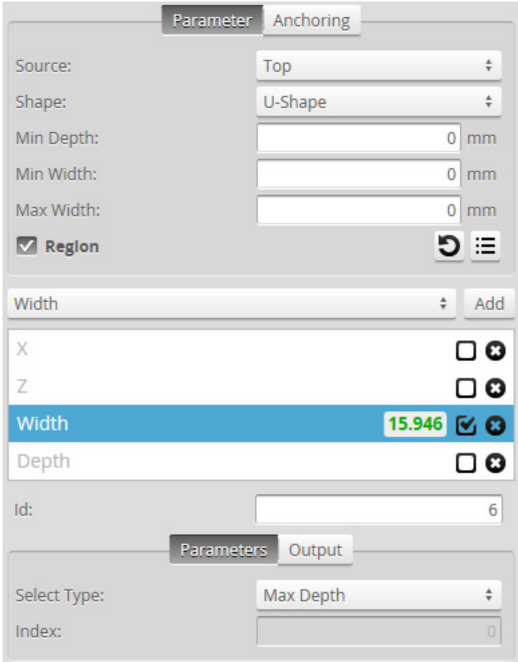
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

5.11 Groove

The Groove tool provides measurements of V-shape, U-shape, or open-shape grooves.





The Groove tool uses a complex feature-locating algorithm to find a groove and then return measurements. See "Groove Algorithm" in the SurfaceMeasure1008S Measurement Tool Technical Manual for a detailed explanation of the algorithm. The behavior of the algorithm can be adjusted by changing the parameters in the measurement panel.

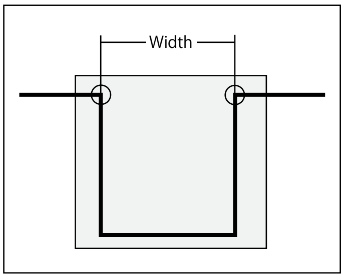
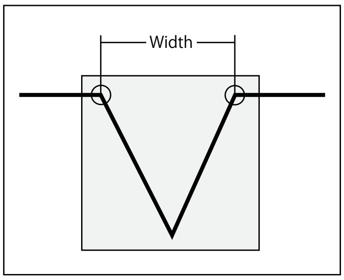
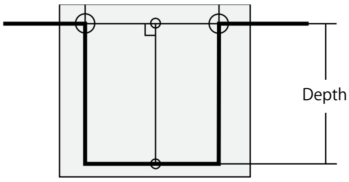
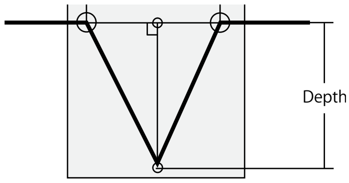
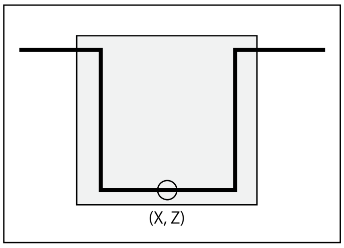
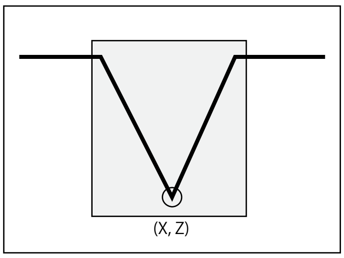
The Groove tool lets you add multiple measurements of the same type to receive measurements and set decisions for multiple grooves. Multiple measurements are added by using the drop-down above the list of measurements and clicking on the [Add] button.

For example, if a target has three grooves, by adding two measurements, choosing [Index From The Left] in the [Select Type] setting of those measurements, and providing values of 0 and 2 in the [Index] setting of the measurements, respectively, the Groove tool will return measurements and decisions for the first and third grooves.

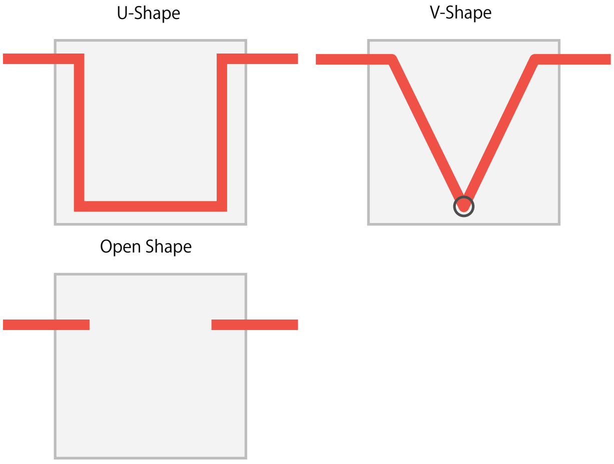
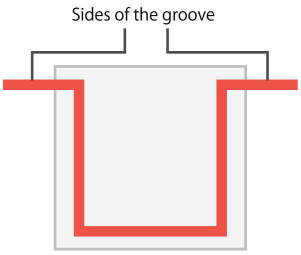
For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.11.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Width] Measures the width of a groove.	 
[Depth] Measures the depth of a groove as the maximum perpendicular distance from a line connecting the edge points of the groove.	 
[X] Measures the X position of the bottom of a groove.	
[Z] Measures the Z position of the bottom of a groove.	

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Shape]	Shape of the groove 
[Min Depth]	Minimum depth for a groove to be considered valid.
[Min Width]	Minimum width for a groove to be considered valid. The width is the distance between the groove corners.
[Max Width]	Maximum width of a groove to be considered valid. If set to 0, the maximum is set to the width of the measurement area.
[Region]	The measurement region defines the region in which to search for the groove. For a stable measurement, the measurement region should be large enough to cover some data on the left and right sides of the groove.  For more information on regions, see 📖 "●Regions" on page 238.
[Location] (Groove X and Groove Z measurements only)	Specifies the location type to return Bottom - Groove bottom. For a U-shape and open-shape groove, the X position is at the centroid of the groove. For a V-shape groove, the X position is at the intersection of lines fitted to the left and right sides of the groove. See algorithm section below for more details. [Left] - Groove's left corner. [Right] - Groove's right corner.

Parameter	Description
[Select Type]	Specifies how a groove is selected when there are multiple grooves within the measurement area. Maximum Depth - Groove with maximum depth. Index from The Left - 0-based groove index, counting from left to right Index from the Right - 0-based groove index, counting from right to left.
[Index]	0-based groove index.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

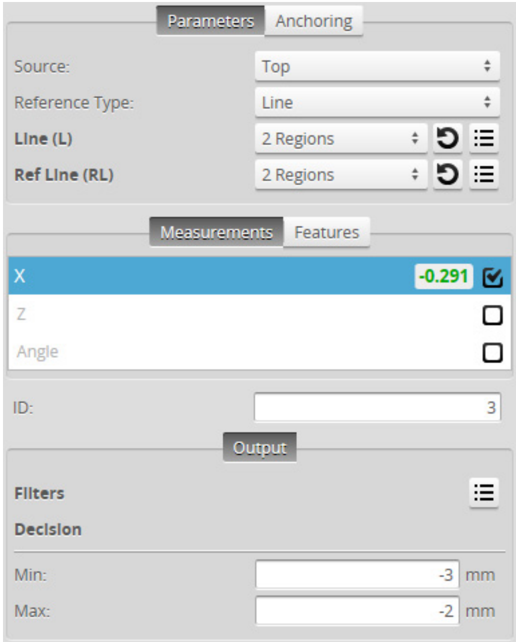
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

5.12 Intersect

The Intersect tool determines intersect points and angles.

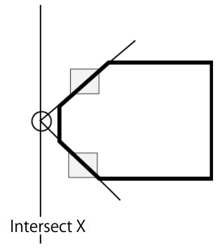
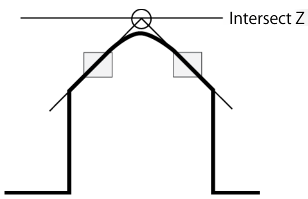
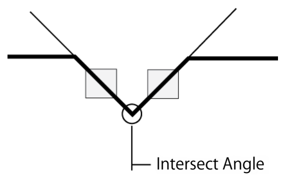
The Intersect tool's measurements require two fit lines, one of which is a reference line set to the X axis (z = 0), the Z axis (x = 0), or a user-defined line.



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

5.12.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Finds the intersection between two fitted lines and measures the X axis position of the intersection point.	
[Z] Finds the intersection between two fitted lines and measures the Z axis position of the intersection point.	
[Angle] Finds the angle subtended by two fitted lines.	

[Features]

Type	Description
[Intersect Point]	The point of intersection.
[Line]	The intersect line.
[Base Line]	The base line.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Reference Type]	Determines the type of the reference line. [X-Axis]: The reference line is set to the X axis. [Z-Axis]: The reference line is set to the Z axis [Line]: The reference line is defined manually using the [Ref Line] parameter. One or two regions can be used to define the line.
[Line]	You can use one or two fit areas for the fit line. To set the region (or regions) of the fit line, adjust it graphically in the data viewer, or expand the feature using the expand button (☰) and enter the values in the fields. For more information on regions, see 📖 "●Regions" on page 238. For more information on fit lines, see 📖 "●Fit Lines" on page 251.
[Ref Line]	Used to define the reference line when [Line] is selected in the [Reference Type] parameter. To set the region (or regions) of the reference line, adjust it graphically in the data viewer, or expand the feature using the expand button (☰) and enter the values in the fields. For more information on regions, see 📖 "●Regions" on page 238. For more information on fit lines, see 📖 "●Fit Lines" on page 251.
[Angle Range] (Angle measurement only)	Determines the angle range. The options are: [-90 – 90] [0 – 180]
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

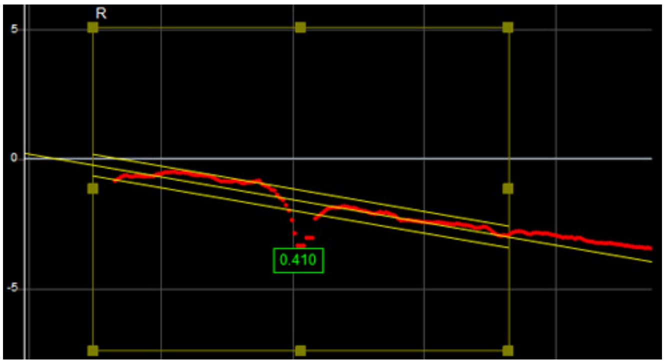
Tips

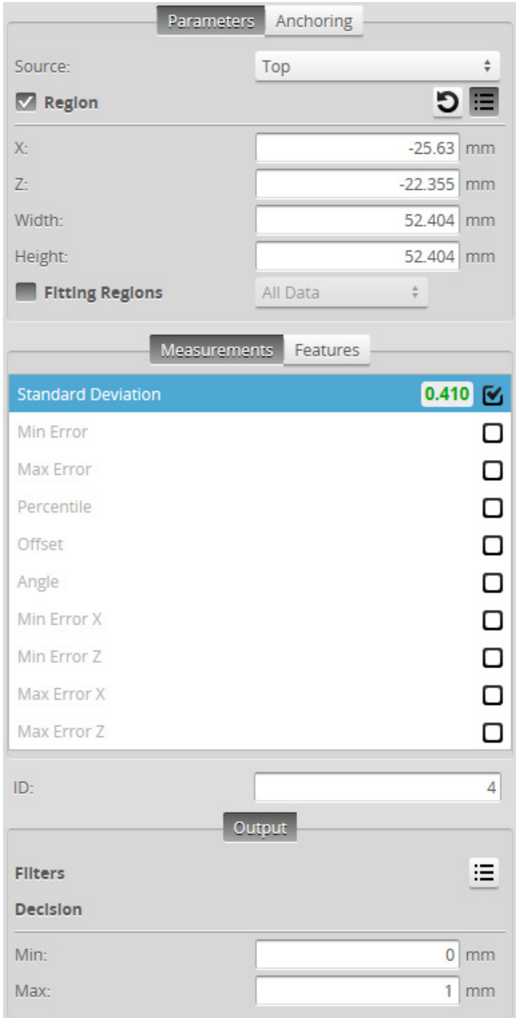
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

5.13 Line

The Line tool fits a line to the profile and measures the deviations from the best-fitted line. The sensor compares the measurement value with the values in [Min] and [Max] to yield a decision. For more information on decisions, see 📖 "●Decisions" on page 251.

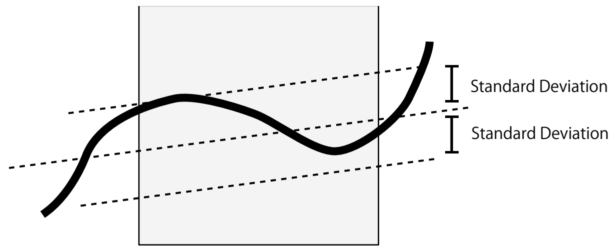
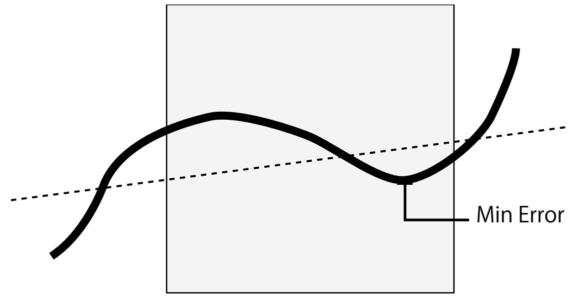
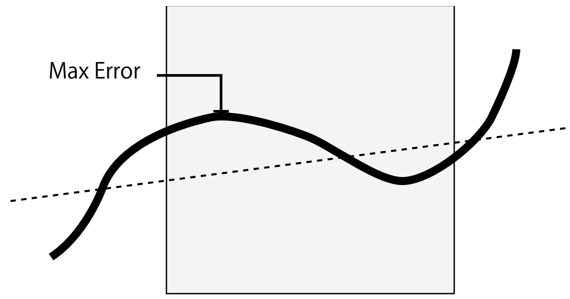
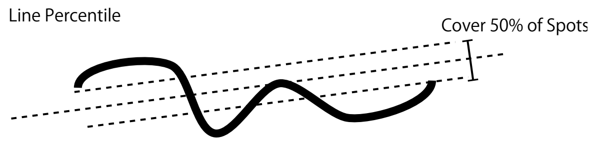
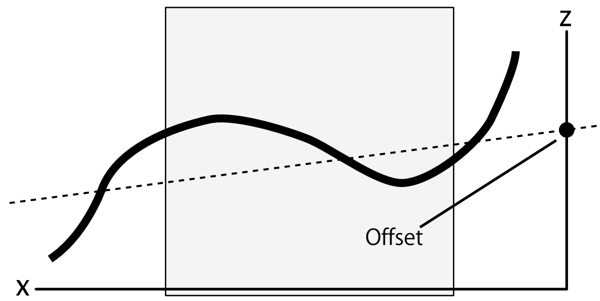
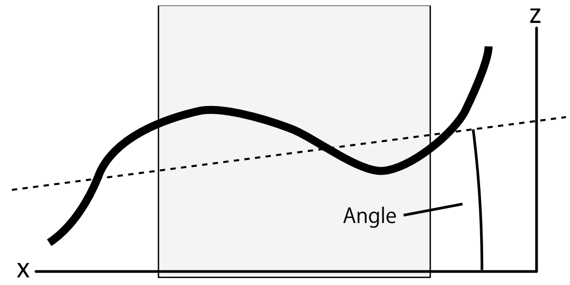


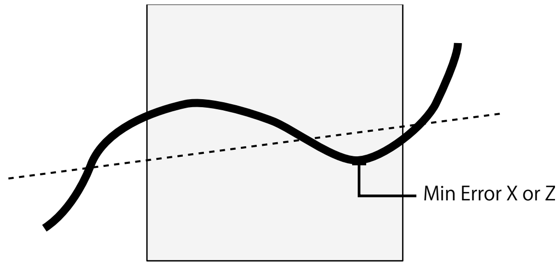
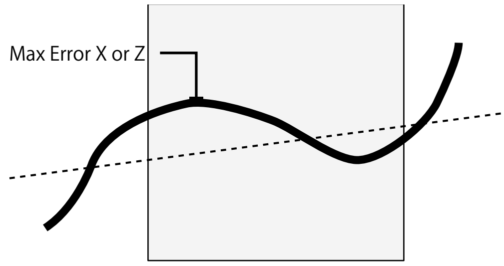


For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.13.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Standard Deviation] Finds the best-fitted line and measures the standard deviation of the data points from the line.	
[Min Error] Finds the best-fitted line and measures the minimum error from the line (the maximum distance below the line).	
[Max Error] Finds the best-fitted line and measures the maximum error from the line (the maximum distance above the line).	
[Percentile] Finds the best-fitted line and measures the range (in Z) that covers a percentage of points around the line.	
[Offset] Finds the best-fitted line and returns the intersection point between that line and the Z axis.	
[Angle] Finds the best-fitted line and returns the angle relative to the X axis.	

Measurement	Illustration
[Min Error X] [Min Error Z] Finds the best-fitted line and returns the X or Z position of the minimum error from the line (the maximum distance below the line).	
[Max Error X] [Max Error Z] Finds the best-fitted line and returns the X or Z position of the maximum error from the line (the maximum distance above the line).	

[Features]

Type	Description
[Line]	The fitted line.
[Error Min Point]	The point of minimum error.
[Error Max Point]	The point of maximum error.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.

Parameter	Description
[Fitting Regions]	Determines which data SurfaceMeasure1008S uses to fit the line over the profile. When Fitting Regions is enabled, SurfaceMeasure1008S uses the data indicated by one of the following options: • All Data: All of the data in the profile is used to fit the line. • 1 Region: Data from a fitting region you define in the data viewer is used to fit the line. • 2 Regions: Data from two fitting regions you define is used to fit the line. When [Fitting Regions] is disabled, to fit the line, SurfaceMeasure1008S uses the measurement region if [Region] is enabled, or the entire profile if [Region] is disabled. When [Fitting Regions] is enabled and [1 Region] or [2 Regions] is selected, you can set the region (or regions) graphically in the data viewer, or you can expand the feature using the expand button ( ) and enter the values in the fields. For more information on regions, see "●Regions" on page 238.
[Percent] (Percentile measurement only)	The specified percentage of points around the best-fitted line.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

5.14 Line Advanced

Tips

The tool is supported in emulator scenarios.

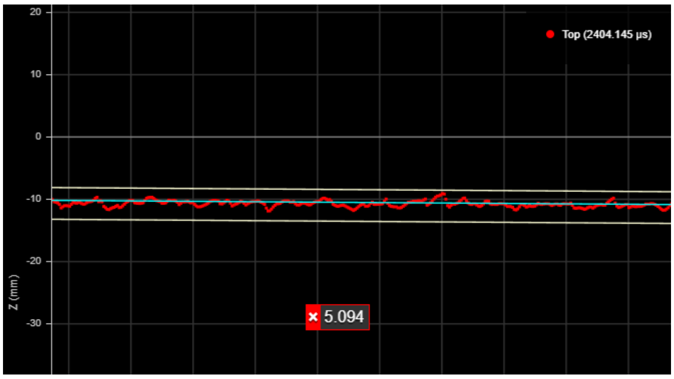
Like the Profile Line tool, the Profile Line Advanced tool fits a line to a profile and measures the deviations from the best-fitted line. Additionally, this version of the tool provides two “roughness parameter” measurements: Ra and Rz. Note that the region-related parameters have been reorganized to make the tool easier to use. The sensor compares the measurement value with the values in Min and Max to yield a decision. For more information on decisions, see 📖 "●Decisions" on page 251.

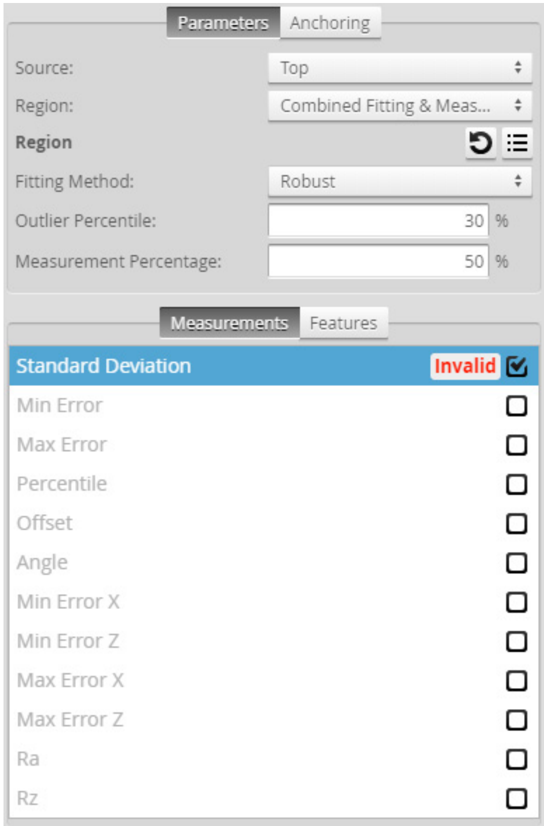
Tips

If you do not need the roughness parameters, Mitutoyo currently recommends using the Profile Line tool (see 📖 "5.13 Line" on page 385).

Tips

Set Fitting Method to Simple to cause the tool to behave like the older Profile Line tool.

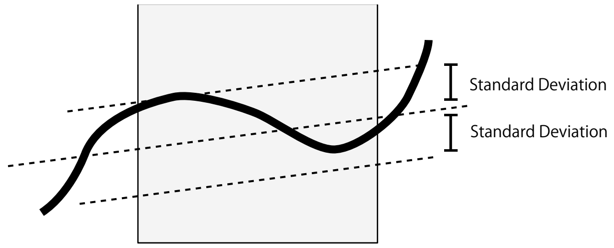
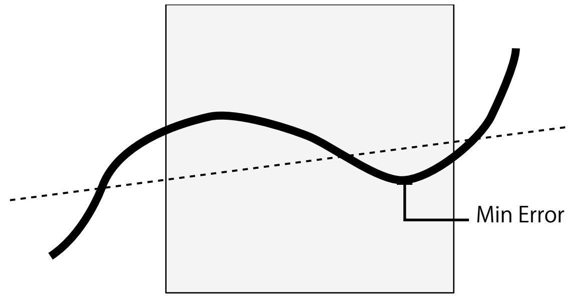
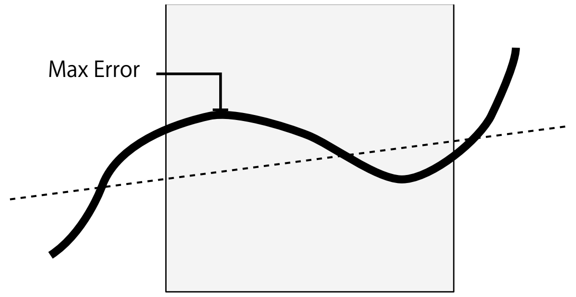
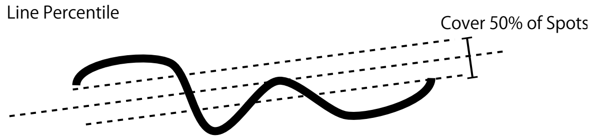
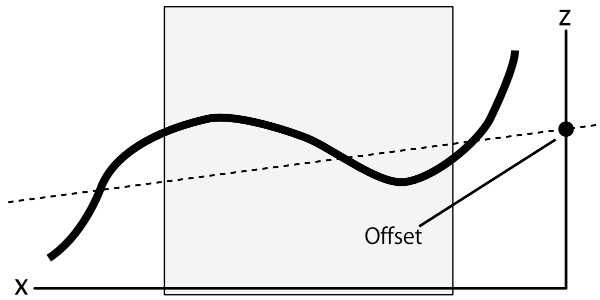
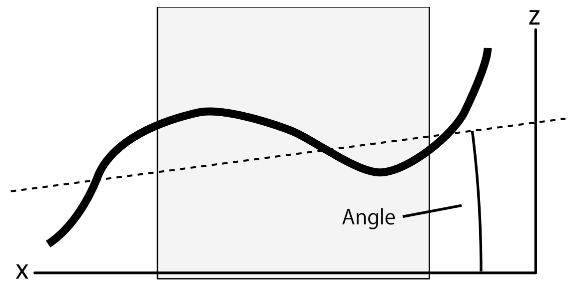


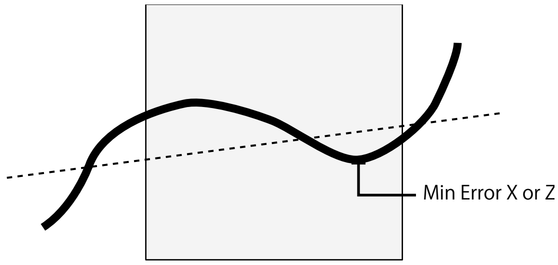
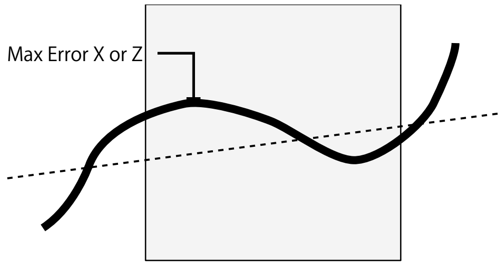
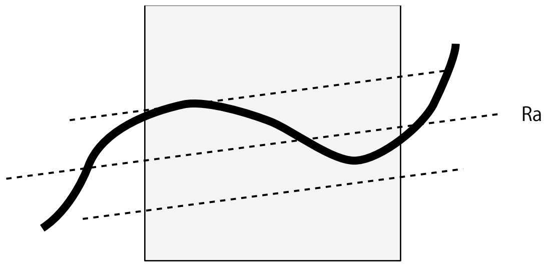
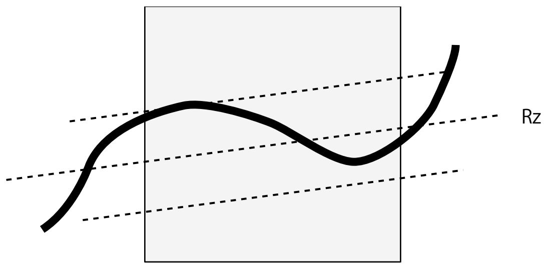


For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.14.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Standard Deviation] Finds the best-fitted line and measures the standard deviation of the data points from the line.	
[Min Error] Finds the best-fitted line and measures the minimum error from the line (the maximum distance below the line).	
[Max Error] Finds the best-fitted line and measures the maximum error from the line (the maximum distance above the line).	
[Percentile] Finds the best-fitted line and measures the range (in Z) that covers a percentage of points around the line.	
[Offset] Finds the best-fitted line and returns the intersection point between that line and the Z axis.	
[Angle] Finds the best-fitted line and returns the angle relative to the X axis.	

Measurement	Illustration
[Min Error X] [Min Error Z] Finds the best-fitted line and returns the X or Z position of the minimum error from the line (the maximum distance below the line).	
[Max Error X] [Max Error Z] Finds the best-fitted line and returns the X or Z position of the maximum error from the line (the maximum distance above the line).	
[Ra] Returns the roughness average of the profile data.	
[Rz] Returns the average maximum height of the profile data.	

[Features]

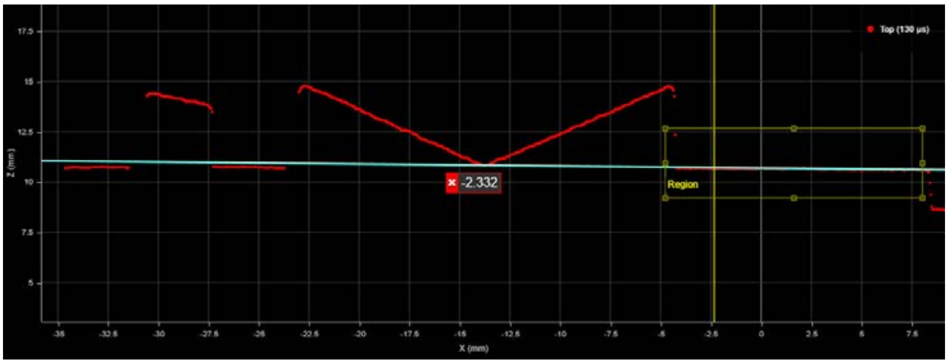
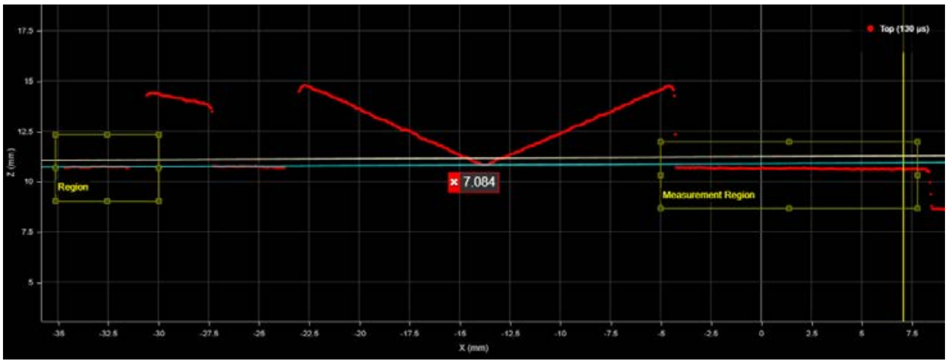
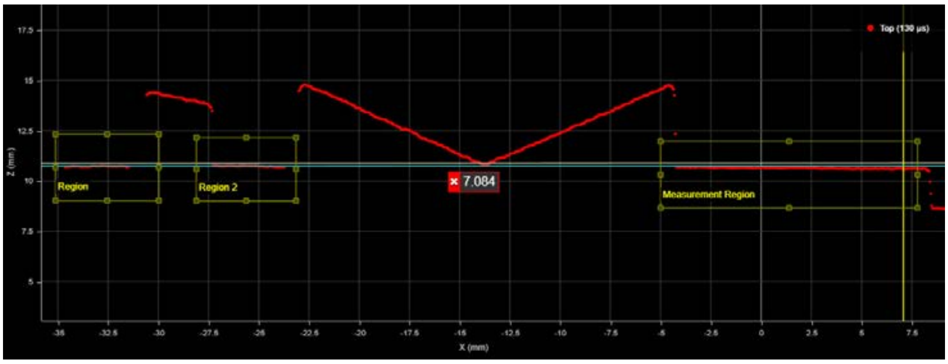
Type	Description
[Line]	The fitted line.
[Error Min Point]	The point of minimum error.
[Error Max Point]	The point of maximum error.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.

Parameter	Description
[Region]	Whether the fitting and measurement regions are combined or separate (or not used). One of the following: [None] The tool uses the entire profile to fit the line and perform measurements. [Combined Fitting & Measurement] The tool uses a single, user-defined region to fit the line and in which it performs measurements. In the following image,  [Separate Fitting & Measurement] The tool uses one or two regions to fit the line, and a single, separate region in which it performs measurements. In the following image, the tools uses a single region to the left to fit the line, and performs measurements in the measurement region to the right:  In the following image, the uses two regions to the left to fit the line, and performs measurements in the measurement region to the right: 
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.

Parameter	Description
[Region] [Region 2] [Measurement Region] (for region definition)	These settings contain parameters to define the position and size of the fitting and measurement regions.
[Fitting Method]	Determines how the tool fits the line to the data. One of the following: [Simple] Uses a less accurate but faster line-fitting method. Use this setting to cause the tool to behave like Profile Line. [Robust] An iterative line-fitting method that removes points and attempts to fit a line until only one-third of the original profile data points is left. More accurate but takes longer.
[Outlier Percentile]	Indicates the number of outlier points to be removed overall during line fitting. Adjust this value based on how much noise is present in the profile. Only displayed when [Method] is set to [Robust].
[Measurement Percentage] (Percentile measurement only)	The specified percentage of points around the best-fitted line that the Percentile measurement uses.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

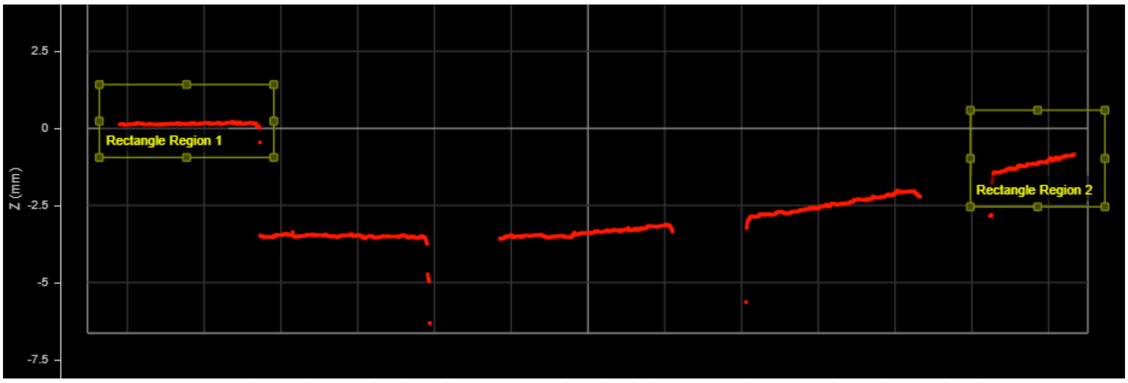
For more information on anchoring, see "●Measurement Anchoring" on page 254.

5.15 Mask

The Profile Mask lets define up to 16 regions to extract data from a profile. Each region's size, position, and shape (circular, elliptical, and rectangular) can be individually configured, and regions can overlap. The tool can also exclude inner data of circular and elliptical regions, letting you avoid measuring noise or unwanted areas of profile data. Extracted data is output in a single profile.

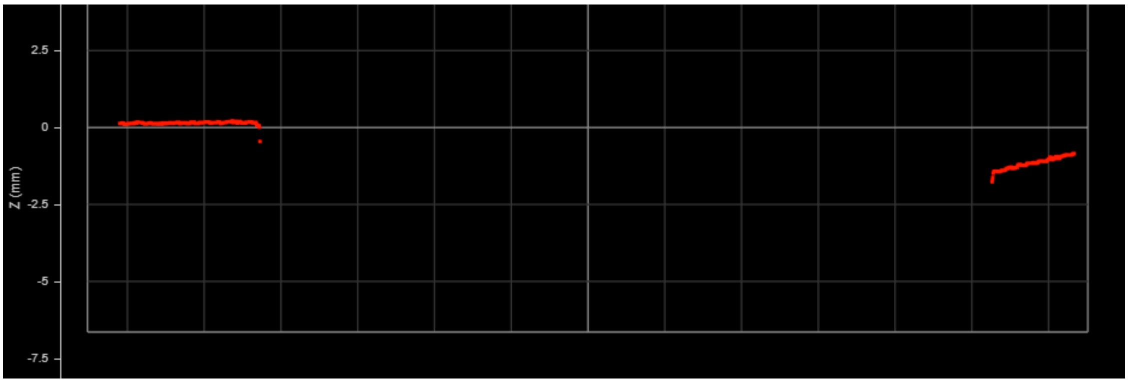
The resulting profile can then be further processed or measured by other tools.

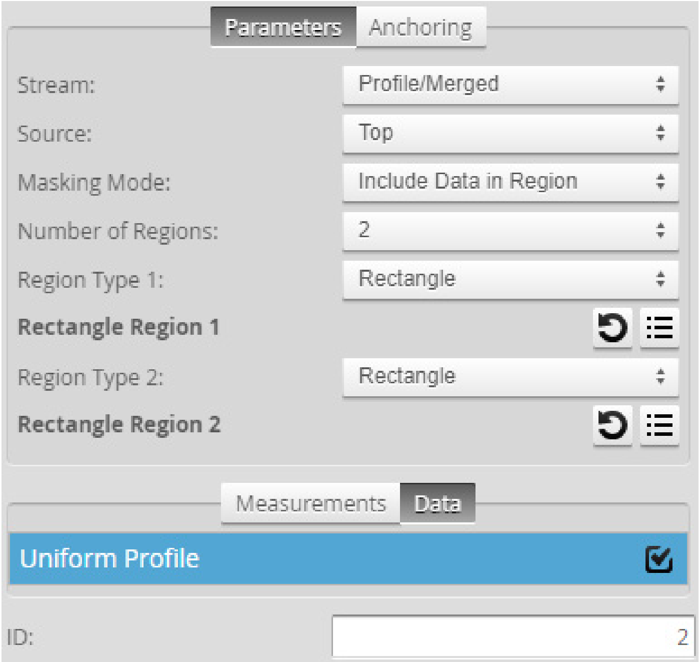
For example, given the following scan data:



Two mask regions defined on a profile (original profile, all data included)

The image below shows the extracted data. The extracted profile data can then be further processed by other tools, or measurements can be applied to the surface data.





Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.15.1 Measurements and Settings

[Measurements]

Measurement	Description
[Processing Time]	The amount of time the tool takes to process.

[Data]

Type	Description
[Uniform Profile] [Point Cloud Profile] [Uniform Profile Sec] [Point Cloud Profile Sec]	The profile containing the extracted region or regions. (The name depends whether you enable Uniform Spacing on the Scan page; for more information, see 📖 "4.4.2 Scan Modes" on page 116.) In multi-sensor systems, when [Source] is set to Top & Bottom, the tool lists a second pair of measurements (for example, Uniform Profile Sec).

[Parameters]

Parameter	Description
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool. If you switch from one type of data to another (for example, from section profile data to surface data), currently set input features will become invalid, and you will need to choose features of the correct data type.
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Masking Mode]	The masking mode the tool uses. One of the following: [Include data in region]: Data in the mask is included [Exclude data in region]: Data in the mask is excluded.
Number of Regions [Mask Type {n}] / [Region Type {n}] [Inner Circle Diameter] [Inner Ellipse Major Axis] [Inner Ellipse Minor Axis] [Sector Start Angle] [Sector Angle Range]	When you enable [Use Region], the tool displays additional settings related to the measure region type. For details on flexible regions and their settings, see "Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

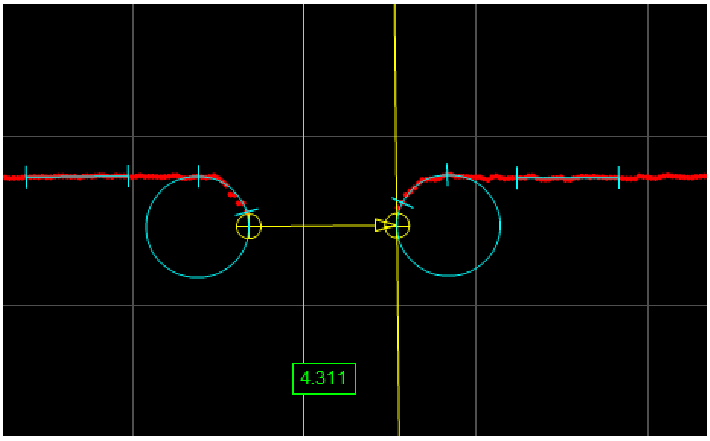
Tips

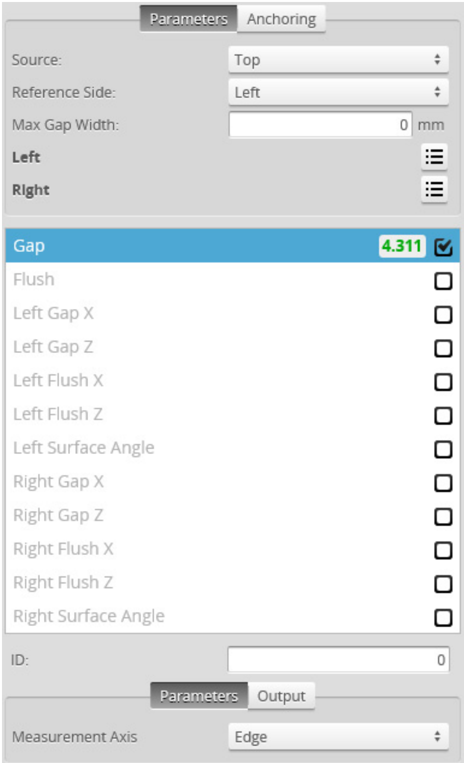
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

5.16 Panel

The Panel tool provides Gap and Flush measurements.





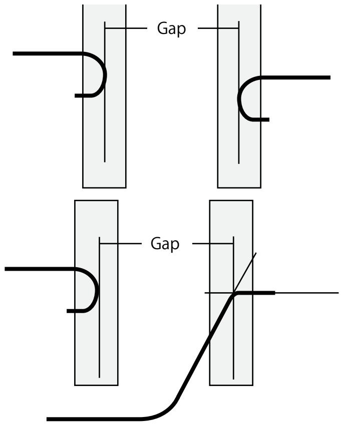
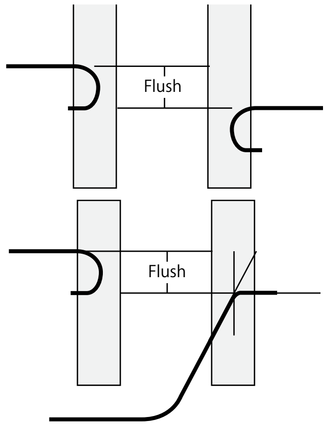
The Panel tool uses a complex feature-locating algorithm to find the gap or calculate flushness and return measurements. The behavior of the algorithm can be adjusted by changing the parameters in the measurement panel. See "Gap and Flush Algorithm" in the SurfaceMeasure1008S Measurement Tool Technical Manual for a detailed explanation of the algorithm.

Tips

You must make sure that there are enough data points to define the edge in the profile, by properly setting up exposure, etc. If not, the algorithm will not function.

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

[Measurements]

Measurement	Illustration
[Gap] Measures the distance between two surfaces. The surface edges can be curved or sharp.	
[Flush] Measures the flushness between two surfaces. The surface edges can be curved or sharp.	
[Left Gap X] Returns the X position of the edge feature on the left side used to measure the gap.	
[Left Gap Z] Returns the Z position of the edge feature on the left side used to measure the gap.	
[Left Flush X] Returns the X position of the feature on the left side used to measure flushness.	
[Left Flush Z] Returns the Z position of the feature on the left side used to measure flushness.	
[Left Surface Angle] The angle of the left side surface relative to the X axis.	
[Right Gap X] Returns the X position of the edge feature on the right side used to measure the gap.	
[Right Gap Z] Returns the Z position of the edge feature on the right side used to measure the gap.	

Measurement	Illustration
[Right Flush X] Returns the X position of the feature on the right side used to measure flushness.	
[Right Flush Z] Returns the Z position of the feature on the right side used to measure flushness.	
[Right Surface Angle] The angle of the right side surface relative to the X axis.	

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Reference SideDirection]	Defines the side used to calculate the measurement axis (see below) rounded corner.
[Max Gap Width]	The maximum width of the gap. Allows the tool to filter gaps greater than the expected width. This can be used to single out the correct gap when there are multiple gaps in the field of view.
[Measurement Axis] Gap measurement only	Defines the direction that the gap is calculated, in relation to the reference side (see above). [Surface]: In the direction of the fitted surface line of the reference surface. [Edge]: In the direction perpendicular to the edge of the reference surface. [Distance]: The Cartesian distance between the two feature locations.
[Absolute] Flush measurement only	When enabled, returns an absolute value rather than a signed value.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Left/Right SideEdge Parameters]

Parameter	Description
[Max Void Width]	The maximum allowed width of missing data caused by occlusion or data dropout.
[Min Depth]	Defines the minimum depth before an opening could be considered to have a potential edge. The depth is the perpendicular distance from the fitted surface line.
[Surface Width]	The width of the surface area in which data is used to form the fitted surface line. This value should be as large as the surface allows.

Parameter	Description
[Surface Offset]	The distance between the edge region and the surface region. Setting a small value allows the edge within a tighter region to be detected. However, the measurement repeatability could be affected if the data from the edge are considered as part of the surface region (or vice versa). A rule of thumb is to set [Surface Offset] equal to [Nominal Radius].
[Nominal Radius]	The radius of the curve edge that the tool uses to locate the edge region.
[Edge Angle]	A point on the best fit circle to be used to calculate the feature point. The selected point is on the circumference at the specified angle from the start of the edge region. The angle is measured from the axis perpendicular to the fitted surface line.
[Edge Type]	Defines the type of feature point to use for the edge (Corner or Tangent). A tangent edge point is the point selected based on the defined Edge Angle. A corner edge point is the intersect point between the fitted surface line and a edge line formed by interpolating the points at and after the tangent within the edge region.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

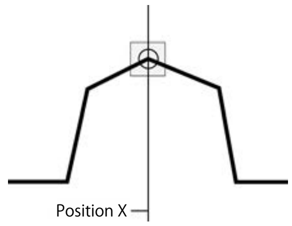
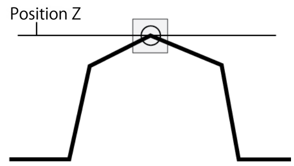
5.17 Position

The Position tool finds the X or Z axis position of a feature point. The feature type must be specified and is one of the following: Max Z, Min Z, Max X, Min X, Corner, Average (the mean X and Z of the data points), Rising Edge, Falling Edge, Any Edge, Top Corner, Bottom Corner, Left Corner, Right Corner, or Median (median X and Z of the data points).

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.17.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Finds the position of a feature on the X axis.	
[Z] Finds the position of a feature on the Z axis.	

[Features]

Type	Description
[Point]	The returned position.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.

Parameter	Description
[Feature]	The feature the tool uses for its measurements. One of the following: • [Max Z] • [Min Z] • [Max X] • [Min X] • [Corner] • [Average] • [Rising Edge] • [Falling Edge] • [Any Edge] • [Top Corner] • [Bottom Corner] • [Left Corner] • [Right Corner] • [Median] To set the region of a feature, adjust it graphically in the data viewer, or expand the feature using the expand button ( ) and enter the values in the fields. For more information on regions, see "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The Max and Min settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

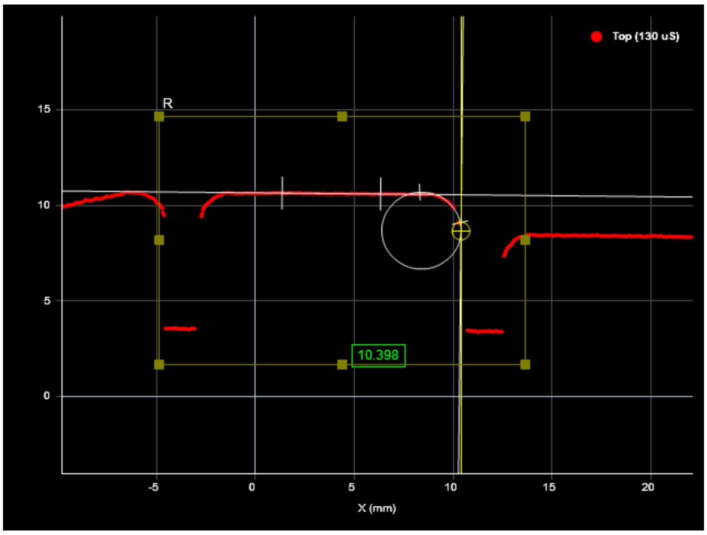
Tips

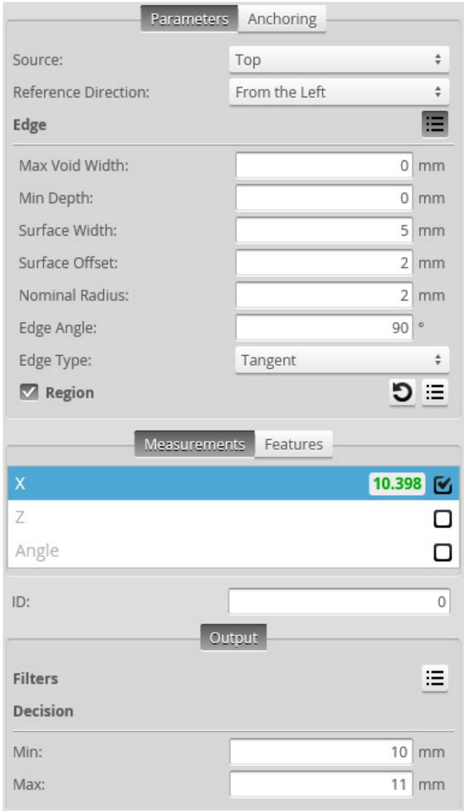
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254

5.18 Round Corner

The Round Corner tool measures corners with a radius, returning the position of the edge of the corner and the angle of adjacent surface with respect to the X axis.



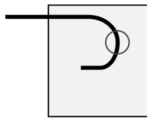
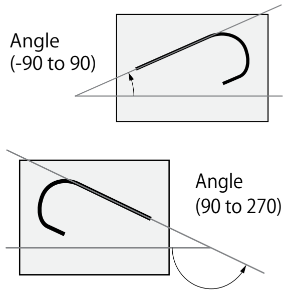


For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

The Round Corner tool uses a complex feature-locating algorithm to find the edge and return measurements. The behavior of the algorithm can be adjusted by changing the parameters in the measurement panel. See "Gap and Flush Algorithm" in the SurfaceMeasure1008S Measurement Tool Technical Manual for a detailed explanation of the algorithm.

Tips
You must make sure that there are enough data points to define the edge (proper exposure, etc.). If not, the algorithm will not function.

[Measurements]

Measurement	Illustration
[X] Measures the X position of the location where the tangent touches the edge, or intersect of the tangent and the line fitted to the surface used by the measurement (see Reference Side, below).	
[Z] Measures the Z position of the location where the tangent touches the edge, or intersect of the tangent and the line fitted to the surface used by the measurement (see Reference Side, below).	
[Angle] Measures the angle of the line fitted to the surface next to the corner (see Reference Side, below), with respect to the x-axis. Left edge angles are from -90 to 90. Right edge angles are from 90 to 270.	

[Features]

Type	Description
[Edge Point]	The position of the edge.
[Radius Center Point]	The center of the radius.

Tips

For more information on geometric features, see "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Reference Direction]	Defines the side used to calculate the rounded corner.
[Max Gap Width]	The maximum width of the gap. Allows the tool to filter gaps greater than the expected width. This can be used to single out the correct gap when there are multiple gaps in the field of view.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.

[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Edge Parameters]

Parameter	Description
[Max Void Width]	The maximum allowed width of missing data caused by occlusion or data dropout.
[Min Depth]	Defines the minimum depth before an opening could be considered to have a potential edge. The depth is the perpendicular distance from the fitted surface line.
[Surface Width]	The width of the surface area in which data is used to form the fitted surface line. This value should be as large as the surface allows.
[Surface Offset]	The distance between the edge region and the surface region. Setting a small value allows the edge within a tighter region to be detected. However, the measurement repeatability could be affected if the data from the edge are considered as part of the surface region (or vice versa). A rule of thumb is to set Surface Offset equal to Nominal Radius.
[Nominal Radius]	The radius of the curve edge that the tool uses to locate the edge region.
[Edge Angle]	A point on the best fit circle to be used to calculate the feature point. The selected point is on the circumference at the specified angle from the start of the edge region. The angle is measured from the axis perpendicular to the fitted surface line.
[Edge Type]	Defines the type of feature point to use for the edge (Corner or Tangent). A tangent edge point is the point selected based on the defined Edge Angle. A corner edge point is the intersect point between the fitted surface line and a edge line formed by interpolating the points at and after the tangent within the edge region.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

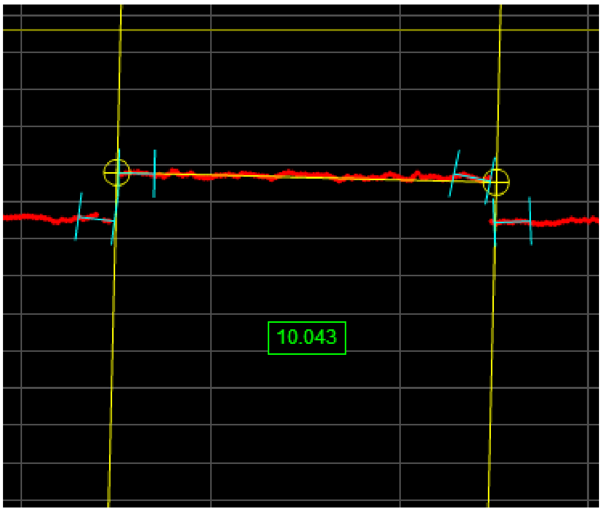
Tips

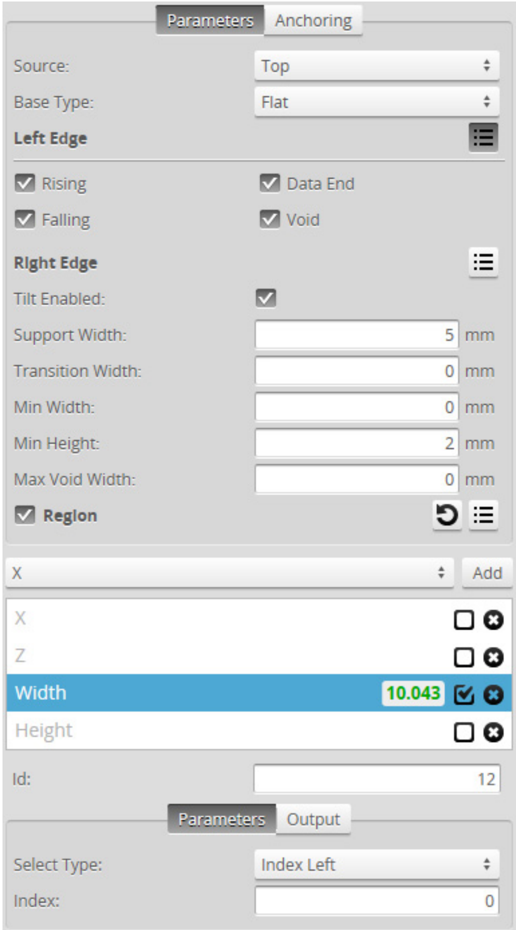
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

5.19 Strip

The Strip tool measures the width of a strip.





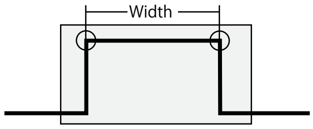
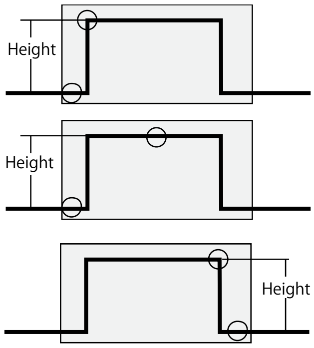
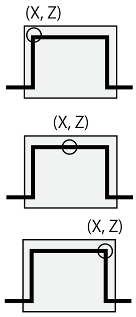
The Strip tool uses a complex feature-locating algorithm to find a strip and then return measurements. See "Strip Algorithm" in the SurfaceMeasure1008S Measurement Tool Technical Manual for a detailed explanation of the algorithm. The behavior of the algorithm can be adjusted by changing the parameters in the measurement panel.

The Strip tool lets you add multiple measurements of the same type to receive measurements and set decisions for multiple strips. Multiple measurements are added by using the drop-down above the list of measurements and clicking on the [Add] button.

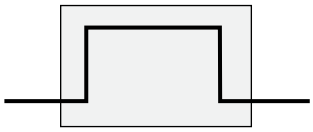
For example, if a target has three strips, by adding two measurements, choosing [Index From The Left] in the [Select Type] setting, and providing values of 1 and 3 in the [Index] of field of the measurements, respectively, the Strip tool will return measurements and decisions for the first and third strip.

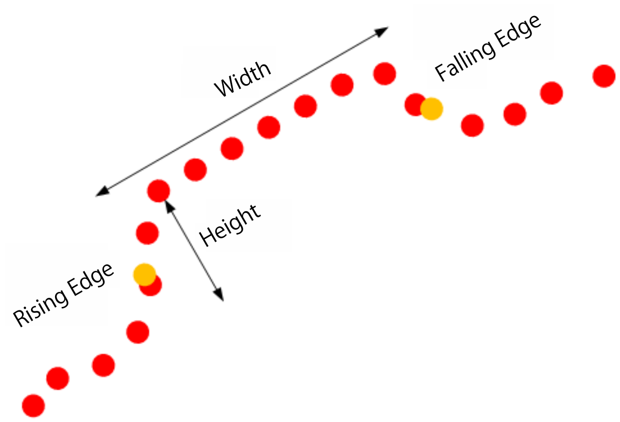
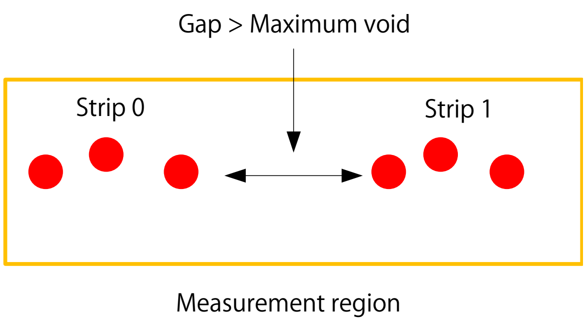
For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

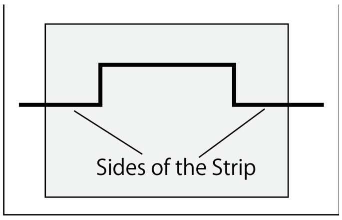
[Measurements]

Measurement	Illustration
[Width] Measures the width of a strip.	
[Height] Measures the height of a strip.	
[X] Measures the X position of a strip.	
[Z] Measures the Z position of a strip.	

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Base Type]	Affects detection of rising and falling edges. Base Type = Flat  Base Type = None  Base Type = Flat  Base Type = None  When [Base Type] is set to [Flat], both strip (raised area) and base support regions are needed. When set to None, only a point that deviates from a smooth strip support region is needed to find a rising or falling edge.
[Left Edge] [Right Edge]	Specifies the features that will be considered as the strip's left and right edges. You can select more than one condition. [Rising] - Rising edge detected based on the strip edge parameters. [Falling] - Falling edge detected based on the strip edge parameters. [Data end] - First valid profile data point in the measurement region. [Void] - Gap in the data that is larger than the maximum void threshold. Gaps connected to the measurement region's boundary are not considered as a void. See "Strip Start and Terminate Conditions" in the SurfaceMeasure1008S Measurement Tool Technical Manual for the definitions of these conditions.

Parameter	Description
[Tilt Enabled]	Enables/disables tilt correction. The strip may be tilted with respect to the sensor's coordinate X axis. This can be caused by conveyor vibration. If the Tilt option is enabled, the tool will report the width and height measurements following the tilt angle of the strip. 
[Support Width]	Specifies the width of the region around the edges from which the data is used to calculate the step change. See "Strip Step Edge Definitions" in the SurfaceMeasure1008S Measurement Tool Technical Manual on how this parameter is used by different base types.
[Transition Width]	Specifies the nominal width needed to make the transition from the base to the strip. See "Strip Step Edge Definitions" in the SurfaceMeasure1008S Measurement Tool Technical Manual on how this parameter is used by different base types.
[Min Width]	Specifies the minimum width for a strip to be considered valid.
[Min Height]	Specifies the minimum deviation from the strip base. See "Strip Step Edge Definitions" in the SurfaceMeasure1008S Measurement Tool Technical Manual on how this parameter is used for different base types.
[Max Void Width]	The maximum width of missing data allowed for the data to be considered as part of a strip when Void is selected in the Left or Right parameter. This value must be smaller than the edge Support Width.  When occlusion and exposure causes data drops, users should use the gap filling function to fill the gaps. See 📖 "■Gap Filling" on page 143 for information.

Parameter	Description
[Region]	The measurement region defines the region in which to search for the strip. If possible, the region should be made large enough to cover the base on the left and right sides of the strip.  For more information, see 📖 "●Regions" on page 238.
[Location] (Strip Height, Strip X, and Strip Z measurements only)	Specifies the strip position from which the measurements are performed. [Left] - Left edge of the strip. [Right] - Right edge of the strip. [Center] - Center of the strip.
[Select Type]	Specifies how a strip is selected when there are multiple strips within the measurement area. [Best] - The widest strip. [Index Left] - 0-based strip index, counting from left to right. [Index Right] - 0-based strip index, counting from right to left.
[Index]	0-based strip index.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

5.20 Template Matching

Tips

The tool is supported in emulator scenarios.

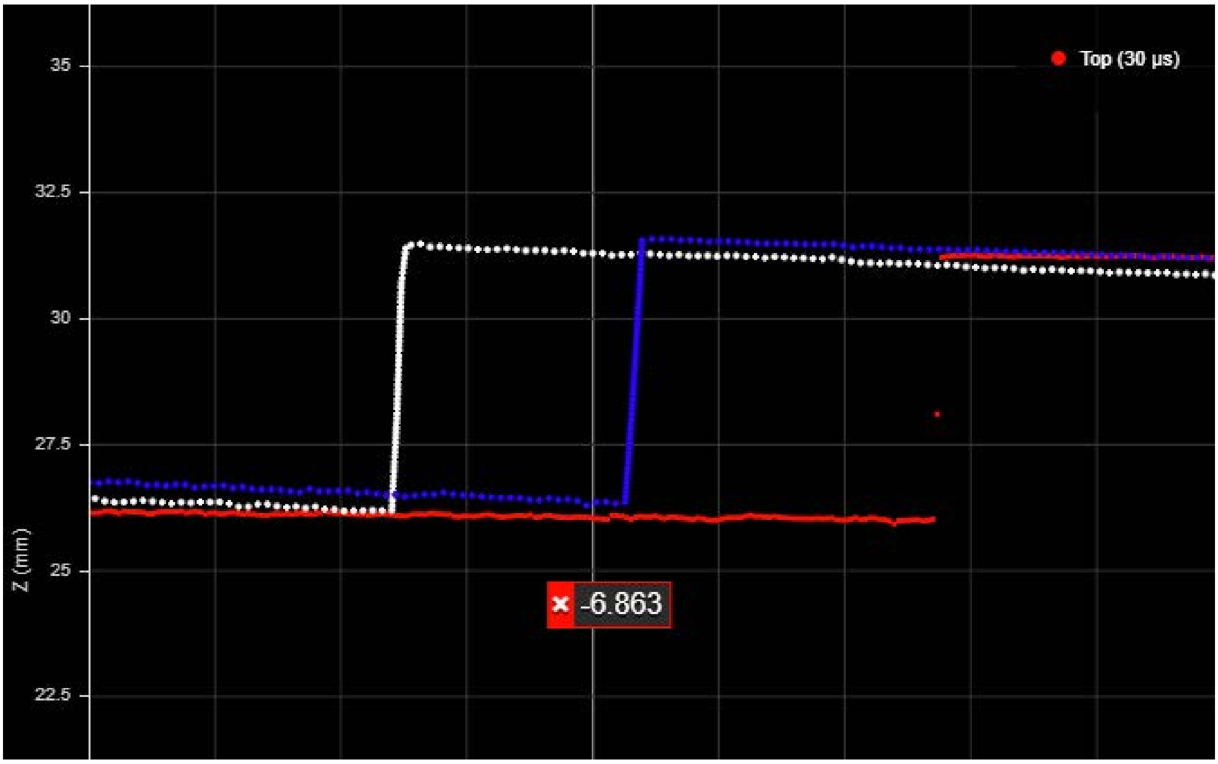
The Profile Template Matching tool lets you align a profile to a "master" template profile you create in the tool (a "golden template"), compensating for movement of the target from frame to frame. As a result, you can perform measurements over on a "stabilized" profile.

The tool returns measurements that represent differences between the profile and the master, letting you perform simple defect detection and location from within the tool.

The tool also outputs an aligned profile that other Profile measurement tools can use as input (via their [Stream] parameter). Finally, the tool produces a "difference" profile on which you can similarly perform measurements.

The sensor compares the measurement value with the values in [Min] and [Max] to yield a decision. For more information on decisions, see "●Decisions" on page 251.

In the data viewer, the profiles are rendered using different colors:



The master profile is rendered in white. The aligned profile is rendered in blue.
The current profile is rendered in red.

Note that in the image above, the tool is performing only a rough alignment to ensure that the different profiles are clearly visible. Typically, the blue aligned profile will be on top of the white master profile.

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

5.20.1 Measurements, Features, and Settings

Note that if no profile alignment is performed (both [Coarse Align] and [Fine Align] are disabled), for example, if the targets are sufficiently fixed from profile to profile, the following measurements return 0.000:

- Transform X
- Transform Z
- Transform Y Angle

[Master Compare] must be enabled for the following measurements; otherwise, they return Invalid values:

- Max Height Difference
- Max Difference Position X
- Max Difference Position Z
- Standard Deviation
- Difference Average
- Difference Sum
- Variance
- Matching Score

Also, for these “master compare” measurements, if the profile has been aligned to the master (either [Coarse Align] or [Fine Align] is enabled), the measurement compares the aligned profile and the master. If the profile has not been aligned (both alignment parameters are disabled), the measurement compares the original (unaligned) profile and the master.

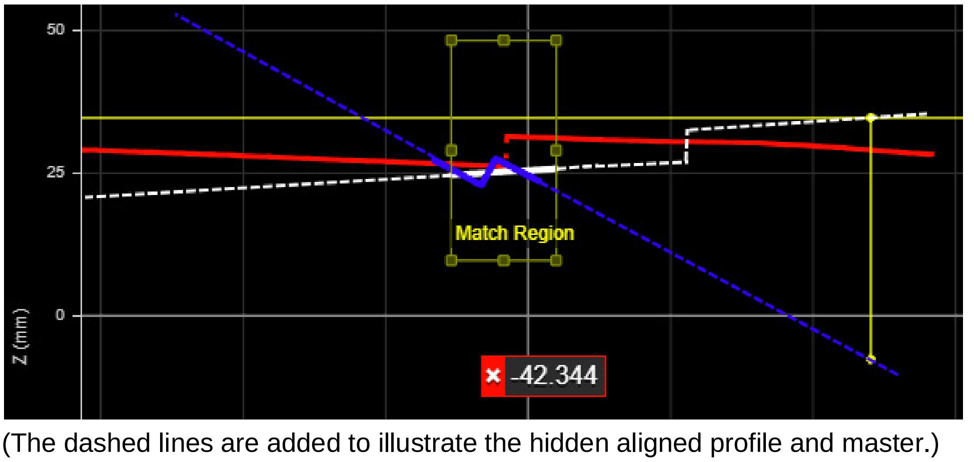
[Measurements]

Measurement	Description
[Transform X] [Transform Z]	The distance the profile has shifted on the X and Z axis after alignment to the master, respectively.
[Transform Y Angle]	The rotation of the profile around the Y axis after alignment.
[Max Height Difference]	The maximum height difference between the profile and the master.
[Max Difference Position X] [Max Difference Position Z]	The X and Z positions of the maximum height difference between the profile and the master.
[Standard Deviation]	The standard deviation between the profile and the master.
[Difference Average]	The average difference on the Z axis between the profile and the master.
[Difference Sum]	The sum of the differences on the Z axis between the profile and the master.
[Variance]	Returns the variance of a difference profile calculated by subtracting the current profile from the master.
[Matching Score]	Returns a value between 0 and 1 that is the is the percentile of standard deviation of a difference profile (calculated by subtracting the current profile from the master) from the tolerance.

[Data]

Type	Description
[Aligned Profile]	The profile aligned to the master.
[Difference Profile]	A profile representing the differences between the profile and the master. The profile differences' Z values express the differences between the data points for the profiles and the masters, and they are 0 when there are no differences between the masters and the profiles. When the profiles are greater than the masters, the values will be negative, and if the profiles are smaller than the masters, the values will be positive.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[File]	A list of templates available to the tool. The template containing the profile the tool uses as a master profile for alignment and comparisons. Use the Operation parameter to add and remove templates to this list.
[Operation]	Provides operations related to profile template files (masters). One of the following: [Save] – Saves the current profile to a template file in the local file system and adds it to the list in [File]. Multiple templates can be available. Files are persistent. [Delete] – Deletes the template file selected in [File]. (This parameter switches to "Normal" after the tool performs one of the file operations.)
[Use Region]	Indicates whether the tool uses a user-defined region to perform matching. (The tool uses only the data profile and master data in this region to perform matching.) If this option is not checked, the tool performs matching using data from the entire active area.
[Match Region]	Size and position of the region in which the matching (alignment) is performed. Master comparison measurements however are applied to the entire profile (current profile and master). For example, in the following image, the tool limits matching to the data in the match region. But the measurement (Max Height Difference in this case) is calculated on the data outside the region.  (The dashed lines are added to illustrate the hidden aligned profile and master.)

Parameter	Description
[Coarse Align]	When enabled, shows the [X Shift Window] parameter. Use this setting by itself if you expect targets will only move along the X and Z axes (that is, you don't expect rotation). Otherwise, when combined with [Fine Align], it provides a good initial start position for fine alignment.
[X Shift Window]	The maximum distance on the X axis the tool can move the current profile in order to align it. Should be set to the maximum amount the part is expected to shift left or right. (Enabled using the [Coarse Align] parameter.)
[Fine Align]	When enabled, lets you set the [Max Iteration] and [Match Window] parameters for fine alignment. This alignment method is more accurate than coarse alignment but takes more time to run.
[Max Iteration]	The maximum number of iterations the tool uses to perform fine alignment of the profile to the master.
[Match Window]	The region in which points are evaluated for a match. It there's a larger difference between the current profile and the master than the match window size, it would ignore the point.
[Master Compare]	Causes the tool to compare the current profile to the master profile and return results in some of the tool's measurements. (See list above.) When disabled, the measurements that compare the profile to the master return invalid values.
[Difference Profile Median Size]	Defines the size of the window the tool uses to smooth out noise in the Difference Profile data output.
[Tolerance]	The difference tolerance for the master comparison.
[Display Master]	Displays the Master template (white profile).
[Display Aligned Profile]	Displays the aligned (blue profile).
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

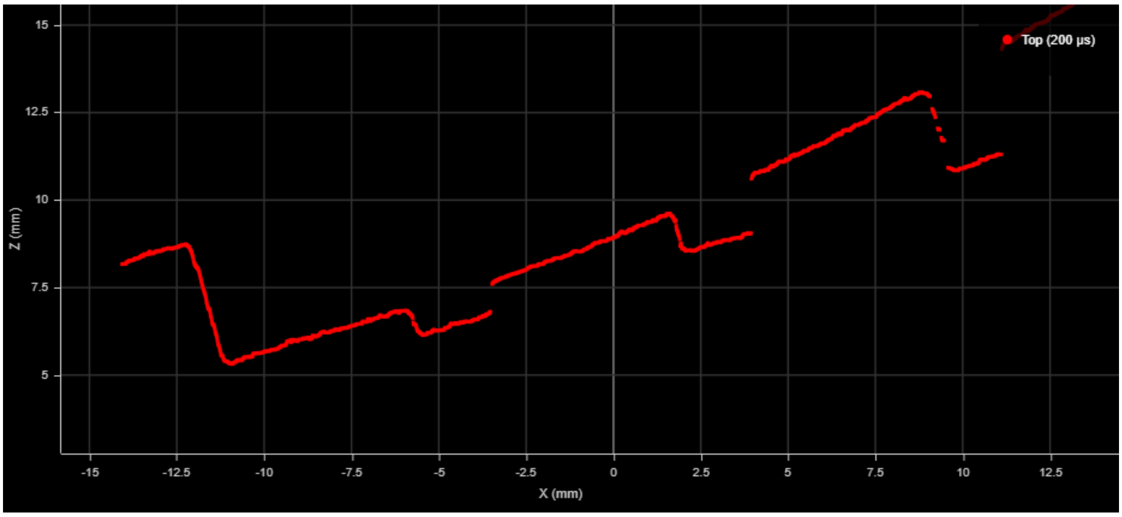
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

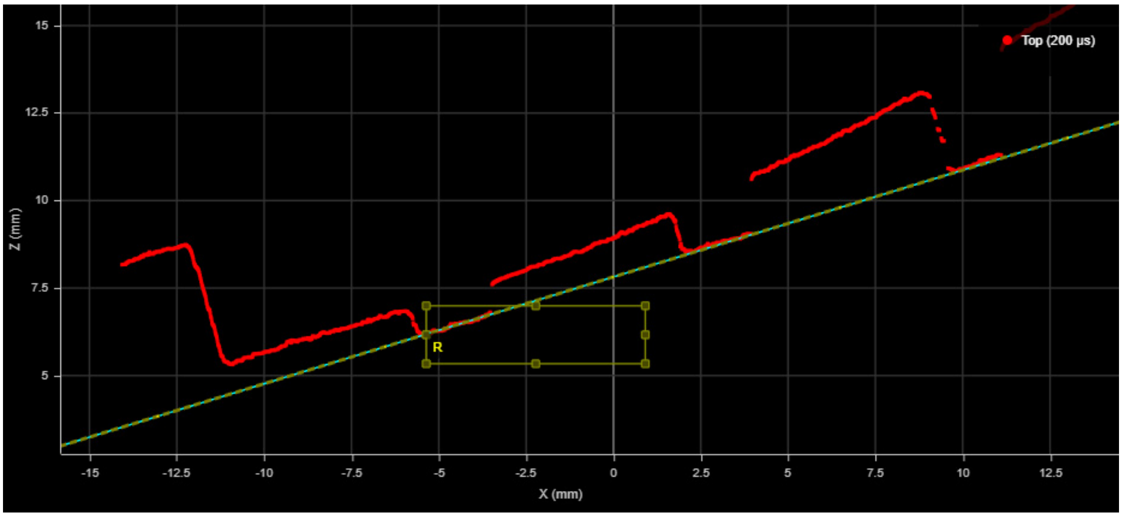
5.21 Transform

Tips
The tool is supported in emulator scenarios.

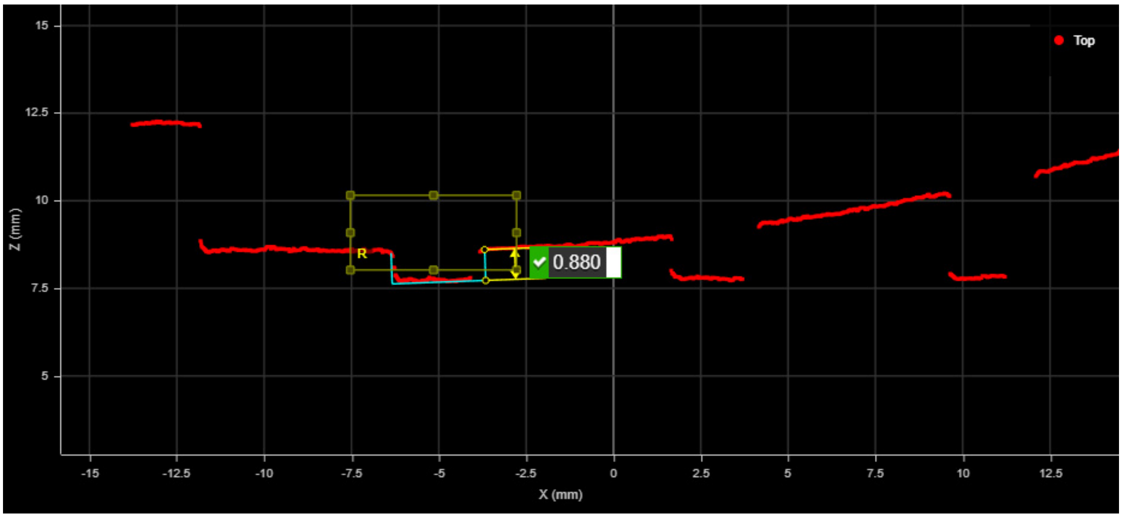
The Profile Transform tool lets you adjust profiles (for example, to align to a line) and perform measurements on the transformed profile. The tool accepts a Line geometric feature (rotating the profile so that the line is parallel to the X axis) and/or a Point geometric feature (using it as the X and Z origin). For example, in the following, if you want to measure the characteristics of the first groove on the left, you can use the tool to rotate the profile.



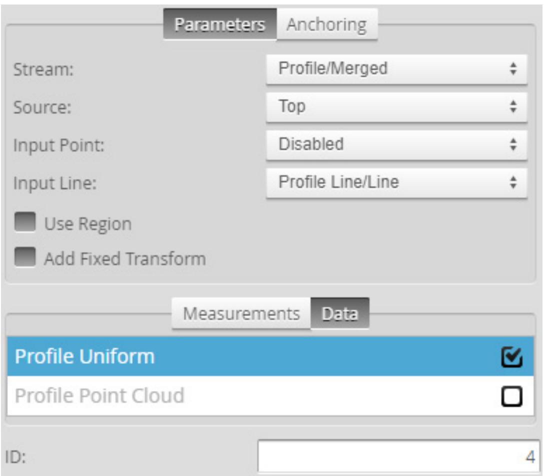
A line geometric feature is output from a Profile Line tool.



A Profile Transform tool takes the line geometric feature as input, and the transformed profile from that tool is used as input for a Profile Groove tool, which measures the groove's characteristics:



The sensor compares the measurement value with the values in [Min] and [Max] to yield a decision. For more information on decisions, see 📖 "●Decisions" on page 251.



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

5.21.1 Measurements, Features, and Settings

[Measurements]

Measurement	Description
[Processing Time]	The time the tool takes to run.

[Data]

Type	Description
[Profile Uniform] [Profile Point Cloud]	The transformed profile. Note that if the Uniform Spacing setting on the Scan page is unchecked (meaning the tool's data input is point cloud data), only the Profile Point Cloud contains data. If the setting is enabled, both data outputs contain profile data. (For more information, see "4.4.2 Scan Modes" on page 116.)

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Input Point]	The Point geometric feature the tool uses to offset a profile to an X and Z origin of 0.
[Input Line]	The Line geometric feature the tool uses to rotate a profile.
[Use Region]	Indicates whether the tool should limit the transformed profile that it outputs to a user-defined region. If this option is not checked, the tool transforms the entire profile.
[Add Fixed Transform]	Enables [X Offset], [Y Offset], and [Angle] parameters you can use to manually set a transformation. Useful if you know the profiles in the scan data will always be in a certain position or orientation.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.

Tips

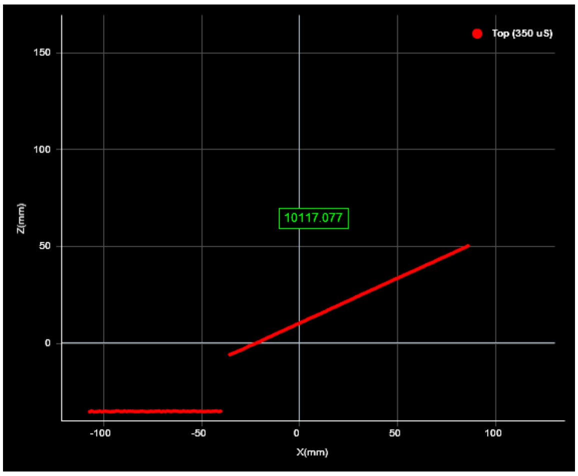
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

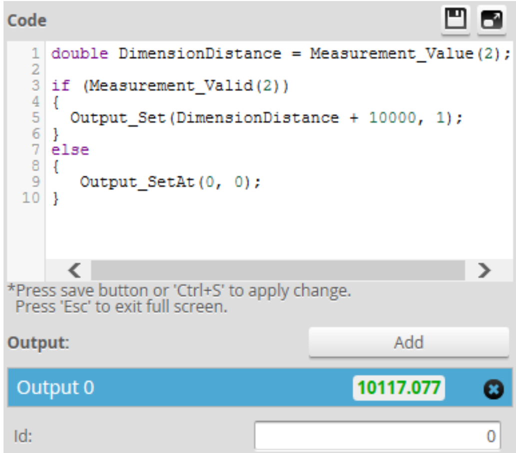
For more information on anchoring, see "●Measurement Anchoring" on page 254.

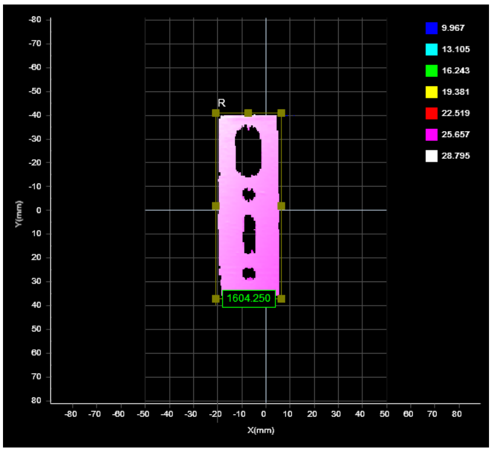
5.22 Script

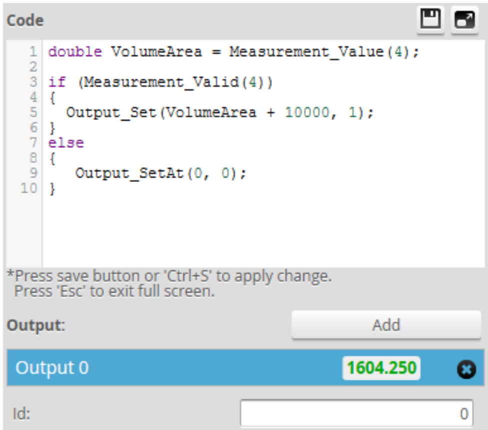
A Script measurement can be used to program a custom measurement using a simplified C-based syntax. A script measurement can produce multiple measurement values and decisions for the output.

For more information on script tool syntax, see "4.7.10 Scripts" on page 321.









To create or edit a Script measurement:

1 Add a new Script tool or select an existing Script measurement.

2 Edit the script code.

3 Add script outputs using the [Add] button.

» For each script output that is added, an index will be added to the [Output] drop-down and a unique ID will be generated.

To remove a script output, click on the button next tol it.

4 Click the [Save] button to save the script code.

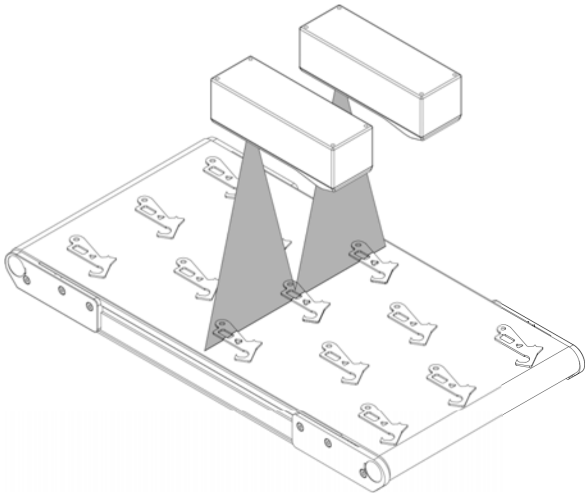
» If there is a mistake in the script syntax, the result will be shown as a "Invalid" with a red border in the data viewer when you run the sensor.

Outputs from multiple measurement tools can be used as inputs to the script. A typical script would take results from other measurement tools using the value and decision function, and output the result using the output function. Stamp information, such as time and encoder stamps, are available in the script, whereas the actual profile3D point cloud data is not. (The script engine is not powerful enough to process the data itself.) Only one script can be created.

6 Surface Measurement

Surface measurement involves capturing a sequence of laser profiles, identifying discrete objects, and measuring properties of the surface or the objects, such as the volume of the object or the height at a certain position of the object.

All volumetric tools have the ability to operate either on the entire surface or the full object, or within a region of interest at a certain position in relation to the surface or an object.



Multiple measurements can be performed on the entire surface or each discrete object, limited only by the available CPU resources.

The frame of reference for the coordinate system of the detected object can be set to [Sensor] or [Part] in the [Part Detection] panel (📖 "4.4.7 Part Detection" on page 149). This setting determines what coordinate system the region of interest for a measurement is positioned in, as well as the coordinate reference used to output measurement values.

For example, if you need to measure the average height in a certain location relative to the sensor's field of view regardless of the objects passing under the [sensor], the frame of reference should be set to [Sensor]. This is typical in applications where a wide web of material is continuously scanned, such as paper, rubber, fabrics, etc.

If on the other hand you need to measure the average height in a certain location of a scanned object, the frame of reference should be set to [Part]. This is typical in applications where discrete objects pass under the sensor and specific locations on the objects need to be inspected.

6.1 Isolating Parts from Surface Data

SurfaceMeasure1008S lets you isolate and then measure parts in two different ways: by configuring the [Part Detection] panel on the [Scan] page in the web interface (for more information, see 📖 "4.4.7 Part Detection" on page 149); and using one of two Surface measurement tools (for more information on these tools, see 📖 "6.5 Blob" on page 431 and 📖 "6.29 Segmentation" on page 573).

The following table lists several differences between the two methods. A key difference however is that part detection extracts scan data that is identified as a "part" and outputs it as a separate frame. This lets you use any measurement tool on parts individually. Note however that parts must be clearly separated and be relatively consistently spaced for the part detection algorithm to separate the parts. In general, if you can successfully isolate parts using part detection, use this method rather than the Surface tools.

With the two Surface measurement tools on the other hand, areas are not extracted as individual frames, and for this reason you can't easily apply measurement tools to the areas individually: given that damaged areas may appear anywhere in the source surface data, you can't know where to place the measurement tools.

The individual parts are however available for consumption by an SDK application or a GDK tool. (For information on the SDK and GDK, see 📖 "11 Development Kits" on page 947.) The main advantage of these tools is that they can separate objects that are touching. Although you can't apply other measurement tools to the identified blobs, the tools do provide measurements such as length, width, and area, which lets you handle common pass/fail needs.

Main Differences Between Part Detection, Surface Blob, and Surface Segmentation

	Part Detection	Surface Blob	Surface Segmentation
Allows output of individual surfaces to separate frames	Yes	No	No
Allows separating touching objects	No	Yes - Limited Through Open filter, some connections between parts can be separated, but the control is more limited than with Surface Segmentation.	Yes
Supports background present	Yes Height threshold must be set above/ below background	Yes Height threshold must be set above/below background	Yes Full support in firmware v6.0 and later
Supports background with significant tilt or intensity gradient	No Fixed height threshold is used	No Fixed height threshold is used	Yes Adaptive threshold is used
Integrated Width/Length/ Area measurements	N/A	Yes	Yes
Includes circularity and convexity filtering	No	Yes	No
Fast operation	Yes	Yes	No
Finds objects above or below background	Yes	Yes	Yes But requires careful region placement

■ Align Ring

This tool is only intended for performing a high-accuracy alignment of ring and partial ring layouts; it is not used for performing measurements in production. For information on using the tool to perform alignment, see 📖 "■Ring Layouts" on page 203.

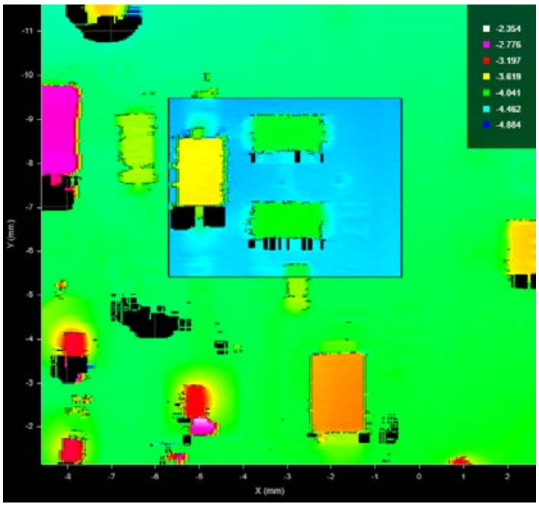
■ Align Wide

This tool is only intended for performing a high-accuracy alignment of wide layouts; it is not used for performing measurements in production. For information on using the tool to perform alignment, see 📖 "■Wide Layouts" on page 198.

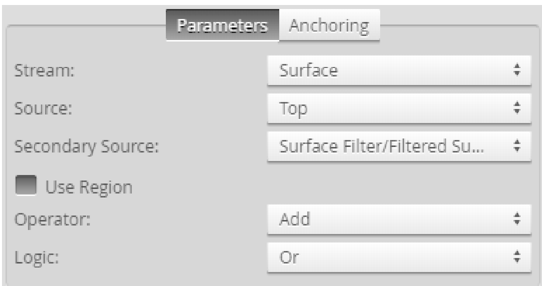
6.2 Arithmetic

> **Tips**
> The tool is supported in emulator scenarios.

The Surface Arithmetic tool lets you perform various operations on a pair of surfaces. For example, you can use the tool to perform dynamic masking from frame to frame. The tool performs bitwise operations (AND or OR) on the corresponding data points in the source surfaces, and also combines height and intensity data with add, subtract, average, and mask operations.



2D View



Tool Setup

6.2.1 Settings

[Parameters]

Parameter	Description
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool. If you switch from one type of data to another (for example, from section profile data to surface data), currently set input features will become invalid, and you will need to choose features of the correct data type.
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238. Can only accept Surface scan data (that is, cannot accept data from other tools).
[Secondary Source]	The data output of another tool, for example, of a Surface Filter tool.
[Use Region]	Indicates whether the tool uses a user-defined region. If this option is not checked, the tool uses data from the entire active area.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Use Intensity]	If enabled, the tool uses intensity data instead of heightmap data. Only available if [Acquire Intensity] is enabled on the Scan page during the scan; for more information, see 📖 "4.4.2 Scan Modes" on page 116.
[Operator]	One of the following: Add – Adds the height values of the corresponding data points in the two sources. Subtract – Subtracts the height values of the corresponding data points in the two sources. Average – Averages the height values of the corresponding data points in the two sources. Mask – Uses the secondary source as a mask.
[Logic]	Performs bitwise-operations on the source and secondary source surface data. One of the following: [And] or [Or]. When [Operator] is set to [Average], this parameter is unavailable.

[Data]

Type	Description
[Surface]	The processed surface data.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

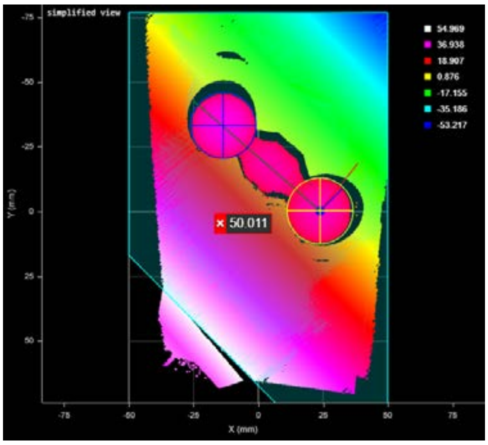
Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

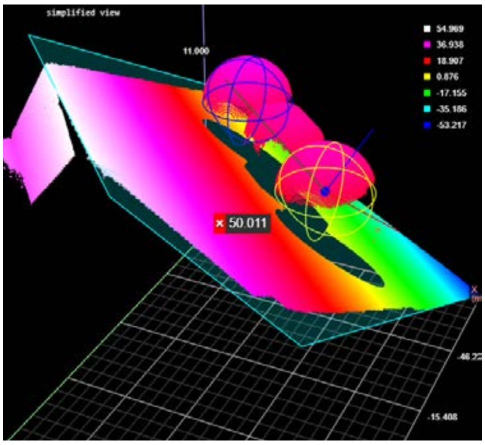
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.3 Ball Bar

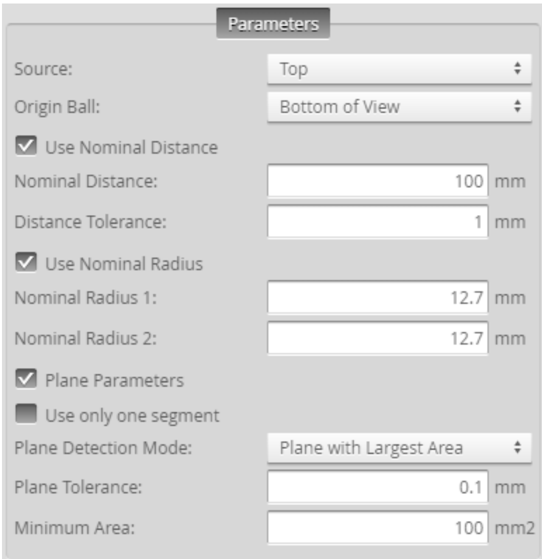
> **Tips**
> The tool is supported in emulator scenarios.
> The Surface Ball Bar tool returns measurements useful for calibrating systems using a ball bar, particularly systems that include a robot.



2D View



3D View



Measurement Panel

6.3.1 Measurements, Data, Features, and Settings

[Measurements]

Measurement	Description
[Distance 3D]	The direct distance between the centers of the spheres fitted to the balls.
[Center X1 / Y1 / Z1] [Center X2 / Y2 / Z2]	These measurements return the X, Y, and Z positions of the centers of the spheres fitted to the balls. Ball 1 (Center X1 / Y1 / Z1) is always used as the origin. (Corresponds to the values returned in Tx / Ty / Tz.)
[Normal X / Y / Z]	These measurements return the X, Y, and Z components of the normal vector of the surface surrounding the calibration target.
[Ix / Iy / Iz] [Jx / Jy / Jz] [Kx / Ky / Kz]	These measurements return the X, Y, and Z components of the I, J, and K unit vectors defining the coordinate system orientation.
[Tx / Ty / Tz]	These measurements return the X, Y, and Z components of the translation vector defining the coordinate system origin location.
[Processing Time]	The time the tool takes to run.

[Data]

Type	Description
[Difference Surface]	Used for diagnostics.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Origin Ball]	Determines which ball is used as the origin. The [Bottom of View] option selects the ball at the bottom of the data viewer in the SurfaceMeasure1008S web interface.
[Use Nominal Distance]	When enabled, displays [Nominal Distance] and [Distance Tolerance] settings. Set these to reflect the distance between the balls of the ball bar (refer to the specifications of the ball bar) and the tolerance you need. This can be useful to ensure invalid results due to false or inaccurate detection are rejected.
[Use Nominal Radius]	When enabled, displays [Nominal Radius] settings. Set these to reflect the radius of the balls of the ball bar (refer to the specifications of the ball bar) and the tolerance you need. This can be useful to ensure invalid results due to false or inaccurate detection are rejected.
[Plane Parameters]	Enables advanced plane settings. For UR integration, you should leave the settings at their default. These parameters allow ensuring the plane detection is accurate and robust to variations.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

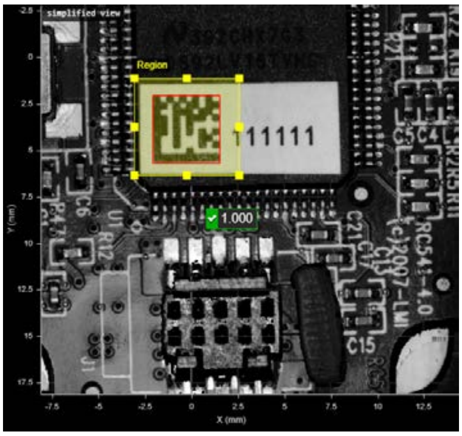
6.4 Barcode

Tips
The tool is supported in emulator scenarios.

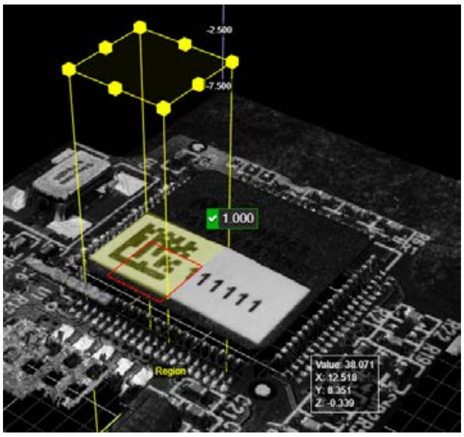
The Barcode tool lets you decode data encoded in 1D (linear) and 2D barcodes from surface data (intensity data or heightmap data) without the need for 2D vision cameras or barcode readers. The tool also supports dot-peened types (Datamatrix and QR code). For a complete list of the types the tool supports, see "Type" in "[Parameters]" on page 428.

Tips
When configuring the tool, make sure you switch the data viewer to the appropriate type of visualization for the barcode: for intensity-based barcodes (such as printed barcodes), switch the data viewer to intensity mode using the Intensity button ( ); for height-based barcodes (such as dot peen codes), switch the data viewer to heightmap mode using the Heightmap button ( ).

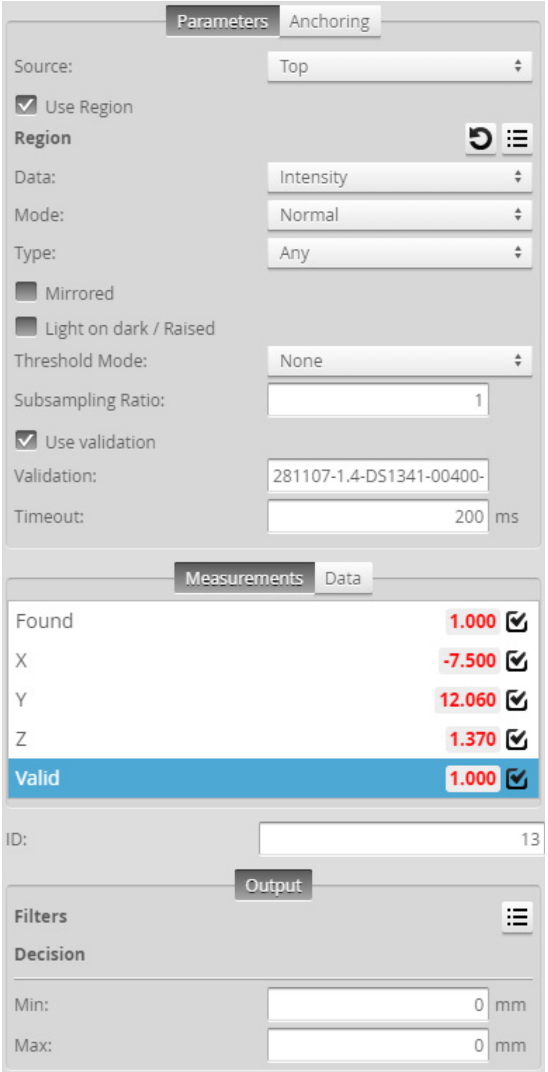
The tool returns whether it has found the barcode and whether it is valid, as well as the X, Y, and Z position of the barcode's lower left corner.
You can use the String Encoding tool to extract the string and pass it as output to a PLC; for more information, see "6.32 String Encoding" on page 587. The extracted string is also available via the SDK; for information on the SDK, see "11.1 GoSDK" on page 947 and the SDK reference documentation.



2D View



3D View



Measurement Panel

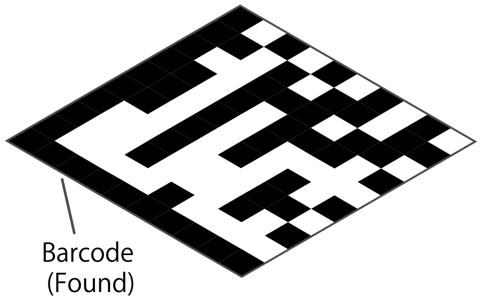
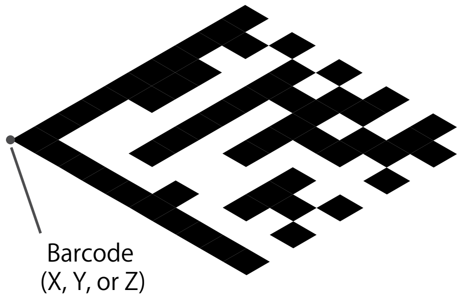
The decoded data is also displayed in the log; for more information on the log, see 📖 "■Log" on page 88.

The tool provides two "learn" functions that can speed up the process of determining appropriate settings.

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.4.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Found] Returns 1.000 if the tool detects the configured barcode; otherwise, 0. Places a red rectangle around detected QR codes and Datamatrix codes.	
[X] [Y] [Z] These measurements return the X, Y, and Z position of the code, respectively.	
[Valid]	Determines whether the barcode is valid by comparing the string in the [Validation] parameter with the decoded string.

[Data]

Type	Description
[Output String]	Data output containing the decoded string.
[Location Image]	The image the tool uses to find the a dot-peen barcode. (When [Type] is set to a printed barcode, that is, a type other than a dot-peen code, this image is the same as the decode image.)
[Decode Image]	The image the tool uses as part of the dot peen decode algorithm. Use this to adjust the image (for example, using one of the filter tools) and to diagnose issues.
[Dot peen decode Image]	A binarized image the tool runs the dot peen decode algorithm on. The points of the code should appear clearly in the image to ensure proper decoding. Use this to adjust the image (for example, using one of the filter tools) and to diagnose issues.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Use Region]	Indicates whether the tool uses a user-defined region. If this option is not checked, the tool uses data from the entire active area.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.

Parameter	Description
[Data]	The data the tool uses to detect a bar code. One of the following: • Intensity • Heightmap
[Type]	The type of barcode the tool expects. One of the following: • [Any]: Detects any type of barcode. • [1D Barcode (All)]: Detects any type of 1D (linear) barcode. • [EAN-8] • [EAN-13] • [ISBN-10] • [ISBN-13] • [UPC-A] • [UPC-E] • [Code-39] • [Code-128] • [Interleave 2 of 5] • [PDF417] • [Data Matrix] • [Data Matrix dot peened] • [QR Code] • [QR Code dot peened]
[Mirrored]	Reverses the scan. Use this if the scan is mirrored. Only useful with 2D barcodes.
[Light on dark] / [Raised]	If you are scanning light-on-dark barcodes or raised barcodes, enable this option.
[Use Threshold]	Enables the [Threshold] setting (see below).
[Threshold Mode]	Sets the threshold mode the tool uses. Any data points below the threshold are ignored and considered part of the "background"; data points not excluded are considered part of the barcode. Useful for cases where the surrounding surface is similar to the intensity or height of the barcode itself. One of the following: • [None]: No thresholding is performed. • [Fixed]: A global thresholding method. Set [Threshold] to a value between 0 and 255. When [Data] is set to Intensity, the value in [Threshold] is simply the intensity cut-off. When [Data] is set to Heightmap, the value is a percentile of the height values, converted to the 0-255 range. • [Otsu]: A global thresholding method. Illumination of the target should be relatively uniform and tilt should be removed (for example, using the Surface Transform tool; see "6.35 Transform" on page 609). • [Adaptive]: A local thresholding method that can help deal with local variation (intensity or height) in the target.
[Threshold]	The threshold of intensity or height values the tool uses to distinguish between the code and the surrounding surface. The parameter accepts a value between 0 and 255, whether [Data] is set to Heightmap or Intensity. This setting is only displayed when [Threshold Mode] is set to [Fixed].
[Subsampling ratio]	Downsamples the image. Can make the tool run faster. (A value of at least 2 is usually necessary.)
[Use validation]	Enables validation of the decoded string, using the string in [Validation] for the comparison.

Parameter	Description
[Validation]	The case-sensitive string the tool compares to the decoded string. The parameter does not support wild cards or truncated values. If the comparison is valid, the Valid measurement returns 1.000.
[Timeout]	The maximum time the tool is allowed to take.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

6.5 Blob

Tips

The tool is supported in emulator scenarios.

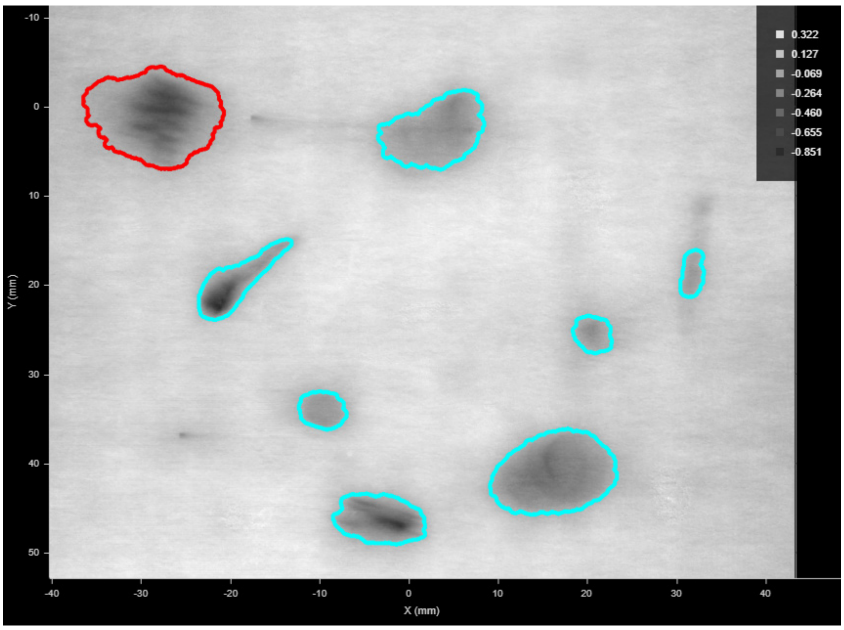
The Surface Blob tool lets you detect surface defects, such as uneven or excess material, gouges, or blemishes, on a relatively uniform or flat background, in either 3D height map data or intensity data. It can also extract targets from the surface. The tool optionally lets you set its height threshold relative to a user-defined reference region. It also lets you use a reference plane to correct for a minor tilt of the target surface (up to 10 degrees); this lets you detect low or shallow defects that would otherwise not be detectable due to a tilt.

Tips

The Surface Blob tool provides functionality similar to the Surface Segmentation tool. For a comparison of these tools and the part detection capabilities you can configure on the [Scan] page, see 📖 "6.1 Isolating Parts from Surface Data" on page 421. For information on the Surface Segmentation tool, see 📖 "6.29 Segmentation" on page 573.

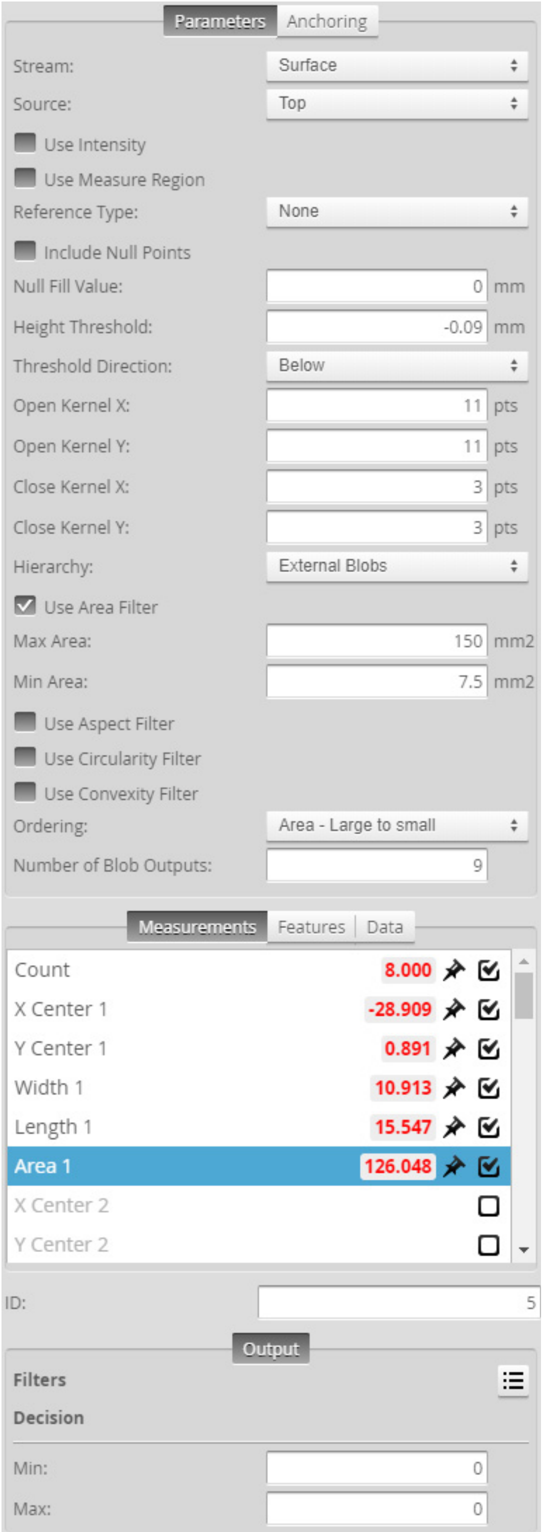
The tool first filters data based on a height or intensity threshold (above or below it), and then uses configurable morphological operations to better isolate parts. Finally, the tool uses various size- and shape-based filters that let you exclude or include the expected defects or the targets you need (potential blobs).

The tool lets you configure the maximum number of "blobs" to output, and returns the total blob count, and for each blob, the X and Y center, the width and length, and the area. The center point of each blob is available as a geometric feature. The blobs themselves are available in an array that can be accessed and processed by an SDK application or a GDK tool. For more information on the SDK, see 📖 "11.1 GoSDK" on page 947. For more information on the GDK, see 📖 "11.2 GDK" on page 958.



Several dents outlined on a surface. The currently selected blob is outlined in red.
(Grayscale heightmap mode is used to better see the outlines.)

Note that knowing the rough size and shape of the kinds of detects you expect is important when you are configuring the open and close kernels and the tool's filters.



Tool configuration panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.5.1 Measurements, Data, and Settings

[Measurements]

Type	Measurement
[Count]	Returns the total number of blobs identified, based on the tool's parameters.
[Area {n}]	The area of a blob. The area is calculated using the contour of the blob and resampling. For this reason, areas calculated using the Surface Volume tool will produce different measurements; for more information, see 📖 "[Area]" on page 624.
[X Center {n}] [Y Center {n}]	The X and Y positions of the center of mass of a blob extracted from the surface. The [Number of Blob Outputs] setting determines the number of measurements listed in the [Measurements] tab.
[Length {n}] [Width {n}]	The length and width of the rotated bounding box that encapsulates the blob extracted from the surface. These are always the major and minor axis of a blob, respectively. The [Number of Blob Outputs] setting determines the number of measurements listed in the [Measurements] tab.

[Features]

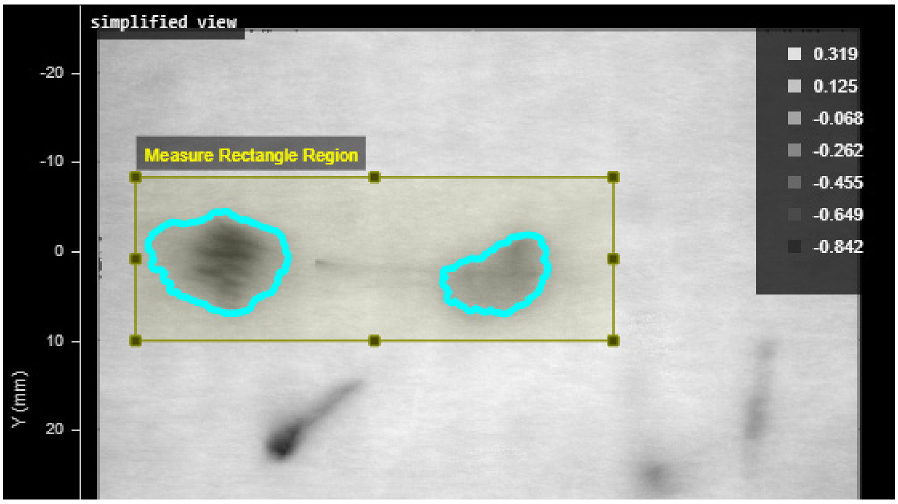
Type	Description
[Center Point {n}]	The point representing the center of a blob.

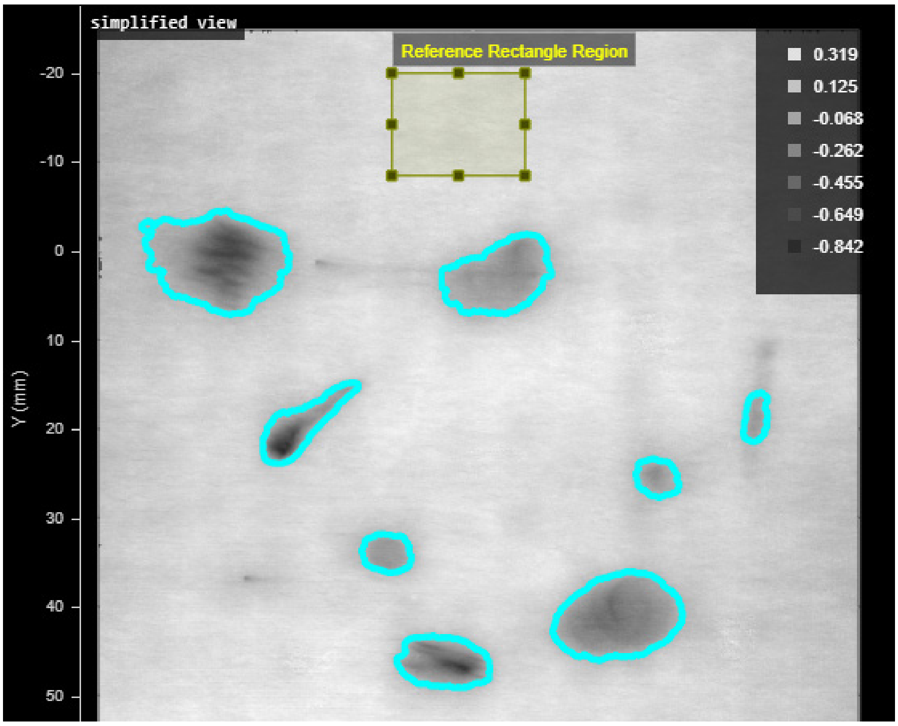
[Data]

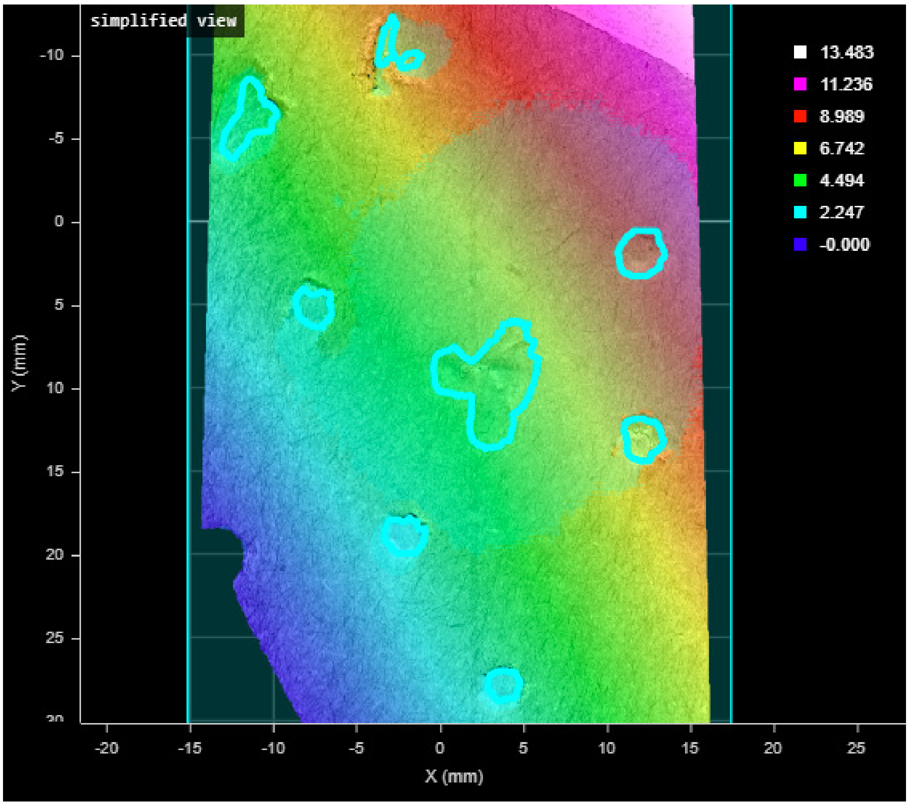
Type	Description
[Blobs Array]	An array containing the blobs. For an example of how to access this data from an SDK application or a GDK tool, see the appropriate sample in the SDK samples; for more information, see 📖 "11.1.1 Setup and Locations" on page 948.
[Diagnostics Surface]	Surface data you can use to evaluate the impact of the tool's parameters, before the tool's filters are applied, to properly separate the areas corresponding to the defects or targets you need to detect.
[Surface {n}]	Surface data corresponding to each blob.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Use Intensity]	If enabled, the tool uses intensity data instead of heightmap data. Only available if [Acquire Intensity] is enabled on the Scan page during the scan; for more information, see 📖 "4.4.2 Scan Modes" on page 116.

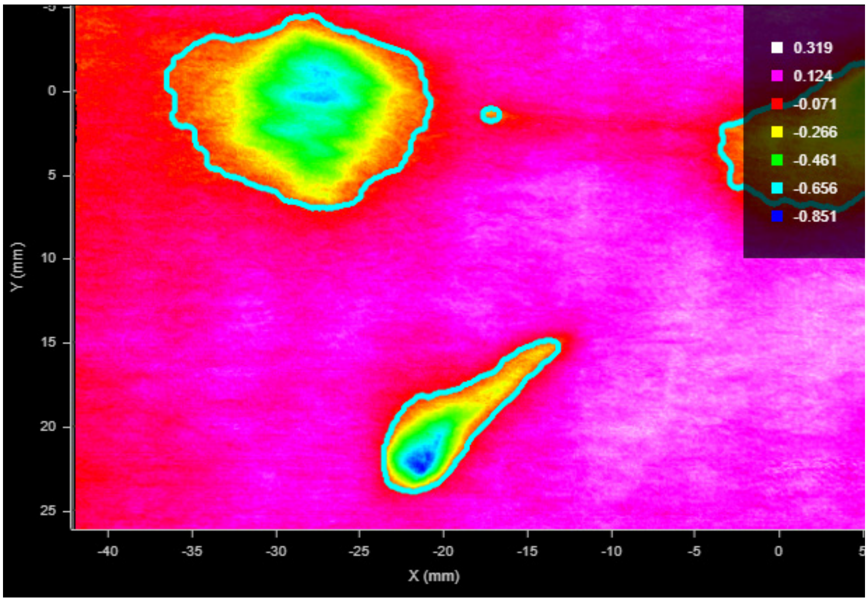
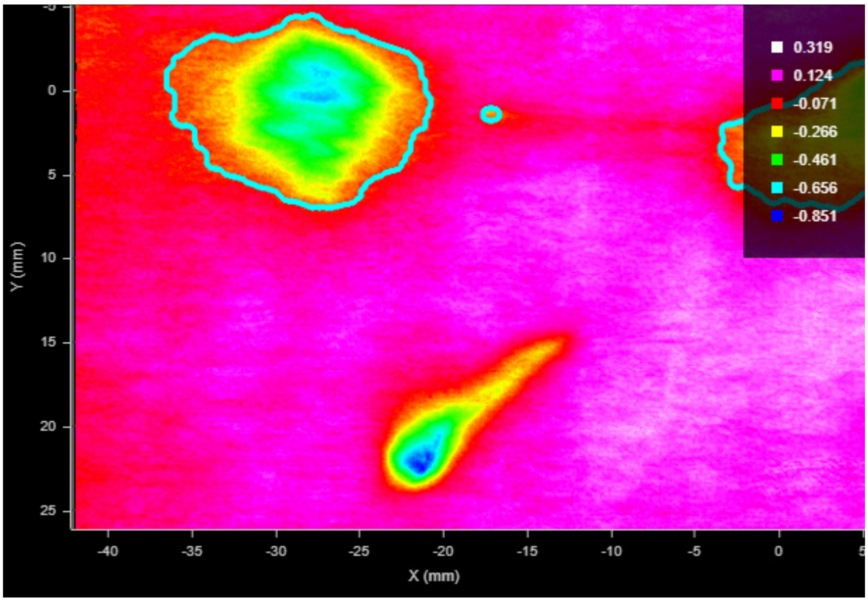
Parameter	Description
[Use Measure Region]	Limits blob detection to a user-defined region. If this option is not checked, the tool detects blobs in the entire active area. In the following, blobs are only detected in the rectangular measure region: 
[Measure Region Type]	When you enable [Use Measure Region], the tool displays this and additional settings related to the type selected in this parameter. For details on flexible regions and their settings, see "• Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see "●Regions" on page 238.
[Reference Type]	Provides three options: None, Reference Region, and Reference Plane. If the reference type is set to None, the [Height Threshold] setting is absolute (relative to zero). For the Reference Region and Reference Plane options, see the descriptions of the [Reference Region] Type and [Reference Plane] parameters below.

Parameter	Description
[Reference Region Type]	If you set [Reference Type] (see above) to Reference Region, the tool displays a drop-down that lets you choose the reference region type, as well as additional settings related to the type you select. (For details, see 📖 "• Flexible Regions" on page 240.) The tool calculates an average height or intensity of the data in the reference region. [Height Threshold] is relative to this value. For example, in the following, blobs are detected using a relative height threshold of -0.2 mm, relative to the average in the reference region:  For general information on regions and the difference between standard and "flexible" regions, see 📖 "●Regions" on page 238.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Reference Plane]</td><td>
If you set [Reference Type] (see above) to Reference Plane, the tool uses the specified plane geometric feature to correct for a tilt of the target. Note however that using a reference plane to correct the tilt distorts the scan data: it sheers the data by the same angle as the tilt. The maximum tilt angle with which you can use the tool therefore depends on how much sheer angle you can tolerate in your application (which can effect the tool's ability to detect blobs). Typically, you add and configure a Surface Plane tool to generate a plane (for more information, see "■Plane" on page 291).
For information on geometric features, see "●Geometric Features" on page 250.
For applications where sheer distortion can't be tolerated, use Surface Transform to correct the tilt (see "6.35 Transform" on page 609), and use the latter tool's output as the input for Surface Blob.
For example, in the following, despite the overall tilt of the target, the tool detects the flaws on the surface. (Note the gradient of the heightmap colors, indicating a height difference of roughly 9 millimeters between the lower and higher areas near the dents on the target's surface.)


</td></tr>
<tr><td>[Include Null Points]</td><td>
Indicates whether null points (points where no height or intensity value is available, due to dropouts or regions outside of the measurement range) are filled with the value in [Null Fill Value] as a general “background level” or to fill gaps to aid in isolating blobs.
If [Use Intensity] is enabled, the value in [Null Fill Value] is an intensity.
</td></tr>
<tr><td>[Height Threshold
Intensity Threshold]</td><td>
The threshold above or below which data is considered for being a blob. Use the [Threshold Direction] setting to determine whether data above or below the threshold is considered.
If [Use Intensity] is enabled, this setting is named [Intensity Threshold]. Otherwise, it is named [Height Threshold].
</td></tr>
</table>

Parameter	Description
[Threshold Direction]	Determines whether data above or below the threshold is considered as being a blob. [Below]: The [Height Threshold] value is the maximum that will be considered as part of a blob (for example, a dent below the surrounding surface). [Above]: The [Height Threshold] value is the minimum that will be considered as part of a blob (so a raised feature).
[Open Kernel X] [Open Kernel Y]	The X and Y kernel size, respectively, for morphological opening to remove small areas of data. Use these settings, for example, to remove bridges between areas to properly isolate them or to remove small areas entirely (perhaps caused by noise). Use different values of X and Y to use a non-rectangular filter to adapt the kernel to the kinds of unwanted data you see in the scan data.
[Close Kernel X] [Close Kernel Y]	The X and Y kernel size, respectively, for morphological closing to fill in holes smaller than the specified kernel size. Use these settings, for example, to fill small areas within potential blobs that may be caused by drop-outs. Use different values of X and Y to use a non-rectangular filter to adapt the kernel to the kinds of holes you see in the scan data.
[Hierarchy]	Provides options to let you find either external blobs only or both external and internal blobs. [External Blobs] Use this option to ignore smaller blobs in larger blobs: only the outermost blob is returned. [External + Internal Blobs] Use this option to include smaller blobs in larger blobs.
[Use Area Filter] [Max Area] [Min Area]	If [Use Area Filter] is enabled, the tool applies an area filter to potential blobs using the values in [Max Area] and [Min Area].

Parameter	Description
[Use Aspect Filter] [Max Aspect] [Min Aspect]	If [Use Aspect Filter] is enabled, the tool applies an aspect filter (ratio of length and width) to the rotated bounding box that would encapsulate the area, using the values in [Max Aspect] and [Min Aspect]. For example, the following dent in a surface is included as a blob if these aspect values are set to 1 and 0.354, respectively (the rotated bounding box encapsulating would be 13.059 mm x 4.704 mm).  In the following, the same dent is excluded if [Min Aspect] is set to a value greater than 0.354. 
[Use Circularity Filter] [Max Circularity] [Min Circularity]	If [Use Circularity Filter] is enabled, the tool applies a circularity filter to potential blobs to measure how close to a circle the blob is, using the values in [Max Circularity] and [Min Circularity]. Circularity is determined from area within the contour of the blob and the perimeter of its contour. With increasing perimeter for the same area, circularity is reduced.

Parameter	Description
[Use Convexity Filter] [Max Convexity] [Min Convexity]	If [Use Convexity Filter] is enabled, the tool applies a convexity filter to potential blobs, using the values in [Max Convexity] and [Min Convexity]. Convexity is defined as the (Area of the Blob / Area of its convex hull), and "convex hull" of a shape is the tightest convex shape that completely encloses the shape.
[Ordering]	Orders the measurements, features, and surface data of the individual blobs output by the tool. Choose one of the following: • [Area - Large to small] • [Area - Small to large] • [Position - X increasing] • [Position - X decreasing] • [Position - Y increasing] • [Position - Y decreasing]
[Number of Blob Outputs]	Determines the number of blobs the tool outputs as measurements, features (center points of blobs), and surface data. Currently limited to 200 blobs.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

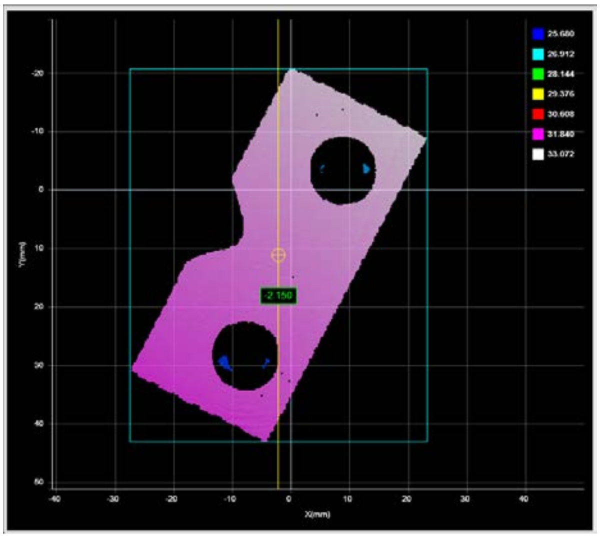
6.6 Bounding Box

The Bounding Box tool provides measurements related to the smallest box that contains the scan data from a part (for example, X position, Y position, width, length, etc.).

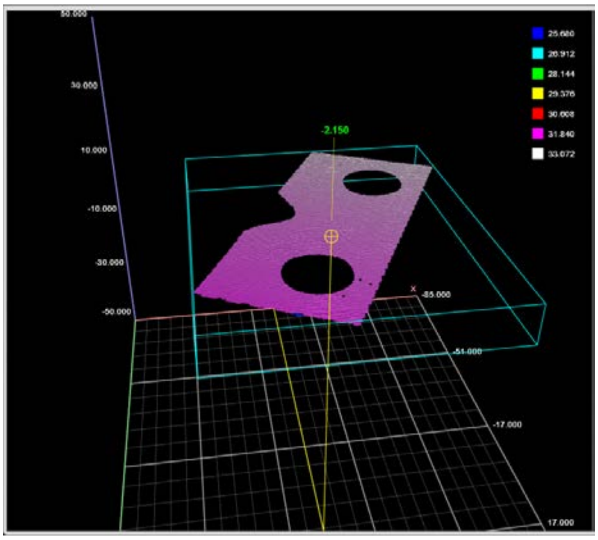
> **Tips**
> If you need to measure the height of the target relative to the Z = 0 reference (such as if you want to measure the height of a box or other container), use the Surface Bounding Box Advanced tool; for more information, see 📖 "6.7 Bounding Box Advanced" on page 445.

A bounding box can be vertical or rotated. A vertical bounding box provides the absolute position from which the Position centroids tools are referenced.

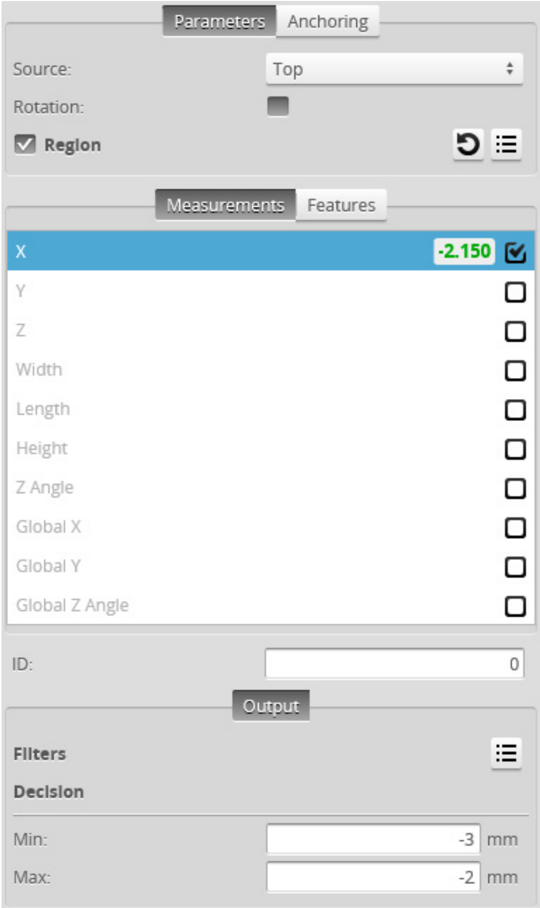
> **Tips**
> The vertical bounding box X and Y correspond to the part frame of reference origin. For this reason all X and Y measurements (except Bounding Box Global X and Global Y) are referenced to this point when [Frame of Reference] on the [Part Detection] panel is set to [Part]. See 📖 "4.4.7 Part Detection" on page 149 for more information.



2D View



3D View

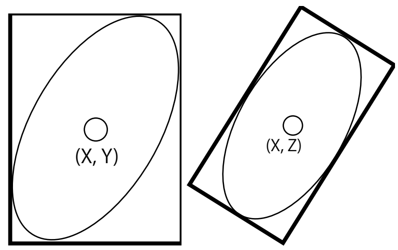
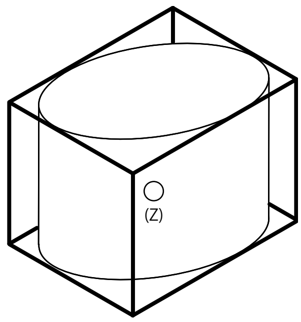
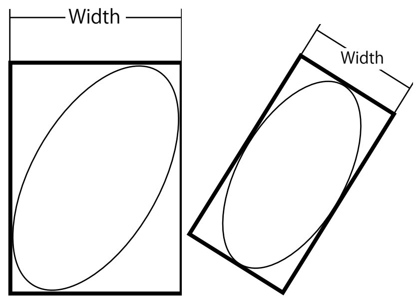
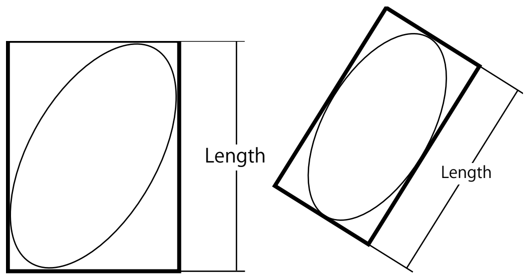
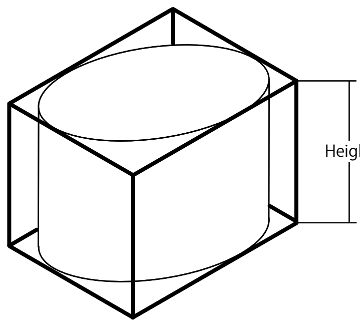


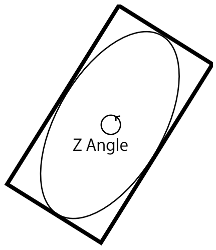
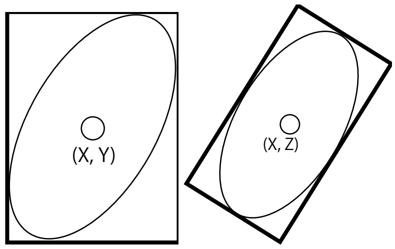
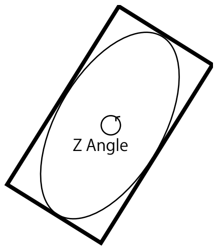
Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.6.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Determines the X position of the center of the bounding box that contains the part. The value returned is relative to the part.	
[Y] Determines the Y position of the center of the bounding box that contains the part. The value returned is relative to the part.	
[Z] Determines the Z position of the center of the bounding box that contains the part. The value returned is relative to the part.	
[Width] Determines the width of the bounding box that contains the part. When the [Rotation] setting is disabled, the bounding box is the smallest rectangle whose sides are parallel to the X and Y axes. Width is on the X axis. When [Rotation] is enabled, the width is the smaller side dimension.	
[Length] Determines the length of the bounding box that contains the part. When the [Rotation] setting is disabled, the bounding box is the smallest rectangle whose sides are parallel to the X and Y axes. Length is on the Y axis. When [Rotation] is enabled, the length is the longer side dimension.	
[Height] Determines the height of the bounding box that contains the part.	

Measurement	Illustration
[Z Angle] Determines the rotation around the Z axis and the angle of the longer side of the bounding box relative to the X axis. If [Rotation] is not enabled, the measurement returns 90.000 degrees. In order to use this measurement for angle anchoring, you must enable [Rotation]; for more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.	
[Global X]* Determines the X position of the center of the bounding box that contains the part on the surface from which the part was extracted.	
[Global Y]* Determines the Y position of the center of the bounding box that contains the part on the surface from which the part was extracted. If the part is extracted from a continuous surface, the Y origin of that surface is at the encoder starting position.	
[Global Z Angle]* Determines the rotation of the longer side of the bounding box around the Z axis on the surface from which the part was extracted. If part matching is enabled, the returned value represents the rotation of the part before part matching rotates it. If [Rotation] is not enabled, the measurement returns 90.000 degrees.	

*These measurements are mostly useful with parts extracted from a surface. For more information on parts, see 📖 "4.4.7 Part Detection" on page 149.

[Features]

Type	Description
[Center Point]	The center point of the bounding box.
[Box Axis Line]	The axis of the bounding box.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Rotation]	A bounding box can be vertical or rotated. A vertical bounding box provides the absolute position from which the part's Position centroid measurements are referenced. Check the [Rotation] setting to select rotated bounding box.
[Asymmetry Detection]	Resolves the orientation of an object over 360 degrees. The possible values are: [0] – None [1] – Along Major Axis [2] – Along Minor Axis This setting is only visible if [Rotation] is checked.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.7 Bounding Box Advanced

Tips

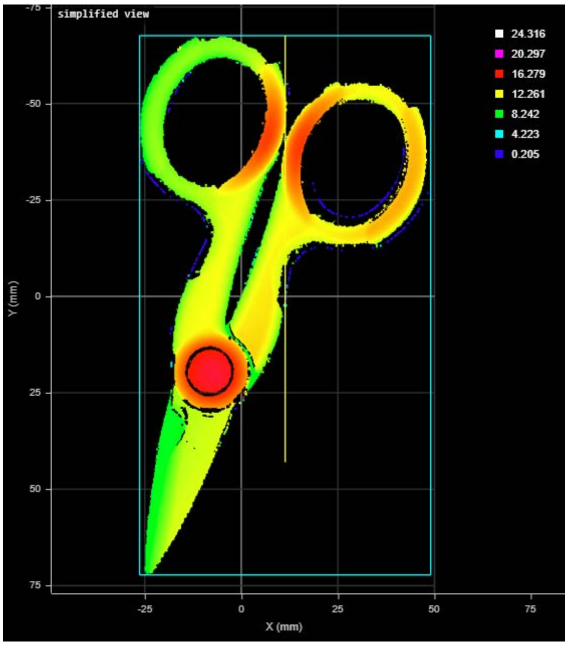
The tool is supported in emulator scenarios.

Like the Bounding Box tool (see "6.6 Bounding Box" on page 440), the Bounding Box Advanced tool provides measurements related to the smallest box that contains the scan data from a part (for example, X position, Y position, width, length, etc.). However, this version of the tool also lets you get the height of bounding box relative to the Z origin (typically the conveyor on which the target is sitting). This lets you determine, for example, the height of a box or other container on the conveyor as part of a product packaging process. New settings also let you easily filter out noise that can affect height, width, and length measurements.

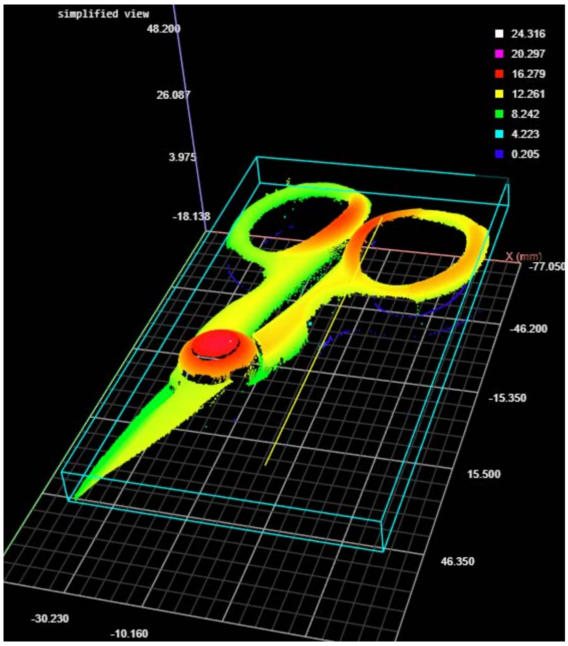
A bounding box can be vertical or rotated. A vertical bounding box provides the absolute position from which the Position centroids tools are referenced.

Tips

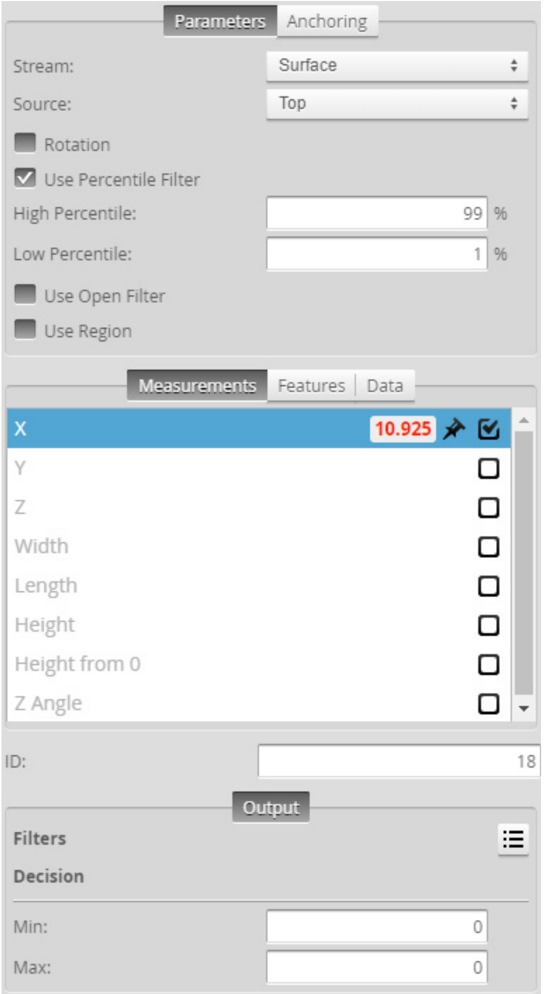
The vertical bounding box X and Y correspond to the part frame of reference origin. For this reason all X and Y measurements (except Bounding Box Global X and Global Y) are referenced to this point when [Frame of Reference] on the [Part Detection] panel is set to [Part]. See "4.4.7 Part Detection" on page 149 for more information.



2D View



3D View

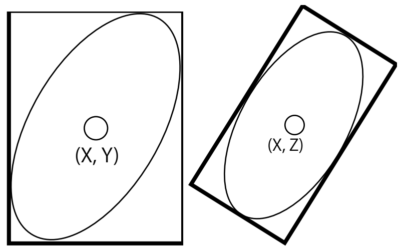
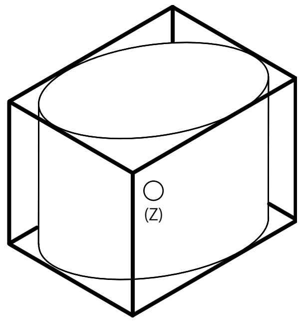
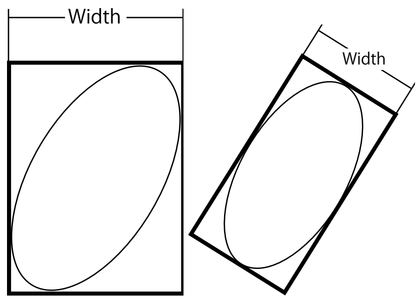
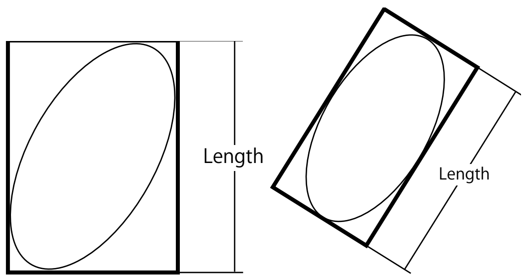
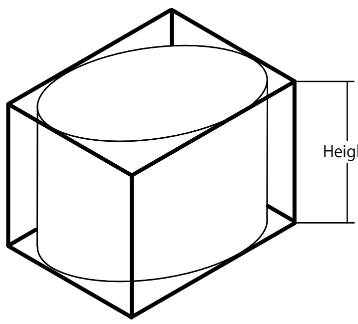


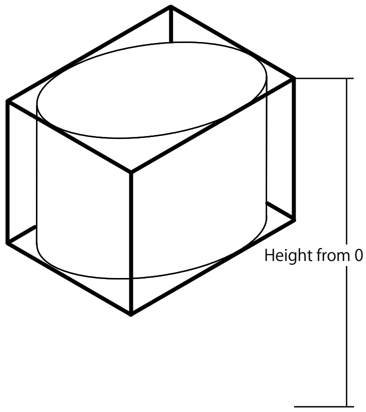
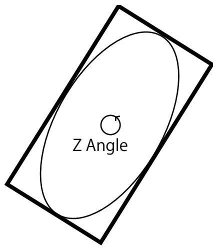
Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.7.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Determines the X position of the center of the bounding box that contains the part. The value returned is relative to the part.	
[Y] Determines the Y position of the center of the bounding box that contains the part. The value returned is relative to the part.	
[Z] Determines the Z position of the center of the bounding box that contains the part. The value returned is relative to the part.	
[Width] Determines the width of the bounding box that contains the part. When the [Rotation] setting is disabled, the bounding box is the smallest rectangle whose sides are parallel to the X and Y axes. Width is on the X axis. When [Rotation] is enabled, the width is the smaller side dimension.	
[Length] Determines the length of the bounding box that contains the part. When the [Rotation] setting is disabled, the bounding box is the smallest rectangle whose sides are parallel to the X and Y axes. Length is on the Y axis. When [Rotation] is enabled, the length is the longer side dimension.	
[Height] Determines the height of the bounding box that contains the part.	

Measurement	Illustration
[Height from 0] Determines the distance from the top of the bounding box to the Z origin (Z = 0).	
[Z Angle] Determines the rotation around the Z axis and the angle of the longer side of the bounding box relative to the X axis. If [Rotation] is not enabled, the measurement returns 90.000 degrees. In order to use this measurement for angle anchoring, you must enable [Rotation]; for more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.	

[Features]

Type	Description
[Center]	The center point of the bounding box.

> **Tips**
> For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Data]

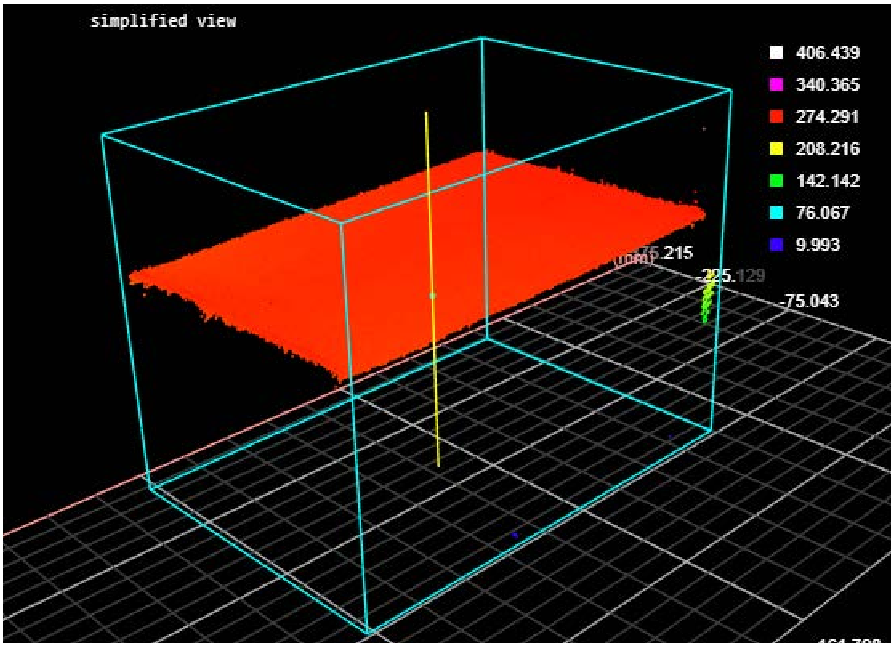
Type	Description
[Diagnostics Surface]	A surface useful for evaluating the impact of the open filter. For more information, see 📖 "[Use Open Filter]" on page 450.

[Parameters]

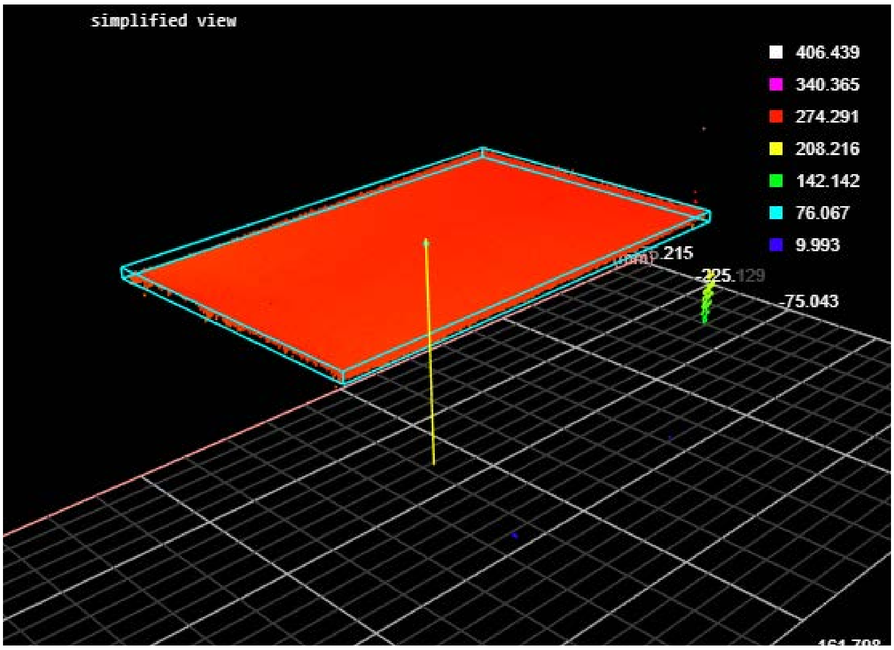
Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Rotation]	A bounding box can be vertical or rotated. A vertical bounding box provides the absolute position from which the part's Position centroid measurements are referenced. Check the [Rotation] setting to select rotated bounding box.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Use Percentile Filter]</td><td>Limits the bounding box to data points along the Z axis between the values you set in [High Percentile] and [Low Percentile], which are displayed when you choose this option. Use this setting to obtain more "robust" height measurements.

This setting is useful to exclude noise that would otherwise cause inaccurate height measurements. For example, in the following scan of a box, without excluding a small percentage of the highest data points, data points caused by noise to the upper right produces an inaccurate height measurement of the box of 406.457 mm.



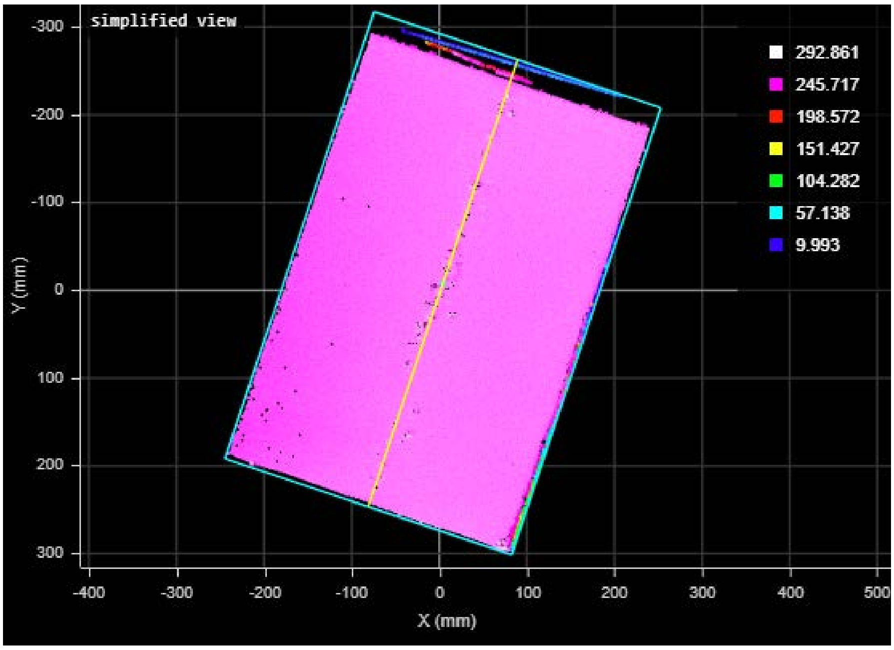
When [High Percentile] is set to 99%, the highest 1 percent of data points is excluded from the placement of the bounding box, and an accurate height of the target box of 270.477 mm is returned.



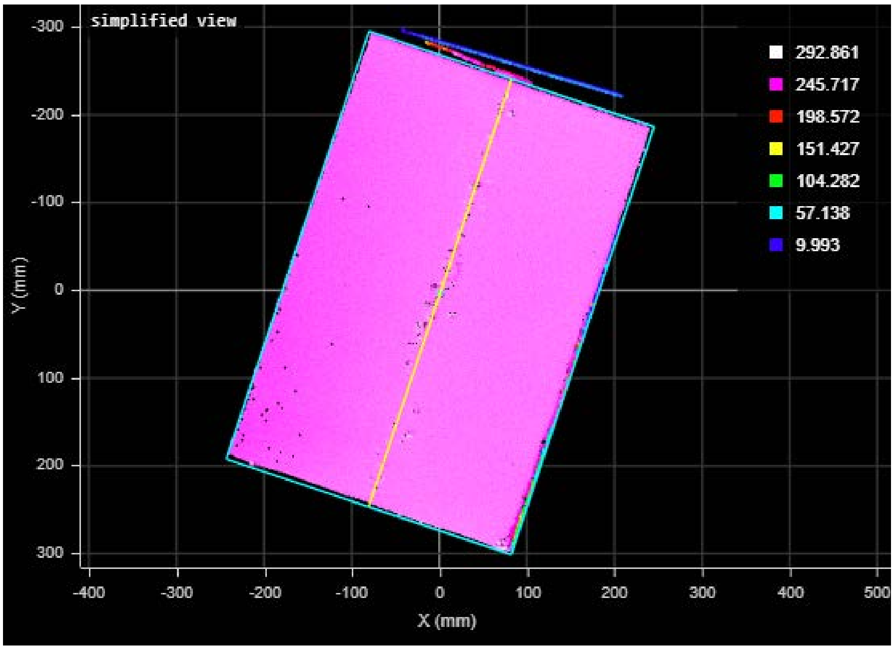
</td></tr>
</table>

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Use Open Filter]</td><td>When enabled, this setting lets you set the value of [Kernel Size] for an open morphological operation applied to the scan data on the XY plane, letting you achieve "robust" width and length measurements.

This filter removes noise or small objects from scan data, while keeping the shape and size of the larger objects in the scan data. For example, in the following, noise along the edge at the top of the data viewer results in an inaccurate length measurement.



When the filter is set to an appropriately sized kernel (here, 11 points), the noise is excluded from the calculation of the bounding box, and an accurate length is returned.



Use the Diagnostics Surface on the [Data] tab to evaluate the impact of the open filter, to avoid removing too much data.</td></tr>
<tr><td>[Use Region]</td><td>When enabled, displays additional settings to let you set a region (see below).</td></tr>
</table>

Parameter	Description
[Region Type] [Inner Circle Diameter] [Inner Ellipse Major Axis] [Inner Ellipse Minor Axis] [Sector Start Angle] [Sector Angle Range] [Mask Source] [Low Threshold] [High Threshold]	When you enable [Use Region], the tool displays additional settings related to the measure region type. For details on flexible regions and their settings, see "• Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

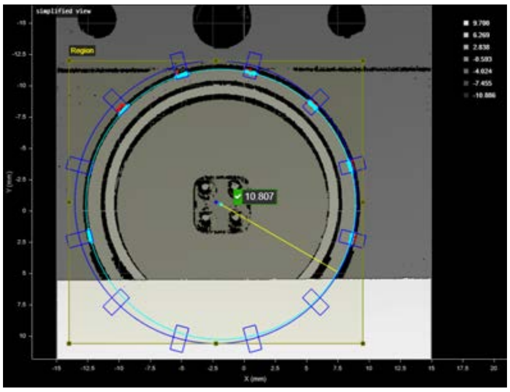
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

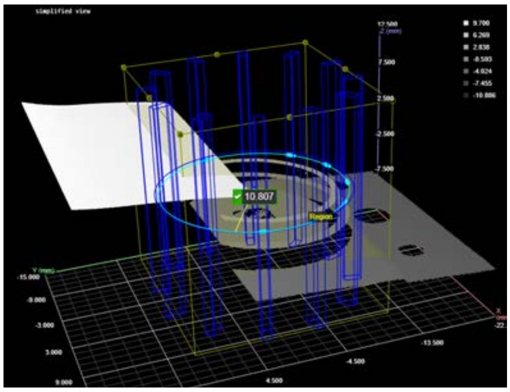
6.8 Circular Edge

The Circular Edge tool fits a circle to a circular edge in the scan data, using either height map or intensity data. The edge can be the outer edge of a disc-like feature or the inner edge of a hole. The tool can optionally work with partial data, as little as 1/4 of a circle, letting it work with rounded corners.

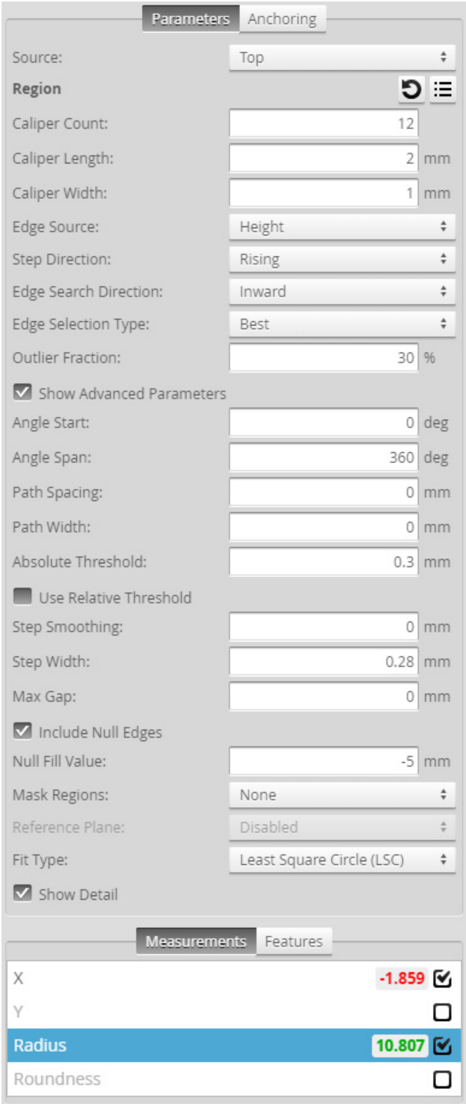
The tool lets you measure the position and radius of the circular feature and determine its roundness error. The feature is expected to be relatively round and not, for example, ovoid. In the following images, the outer edge of a circular feature is measured. The same tool could just as easily measure the characteristics of one of the holes at the top.



2D View



3D View



Measurement Panel

The tool uses one of four standard methods to calculate roundness. The choice of method affects the other measurements.

- Least Square Circle (LSC)
- Minimum Zone Circle (MZC)
- Maximum Inscribed Circle (MIC)
- Minimum Circumscribed Circle (MCC)

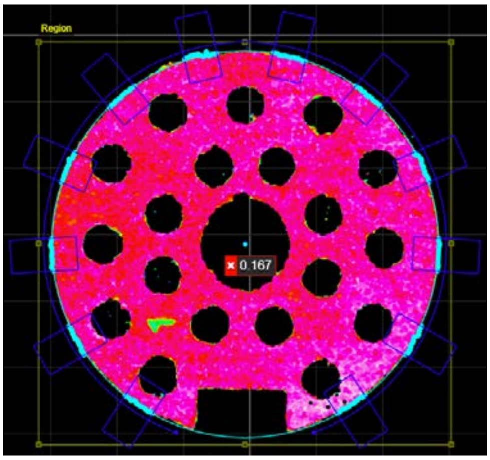
The tool can also generate circle and center point geometric features that Feature tools can take as input for measurement. For more information on Feature tools, see 📖 "4.7.9 Feature Measurement" on page 301.

Some of the tool parameters are hidden unless [Show Advanced Parameters] is checked.

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.8.1 Calipers, Extracted Paths, and Edge Points

To fit a circle to the scan data, the Surface Circular Edge tool starts by overlaying evenly spaced calipers along a circular path constrained by the region of interest.



Rectangular calipers (dark blue) placed along circular path (dark blue), constrained by the region

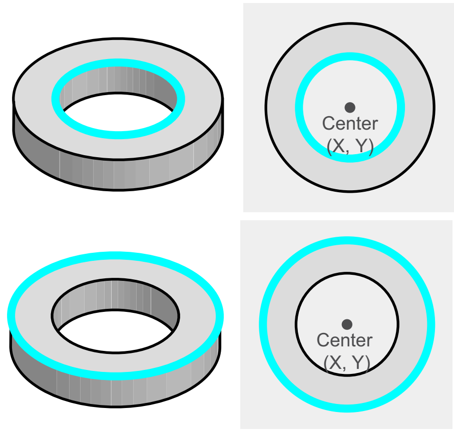
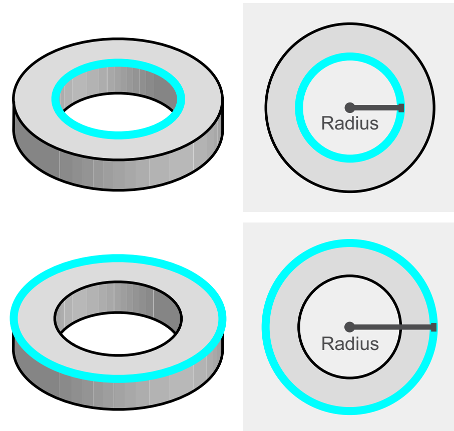
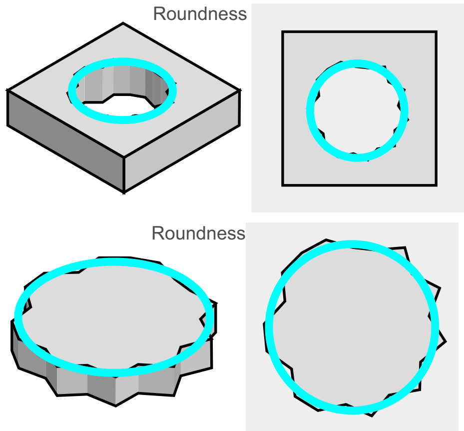
The circular path can optionally be partial, and starts at a defined orientation around the Z axis. The circular path can be as short as 1/4 of a circle, letting it work with rounded corners. Calipers extend vertically to fill the entire region of interest.

Internally, the tool extracts profiles from the data within each caliper, running from the end of the caliper closest to the center of the tool's region of interest to the end farthest from the center. The tool then searches for steps in each profile that meet the criteria set by the tool’s settings, such as minimum height, direction (whether it is rising or falling), and so on.

The tool places an edge point on each selected step. The tool then uses the edge points in all the calipers to fit a circle: the various characteristics of the fitted circle are then returned as measurements.

6.8.2 Measurements, Features, and Settings

[Measurements]

<table>
<tr><th>Measurement</th><th>Illustration</th></tr>
<tr><td>[X]
[Y]
Returns the X and Y position of the center of the fitted circle, respectively.</td><td>
</td></tr>
<tr><td>[Radius]
Returns the radius of the fitted circle.</td><td>
</td></tr>
<tr><td>[Roundness]
Returns the roundness or circularity of the edge points with respect to the reference circle of the selected roundness error method set in [Fit Type].</td><td>
</td></tr>
<tr><td>[Min Error]
[Max Error]
These measurements return information on the points furthest inside and outside the fitted circle, respectively.</td><td></td></tr>
</table>

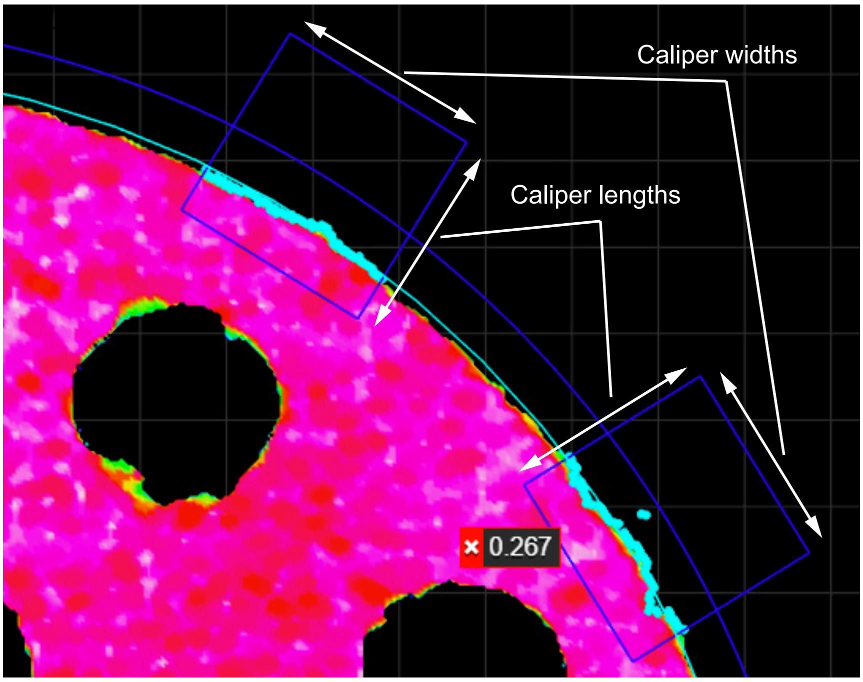
[Features]

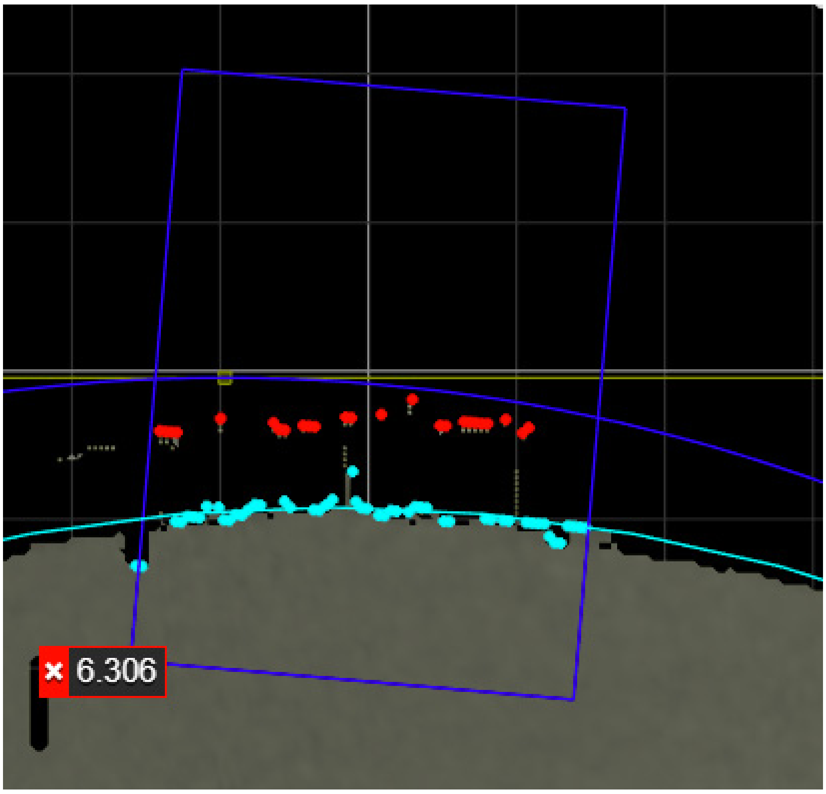
Type	Description
[Center]	The center of the fitted circle.
[Circle]	The fitted circle.

Tips

For more information on geometric features, see "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238. The region also constrains the circular path along which the tool places the calipers.
[Caliper Count]	The number of calipers the tool places along the circular path. Using a higher number of calipers increases the amount of data available to the tool, but also increases the amount of time the tool takes to run. Choose a balance between the runtime of the tool and the number of calipers needed to get enough edge points to properly fit the circle to the scan data.
[Caliper Length] [Caliper Width]	[Caliper Length] is the length of the calipers (extending perpendicular to a tangent on the circular caliper path, centered on the path). The length of the calipers determines the length of the extracted profiles the tool examines for steps. Longer calipers increase the amount of data the tool must analyze and therefore the time the tool takes to run; longer calipers can also include unwanted steps when the tool searches for the edge. [Caliper Width] is the width of the calipers (extending parallel to a tangent on the circular path). A wider caliper increases the time the tool takes to run. It does however increase the number of edge points, which may help the tool fit the circle. 

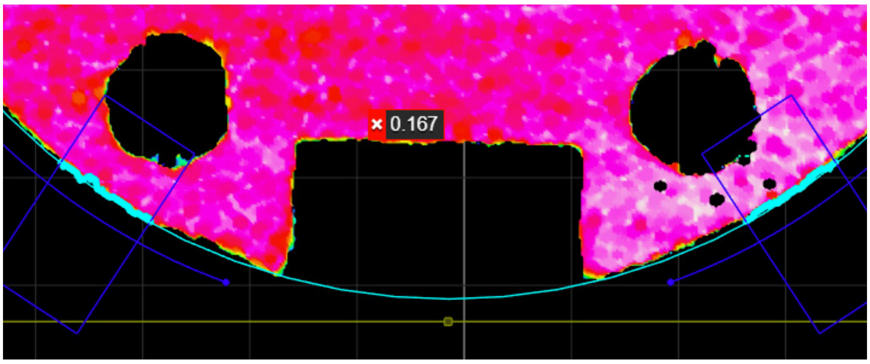
Parameter	Description
[Edge Source]	Specifies the type of data the tool uses. Either Height or Intensity. Use intensity data as the edge source when contrast differences on a flat area of a target, which would not be detected using height map data, are distinct, letting the tool use the detected edge to fit the circle.
[Step Direction]	Determines whether the expected step in the data rises or falls, or moves from valid to null or null to valid. Note that this setting depends on the [Edge Search Direction] setting for its interpretation of what "rises" and "falls." One of the following: [Rising & Falling]: Searches for edge points on rising or falling edges. [Rising]: Searches for edge points only on rising edges. [Falling]: Searches for edge points only on falling edges.
[Edge Search Direction]	Specifies the search direction along the calipers. Either Inward (toward the center of the region of interest) or Outward.
[Edge Selection Type]	Determines which step the tool uses on each of the profiles internally extracted from the calipers when there are multiple steps. An edge point is placed on each chosen step, and is used to fit the circle. Steps must pass the criteria of the tool's settings, such as threshold and outlier exclusion. [Best]: Selects the greatest step in the search direction on each profile. [First]: Selects the first step in the search direction on each profile. [Last]: Selects the last step in the search direction on each profile.
[Outlier Fraction]	The percentage of outlier points to exclude. Setting this to a small value can help the tool fit the circle better to the edge.  Outlier Fraction set to a low value: rejected outlier edge points are red.
[Show Advanced Parameters]	When enabled, displays advanced settings. Note that most of these settings are applied even when they are hidden. For information on these settings, see "[Advanced Parameters]" on page 458.
[Show Detail]	When disabled, hides the calipers and caliper path, as well as the edge points.

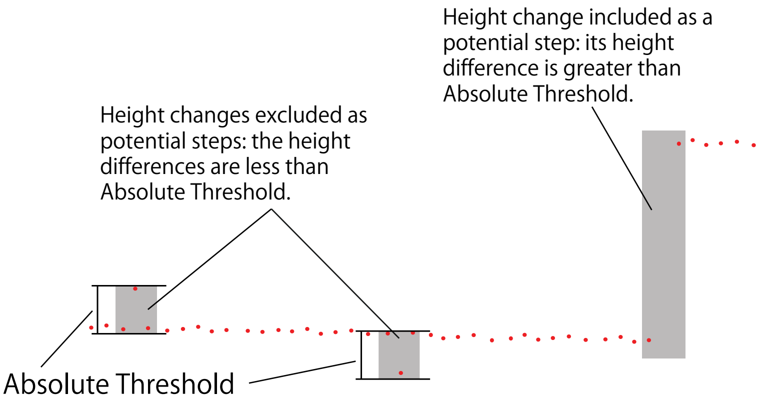
Parameter	Description
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

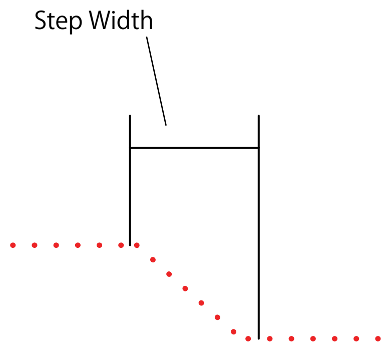
Tips

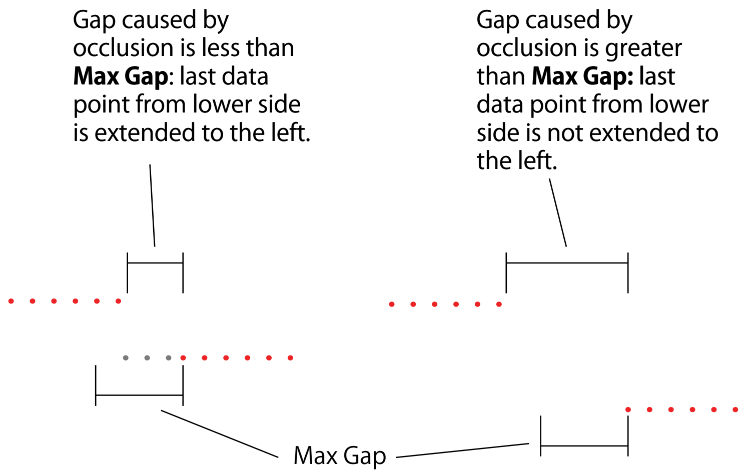
The following parameters are hidden when [Show Advanced Parameters] is unchecked. All advanced parameters, except [Reference Plane], are applied when they are hidden. Mask regions are not rendered, even though they are applied.

[Advanced Parameters]

Parameter	Description
[Angle Start] Angle Span]	These settings work together to let you set a partial path and exclude part of the data. In the following close-up image of a circular feature, the dark blue path starts to the right of the notch, continues clockwise around the circular feature, and ends to the left of it.  [Angle Start] is the starting angle, around the Z axis on the XY plane, for the circular path along which calipers are placed. Setting this to 0 aligns the start angle with the positive direction of the X axis. [Angle Span] is the length of the circular path along which calipers are placed.
[Path Spacing]	Sets the spacing between paths in the calipers used to extract the profiles that determine the edge. A higher number of paths results in a higher number of edge points, which makes the fitting of the edge line more accurate. However, a higher number of edge points results in a greater tool execution time. When [Path Spacing] is set to 0, the resolution of the scan data is used as the basis for spacing.
[Path Width]	The size of the windows perpendicular to the path used to calculate an average for each data point on a path profile. Useful to average out noise along the path caused by reflections, and so on. If [Path Width] is set to 0, no averaging is performed (only the data point under the path is used). For averaging along the path, use [Step Smoothing] (see below).

Parameter	Description
[Absolute Threshold]	When [Use Intensity] is disabled, the setting specifies the minimum height difference between points on a path profile for that step to be considered for an edge point. The setting can be used to exclude smaller steps on a part that should not be considered for an edge, or to exclude height differences caused by noise. When used in conjunction with [Relative Threshold, Absolute Threshold] is typically set to a small value, greater than the general surface roughness.  When [Use Intensity] is enabled, the setting specifies the minimum difference in intensity. ([Acquire Intensity] must enabled in the [Scan Mode] panel.)
[Use Relative Threshold]	When this option is enabled, the [Relative Threshold] field is displayed.
[Relative Threshold]	The value for the relative threshold. The tool calculates a relative threshold by scaling the greatest height or intensity difference found on the path profiles by the percentage in [Relative Threshold]. This lets you configure the tool without knowing the actual step height in advance, and is useful for edges with varying step height. For a height or intensity difference to be considered a valid step, both [Absolute Threshold] and [Relative Threshold] must pass.
[Step Smoothing]	The size of the windows along the path used to calculate an average for each data point on a path profile. The setting is useful for averaging out noise. If [Step Smoothing] is set to 0, no averaging is performed (only the data point under the path is used). For averaging perpendicular to the path, use [Path Width] (see above).

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Step Width]</td><td>The distance, along a path profile, separating the points used to find steps on a path profile.


The setting is useful when you must detect a slope as an edge, rather than a sharply defined edge: setting [Step Width] to a value greater than the width of the edge ensures that the tool measures the height difference between the flat regions on either side of the edge. As a result, the height of the step is accurately measured, and the edge is correctly located.
Tips
Setting [Step Width] wider than necessary can reduce the precision of edge location.</td></tr>
<tr><td>[Max Gap]</td><td>Fills in regions of missing data caused by an occlusion near the desired edge. Use this setting when continuity on the target is expected. When [Max Gap] is set to a non-zero value, the tool holds and extends the last data point on the low side next to an edge across a gap of null points, up to the distance specified in [Max Gap].

</td></tr>
</table>

Parameter	Description
[Include Null Edges]	Indicates whether null points (points where no height or intensity value is available, due to dropouts or regions outside of the measurement range) are filled with the value in [Null Fill Value] as a general "background level." If [Use Intensity] (see above) is enabled, the intensity value in [Intensity Null Fill Value] is also used. A typical example is a discrete part produced by part detection of an object sitting on a flat background. The background is not visible in the part, so the tool assumes that any null region are at the background level. **Tips** To find edges along a region of null points, you must use either this option and an appropriate value in [Null Fill Value] (and [Intensity Null Fill Value] if [Use Intensity] is enabled) or [Max Gap]. Otherwise, only edges within areas of contiguous data will be detected.
[Null Fill Value]	The height value (in mm) used to replace null points not filled by [Max Gap] when [Include Null Edges] is enabled.
[Intensity Null Fill Value]	The intensity value (0-255) used to replace null points when [Include Null Edges] and [Use Intensity] are enabled.
[Mask Regions]	Lets you enable up to five regions that you can use to mask data you want the tool to ignore. You can resize and reposition the mask regions using the mouse in the data viewer, or by configuring values manually in the [Mask Region] sections the tool displays in the tool settings for each region. You can only set the rotation of the mask regions manually by modifying the region's [Z angle] parameter. By default, when you add multiple mask regions, they are initially placed in the same position, one on top of the other.
[Reference Plane]	Uses the output of a Surface Plane tool as a reference plane. Useful to correct the scan data if the target is slightly tilted. When [Show Advanced Parameters] is unchecked and [Reference Plane] is set to a plane, the plane is ignored.
[Fit Type]	The method the tool uses to calculate the roundness of the feature. One of the following: [Least Square Circle (LSC)] [Minimum Zone Circle (MZC)]: If you choose this method, set the circle the tool uses with the [Which Circle] parameter. [Maximum Inscribed Circle (MIC)]: Typically used to measure the inner edge of a circular feature, such as a hole. [Minimum Circumscribed Circle (MCC)]: Typically used to measure the outer edge of a circular feature. [Least Square Method]: This algorithm provides more accurate fit results than Iterative Approximation on partial circle data. The execution time is also better on average, so this method should be chosen in general.
[Which Circle]	Tells the tool which circle (Inner or Outer) to use when Minimum Zone Circle is the fit method in [Fit Type].

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

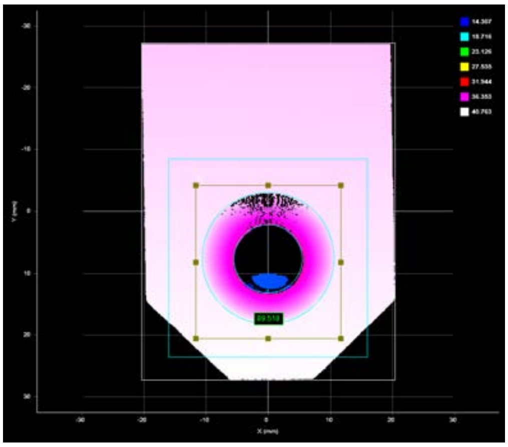
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.9 Countersunk Hole

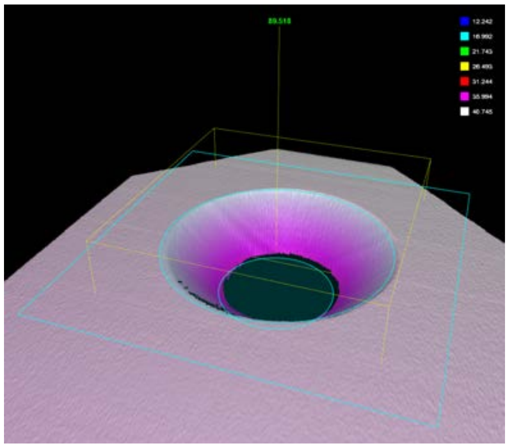
The Countersunk Hole tool locates a countersunk circular opening within a region of interest on the surface and provides measurements to evaluate characteristics of countersunk holes, including the position (X, Y, and Z) of the center of the hole, outside radius of the hole, hole bevel angle, and the depth of the hole. The countersunk hole can be on a surface at an angle to the sensor. The tool also supports measuring holes drilled at an angle relative to the surrounding surface.

Tips

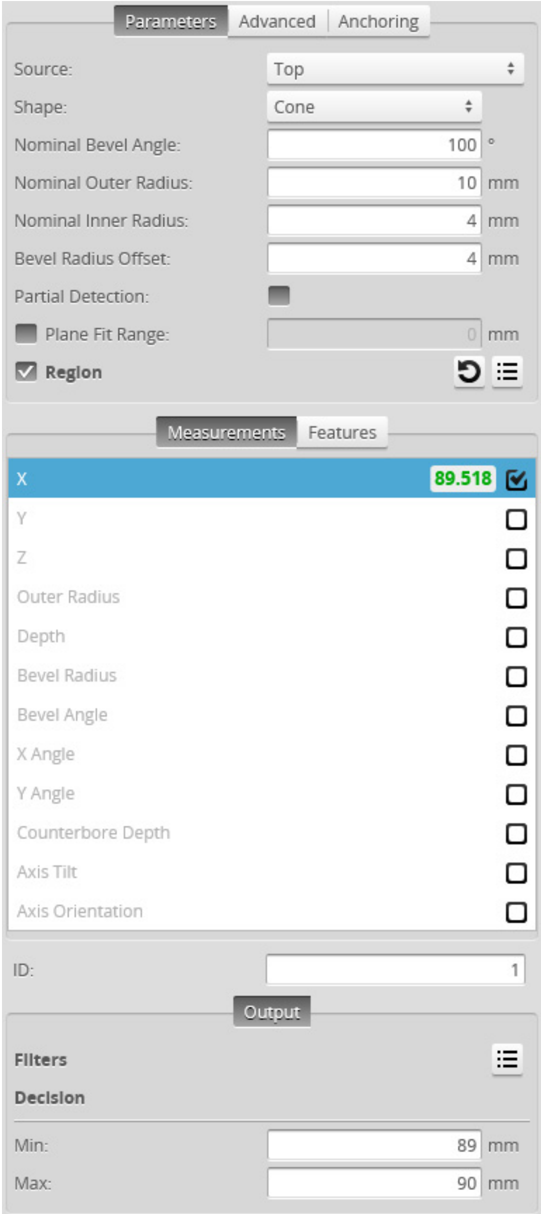
The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

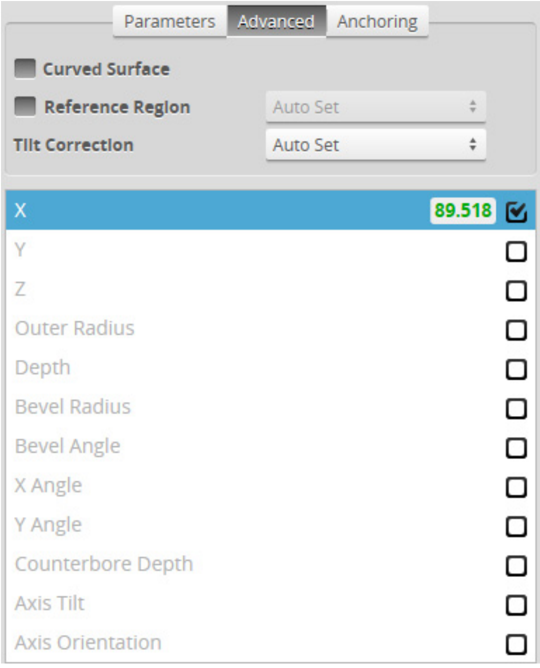


2D View



3D View


Parameters
Advanced
Anchoring
Source:
Top
Shape:
Cone
Nominal Bevel Angle:
100 °
Nominal Outer Radius:
10 mm
Nominal Inner Radius:
4 mm
Bevel Radius Offset:
4 mm
Partial Detection:
Plane Fit Range:
0 mm
Region
Measurements
Features
X
89.518
Y
Z
Outer Radius
Depth
Bevel Radius
Bevel Angle
X Angle
Y Angle
Counterbore Depth
Axis Tilt
Axis Orientation
ID:
1
Output
Filters
Decision
Min:
89 mm
Max:
90 mm

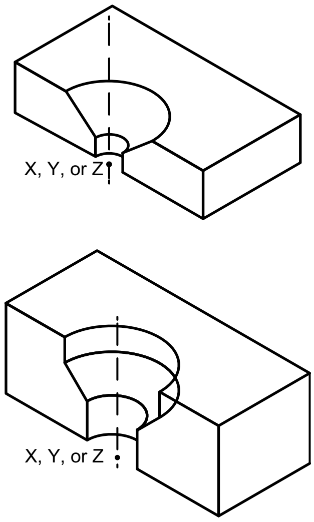
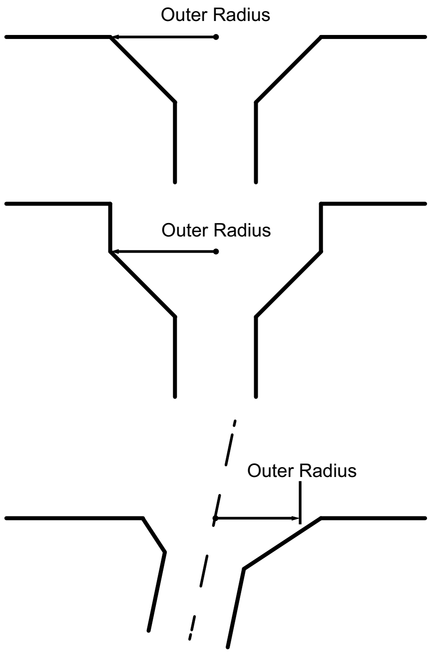
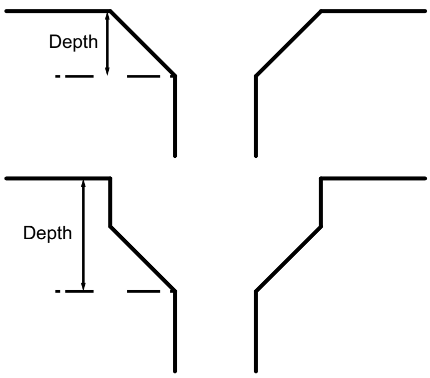


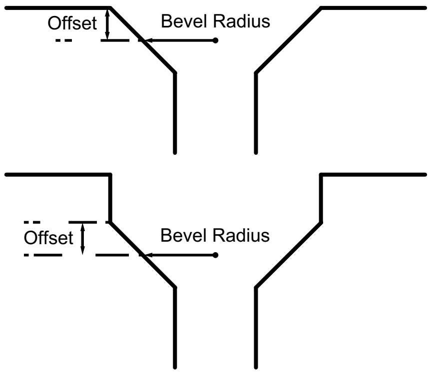
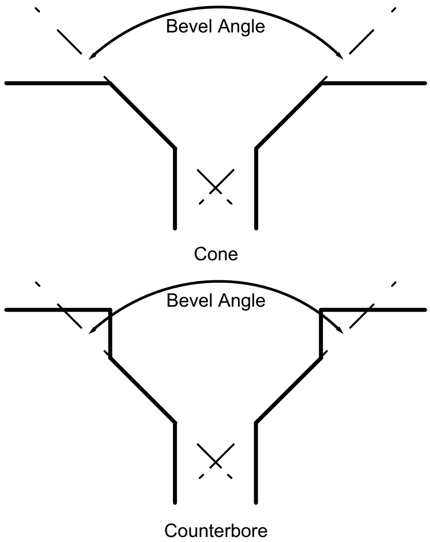
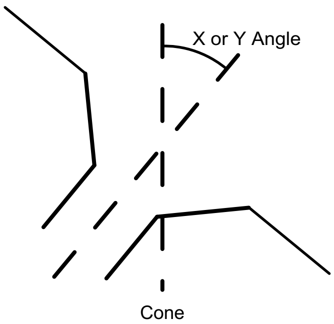
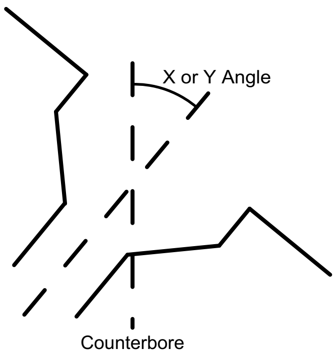
Measurement Panel

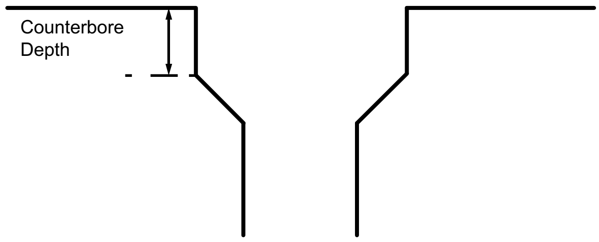
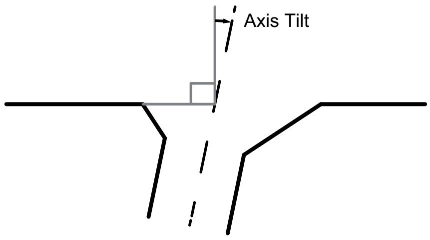
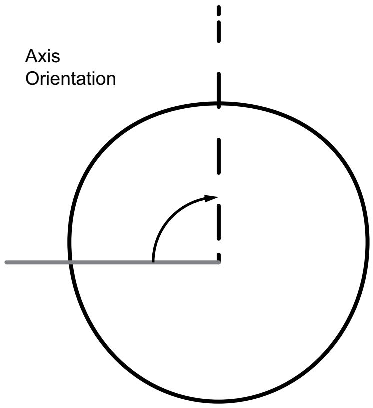
For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.9.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Determines the X position of the center of the countersunk hole.	
[Y] Determines the Y position of the center of the countersunk hole.	
[Z] Determines the Z position of the center of the countersunk hole.	
[Outer Radius] Determines the outer radius of the countersunk hole. When a hole is cut at an angle relative to the surrounding surface, the outer radius is calculated as if the hole were not cut at an angle. **Tips** To convert the radius to a diameter, set the [Scale] setting in the [Output] panel (displayed after expanding the [Filters] section) to 2.	
[Depth] Determines the depth of the countersunk hole relative to the surface that the countersunk hole is on.	

<table>
<tr><th>Measurement</th><th>Illustration</th></tr>
<tr><td>[Bevel Radius]
Determines the radius at a user-defined offset ([Offset] setting) relative to the surface that the countersunk hole is on.
Tips
To convert the radius to a diameter, set the [Scale] setting in the [Output] panel (displayed after expanding the [Filters] section) to 2.</td><td></td></tr>
<tr><td>[Bevel Angle]
Determines the angle of the hole's bevel.</td><td></td></tr>
<tr><td>[X Angle]
Determines the angle the hole relative to the X axis.</td><td></td></tr>
<tr><td>[Y Angle]
Determines the angle of the hole relative to the Y axis.</td><td></td></tr>
</table>

Measurement	Illustration
[Counterbore Depth] Determines the depth of a counterbore.	
[Axis Tilt] Measures the tilt of the axis of the hole relative to the surface surrounding the hole. **Tips** This measurement is not supported when [Shape] is set to [Counterbore].	
[Axis Orientation] Measures the angle of the axis of the hole around the normal of the surface surrounding the hole, relative to the X axis. **Tips** This measurement is not supported when [Shape] is set to [Counterbore].	

[Features]

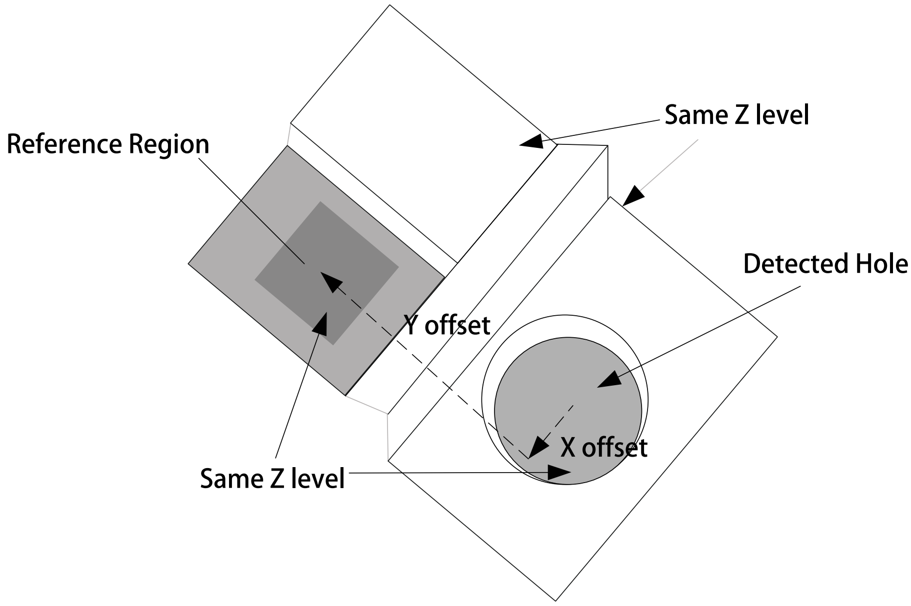
Type	Description
[Center Point]	The center point of the countersunk hole. The Z position of the center point is at the Z position of the surrounding surface.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Shape]	The shape of the countersunk hole. (See illustrations above.) [0] – Cone [1] – Counterbore
[Nominal Bevel Angle]	The expected bevel angle of the countersunk hole.

Parameter	Description
[Nominal Outer Radius]	The expected outer radius of the countersunk hole.
[Nominal Inner Radius]	The expected inner radius of the countersunk hole.
[Bevel Radius Off-set]	The offset, relative to the surface that the countersunk hole is on, at which the bevel radius will be measured.
[Partial Detection]	Enable if only part of the hole is within the measurement region. If disabled, the hole must be completely in the region of interest for results to be valid.
[Plane Fit Range]	Excludes data beyond the specified distance from the plane surrounding the hole. You can use this setting to exclude surfaces close to the countersunk hole that step down from the plane surrounding the hole that could make measurement of the hole less reliable.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.
[Curved Surface]	Whether the surface that the countersunk hole is on is curved. When this setting is enabled, specify the orientation of the curvature in degrees in the [Curve Orientation] setting.
[Curve Orientation]	The orientation of the curvature in degrees. Only visible when [Curved Surface] is enabled.
[Reference Regions]	The tool uses the reference regions to calculate the Z position of the hole. It is typically used in cases where the surface around the hole is not flat.  When this option is set to [Autoset], the algorithm automatically determines the reference region. When the option is not set to [Autoset], you must manually specify one or two reference regions. The location of the reference region is relative to the detected center of the hole and positioned on the nominal surface plane. When [Reference Region] is disabled, the tool measures the hole's Z position using all the data in the measurement region, except for a bounding rectangular region around the hole.

Parameter	Description
[Tilt Correction]	Tilt of the target with respect to the alignment plane. [Autoset]: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes. [Custom]: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below).
[X Angle] [Y Angle]	The X and Y angles you must specify when [Tilt Correction] is set to [Custom]. You can use the Surface Plane tool's X Angle and Y Angle measurements to get the angle of the surrounding surface, and then copy those measurement's values to the [X Angle] and [Y Angle] parameters of this tool.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

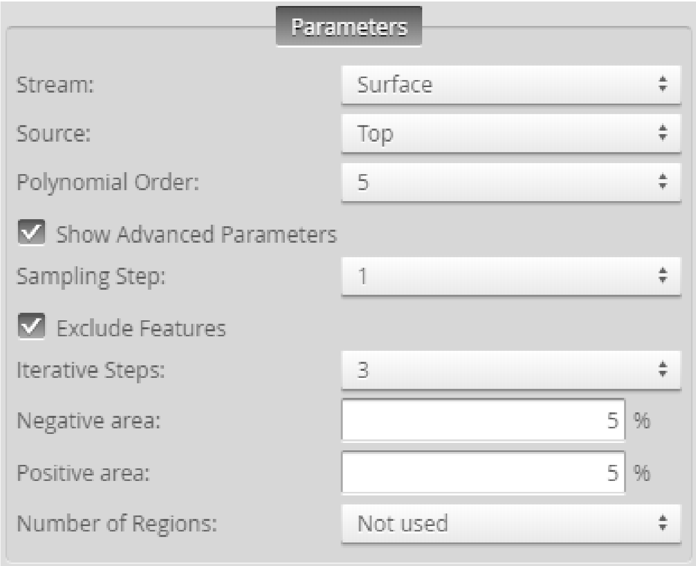
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.10 Curvature

Tips

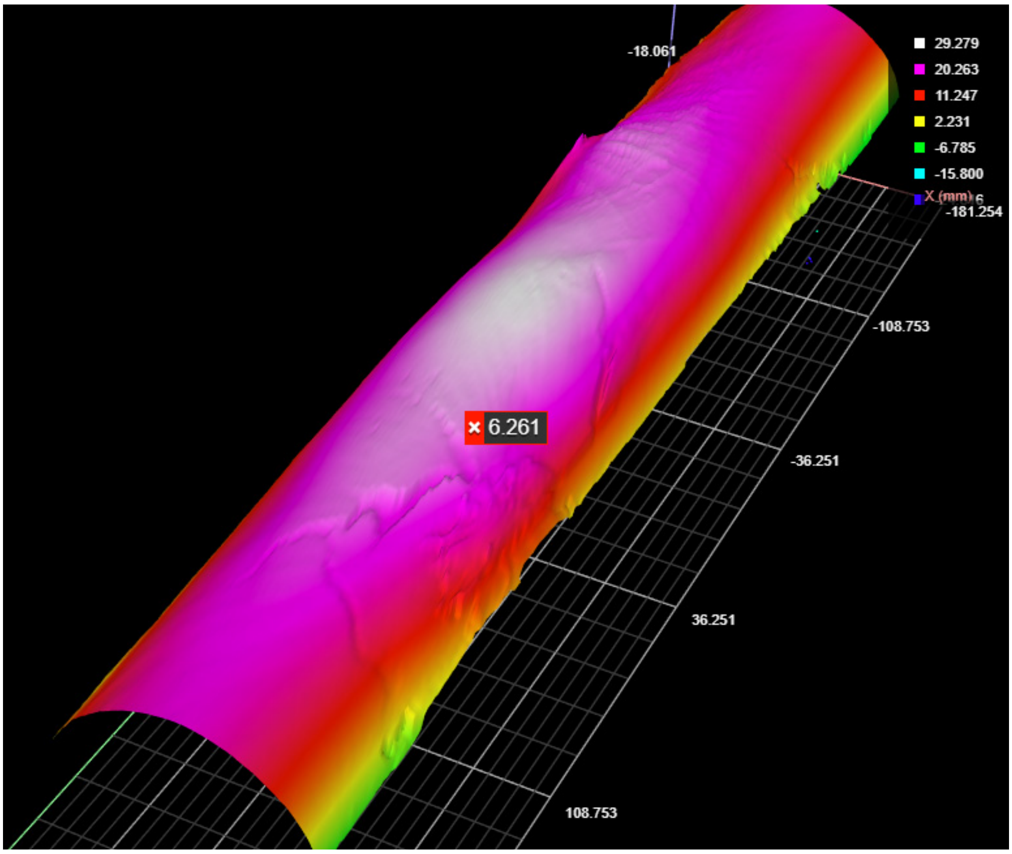
The tool is supported in emulator scenarios.

The Surface Curvature tool removes curvature from curved surfaces while preserving surface features or defects, using a configurable polynomial order (the tool performs a 2D polynomial fit on X and Y to process surfaces). You can then use the tool's output apply measurements to the "flattened" surface.

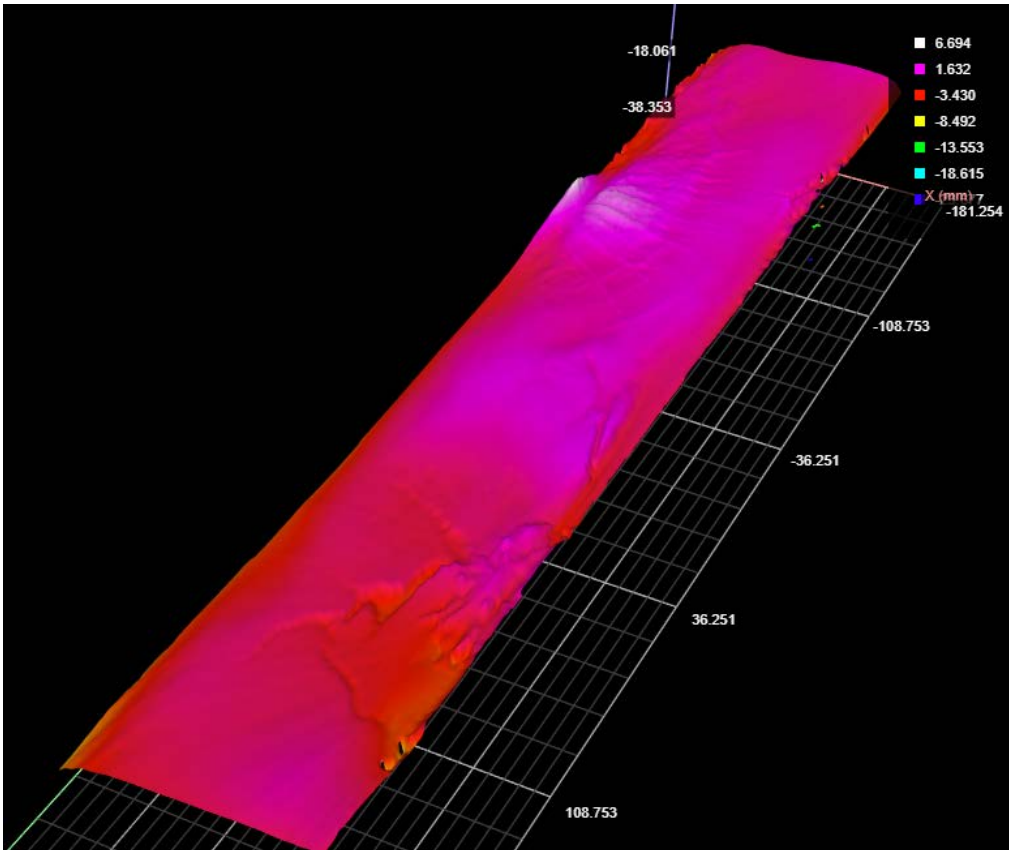


The tool does not support rotational scans (that is, polar "unwrapping").

In the following images, a curved surface (top) is flattened out (bottom), preserving the surface detail.

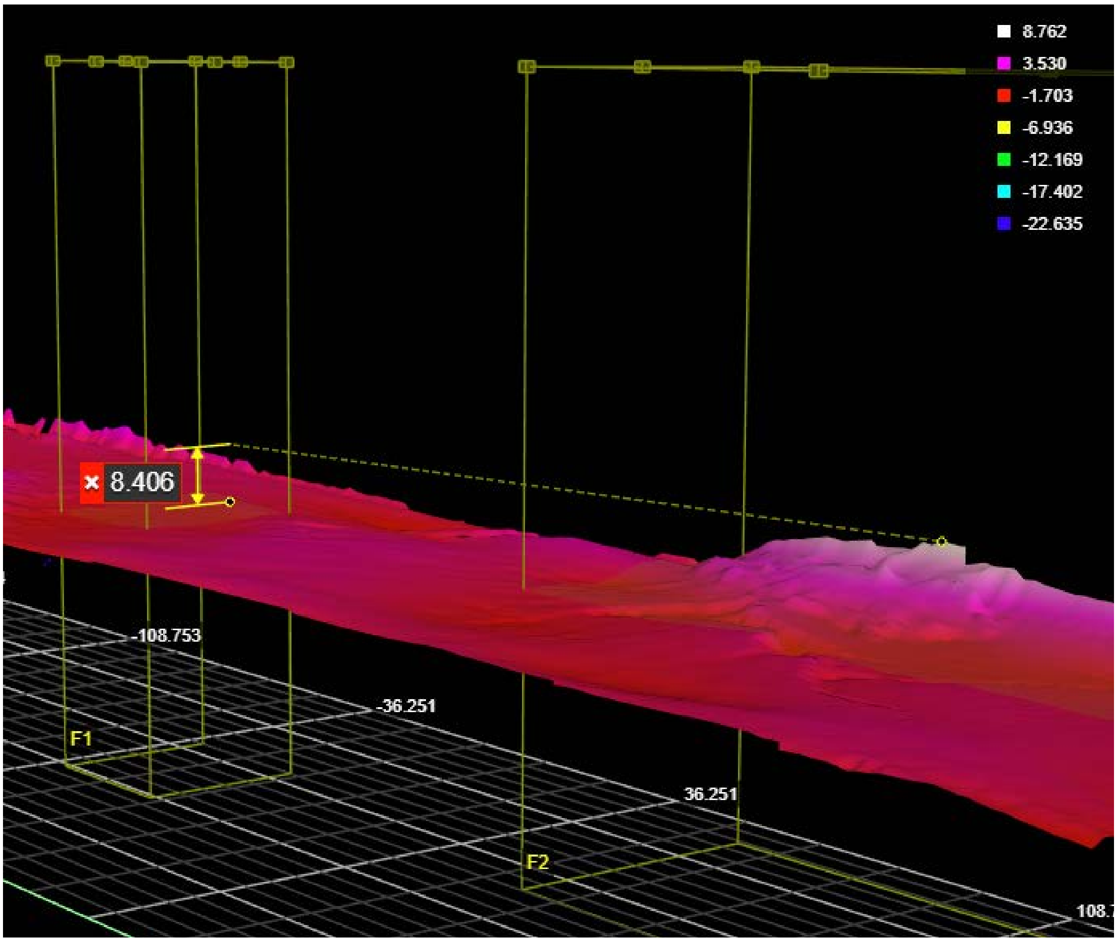


The original, curved scan of a target.



The "flattened" surface data (the tool's Difference Surface data output).

In the following image, a Surface Dimension tool's height measurement runs on the "flattened" output (the Surface Curvature tool's Difference Surface output) to determine the height of one of the raised areas:



Height of a raised feature relative to the previously curved surrounding surface.

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.10.1 Measurements and Settings

[Measurements]

Measurement	Description
[Processing Time]	The amount of time the tool takes to process.

[Data]

Type	Description
[Fit Surface]	The fitted polynomial the tool uses to flatten the original surface.
[Difference Surface]	The “flattened” surface: this is the original surface with the fitted polynomial removed.

[Parameters]

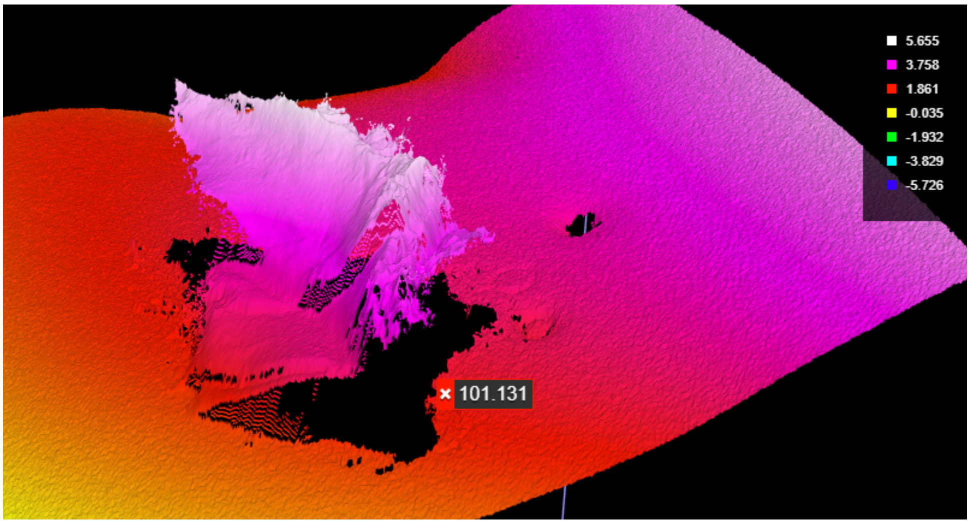
Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool. If you switch from one type of data to another (for example, from section profile data to surface data), currently set input features will become invalid, and you will need to choose features of the correct data type.
[Polynomial Order]	Selects the order (or degree) of the polynomial to be fit to the surface. A higher order results in a better fit but increases processing time.
[Show Advanced Parameters]	Enables a set of advanced parameters. For more information, see "[Advanced Parameters]" on page 474.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

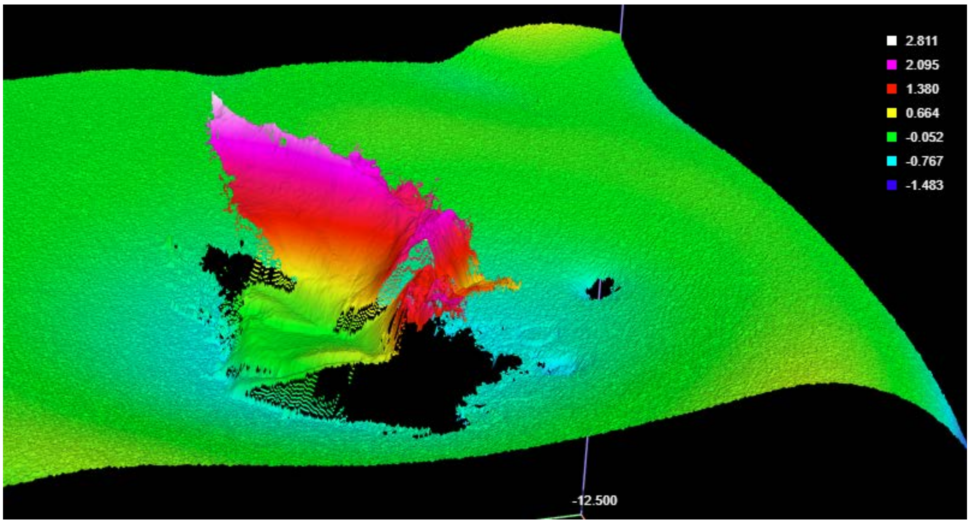
[Advanced Parameters]

Parameter	Description
[Sampling Step]	The step in data points in both directions with which the surface is sampled. Choosing a higher sampling step reduces the processing time the tool requires, but reduces fit accuracy. Useful if the surface being processed has a large number of data points.

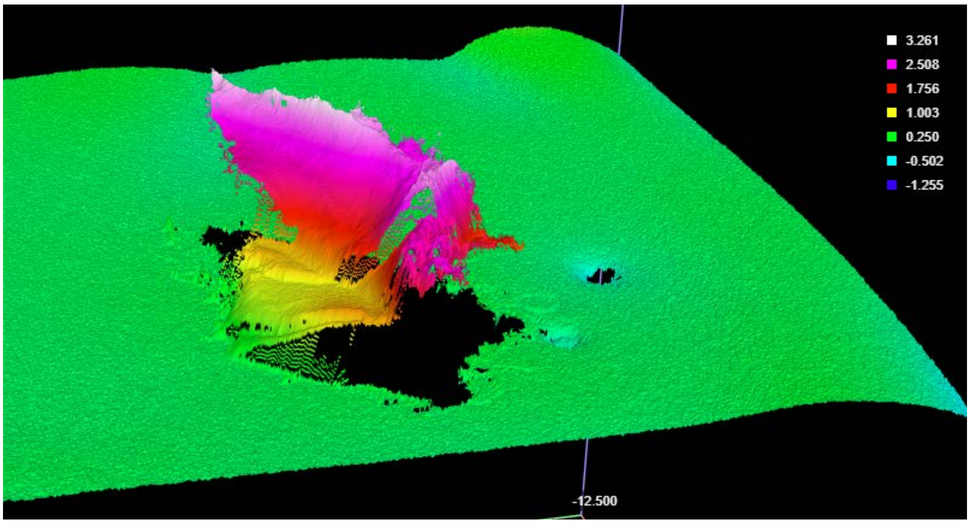
<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Exclude Features]</td><td>Lets you exclude features or surface details from the polynomial fit. This can allow you to get a better fit on the surrounding surface.

Checking this option enables the [Negative area], [Positive area], and [Iterative Steps] parameters. (See below.)

For example, in the following scan data, we would like to accurately measure the circular divots and the small hole near the center of the data on the curved surface.


If the large feature to the left is not excluded for the polynomial fit, the fitted surface will and therefore the measurements on the smaller features will be inaccurate. In the following "flattened" scan data, without excluding the larger feature, the smaller features would be difficult to accurately measure:


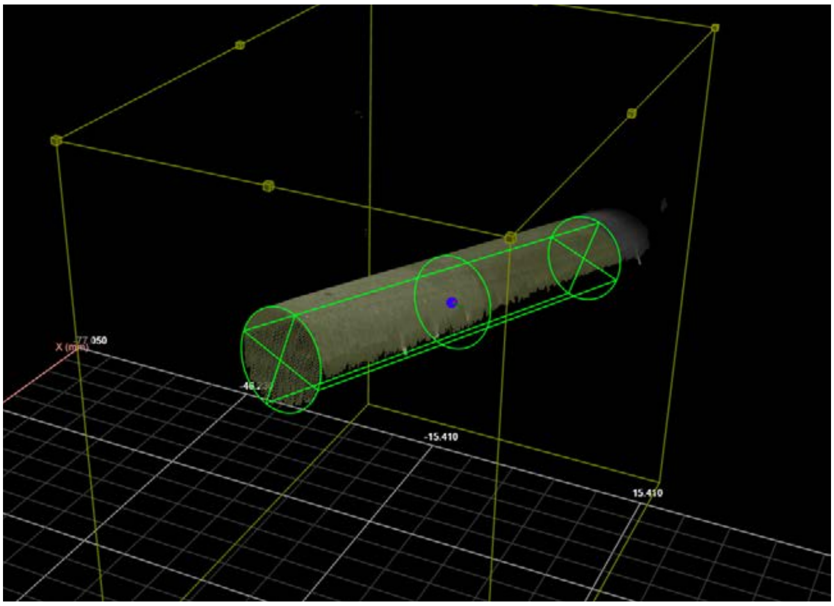
When the larger feature is excluded from the polynomial fitting, the surrounding surface and the smaller features are more properly "flattened."</td></tr>
</table>

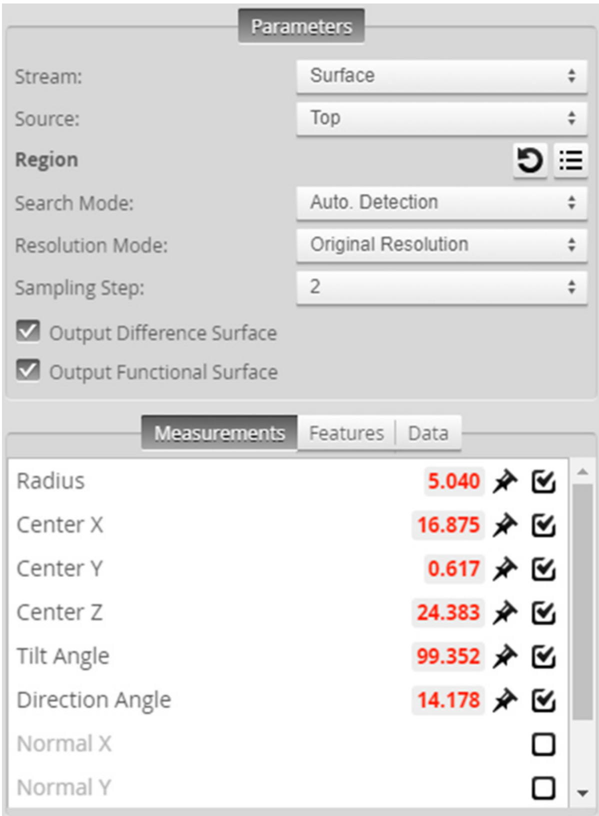
Parameter	Description
	
[Iterative Steps]	The number of times the tool repeats the feature exclusion calculation (see [Exclude Features], above).
[Negative area] [Positive area]	These settings exclude the specified percentage of a histogram of the height values of the scan data from the botom up ([Negative area]) and from the top down ([Positive area]), respectively.
[Number of Regions]	Lets you specify and configure one or more regions that the tool will process. Use this parameter to limit the tool to specific areas on the target.

6.11 Cylinder

Tips
The tool is supported in emulator scenarios.

The Surface Cylinder fits a cylinder to scan data and returns measurements and geometric features related to the fitted cylinder. Unlike the Surface Stud tool, the Surface Cylinder tool does not rely on a flat surface perpendicular to the cylindrical object.





6.11.1 Measurements, Features, and Settings

[Measurements]

Measurement	Description
[Radius]	Returns the radius of the fitted cylinder.
[Center X] [Center Y] [Center Z]	The X, Y, and Z position of the center of a circle place in the middle of the fitted cylinder
[Tilt Angle]	The angle of the cylinder relative to the XY plane. A cylinder parallel to the XY plane has an angle of 90 degrees.
[Direction Angle]	The angle of the cylinder's axis around the Z axis. An angle of 0 degrees is parallel to the X axis.
[Normal X] [Normal Y] [Normal Z]	These measurements return the X, Y, and Z components of the direction vector of the cylindrical target.
[Processing Time]	The time the tool takes to run.

[Features]

Type	Description
[Point]	A point representing the center of a circle at the midpoint of the fitted cylinder
[Line (n)]	A line representing the axis of the fitted cylinder.

[Data]

Type	Description
[Fit Surface]	Displays a surface that is a composite of the fitted cylinder and the original surface.
[Difference Surface]	Displays a surface that is a composite of the fitted cylinder and the original surface.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Search Mode]	Indicates the expected orientation of the cylindrical target's axis around the Z axis. One of the following: Auto Detection – The cylindrical target can be in any orientation. [Processing time] is greater with this search mode. Axis in X Direction / Axis in Y Direction [DR1] – The cylindrical target's axis is expected to be roughly parallel to the X or the Y axis, respectively. Variation typically must be less than +/- 3 or 4 degrees.

Parameter	Description
[Resolution Mode]	Determines whether the tool scales the X or Y resolution so that they are the same (a 1:1 ratio), or leaves the X and Y resolutions as the original. One of the following. • [Optimal (uniform)] Brings the X/Y resolution ratio to 1:1 while preserving the pixel area. Best for random rotation around Z. Provides a balance between the highest and lowest possible resolutions, requiring an average amount of memory and processing time compared to the [High Oriented (uniform)] or [Low Oriented (uniform)] options. • [High Oriented (uniform)] Interpolates the lower resolution to match the higher resolution (between X and Y) in the input. Choose this option when increased resolution is preferred over speed and low memory usage. (This can result in a very high resolution output, creating a lot of data for subsequent tools to process. This can in turn result in slower processing.) • [Low Oriented (uniform)] Decimates the higher resolution to match the lower resolution (between X and Y) in the input. Choose this option when speed and low memory usage is preferred over resolution. (It can result in significant data quality reduction with large Z rotations if the X and Y resolutions of the input are very different.) • [Original Resolution] Keeps the original X and Y resolution of the scan. Use this option only when you expect little or no Z rotation. Otherwise, with X/Y resolution ratios that are not 1:1, large rotation around Z results in severe data quality reduction.
[Sampling Step]	The step in data points in both directions with which the surface is sampled. Choosing a higher sampling step reduces the processing time the tool requires, but reduces fit accuracy. Useful if the surface being processed has a large number of data points.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

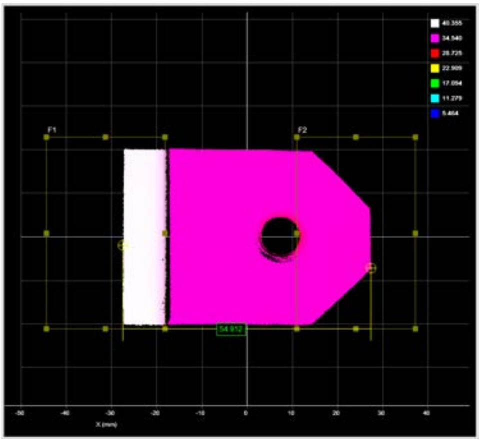
Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

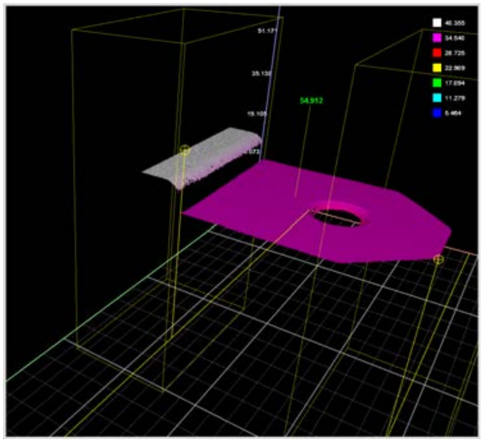
For more information on anchoring, see "●Measurement Anchoring" on page 254.

6.12 Dimension

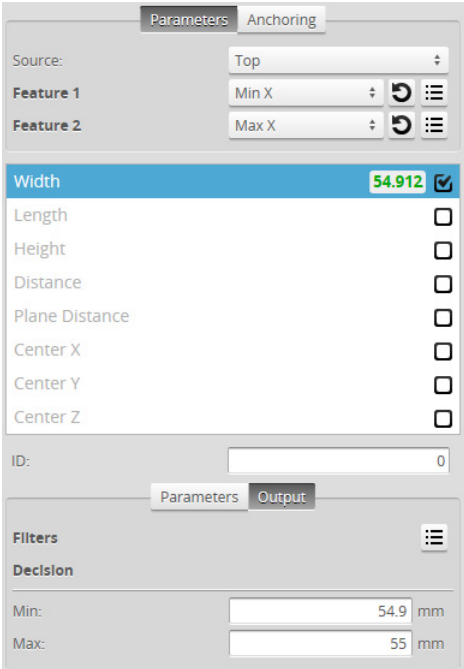
The Dimension tool returns various dimensional measurements of a part. You must specify two feature types. see below.



2D View



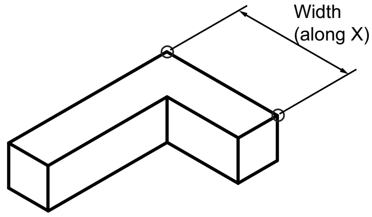
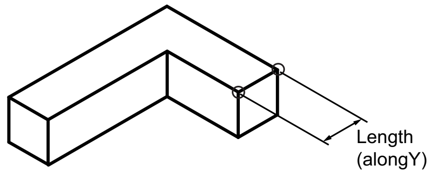
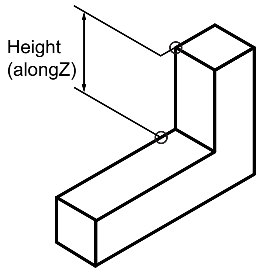
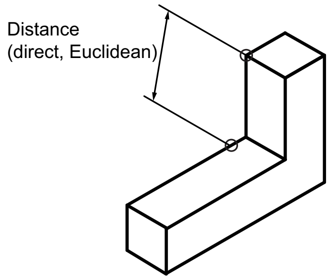
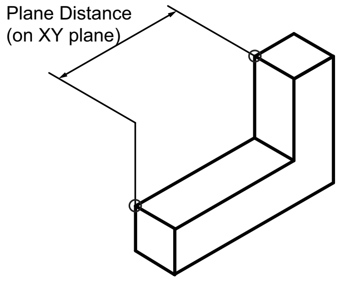
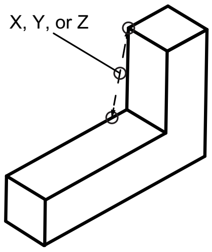
3D View



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

[Measurements]

<table>
<tr><th>Measurement</th><th>Illustration</th></tr>
<tr><td>[Width]
Determines the distance between the selected features along the X axis.</td><td>
</td></tr>
<tr><td>[Length]
Determines the distance between the selected features along the Y axis.</td><td>
</td></tr>
<tr><td>[Height]
Determines the distance between the selected features along the Z axis.</td><td>
</td></tr>
<tr><td>[Distance]
Determines the direct, Euclidean distance between the selected features.</td><td>
</td></tr>
<tr><td>[Plane Distance]
Determines the distance between the selected features. The position of the lowest feature point is projected onto the XY plane of the highest feature point.</td><td>
</td></tr>
<tr><td>[Center X]
Determines the X position of the center point between the selected features.</td><td rowspan="3">
</td></tr>
<tr><td>[Center Y]
Determines the Y position of the center point between the selected features.</td></tr>
<tr><td>[Center Z]
Determines the Z position of the center point between the selected features.</td></tr>
</table>

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Feature 1] [Feature 2]	The Feature 1 and Feature 2 settings represent the two features the tool uses to perform measurements. For each, one of the following: • [Average] • [Median] • [Centroid] • [Max X] • [Min X] • [Max Y] • [Min Y] • [Max Z] • [Min Z] To set the region of a feature, adjust it graphically in the data viewer, or expand the feature using the expand button (⁝☰) and enter the values in the fields. For more information on regions, see 📖 "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

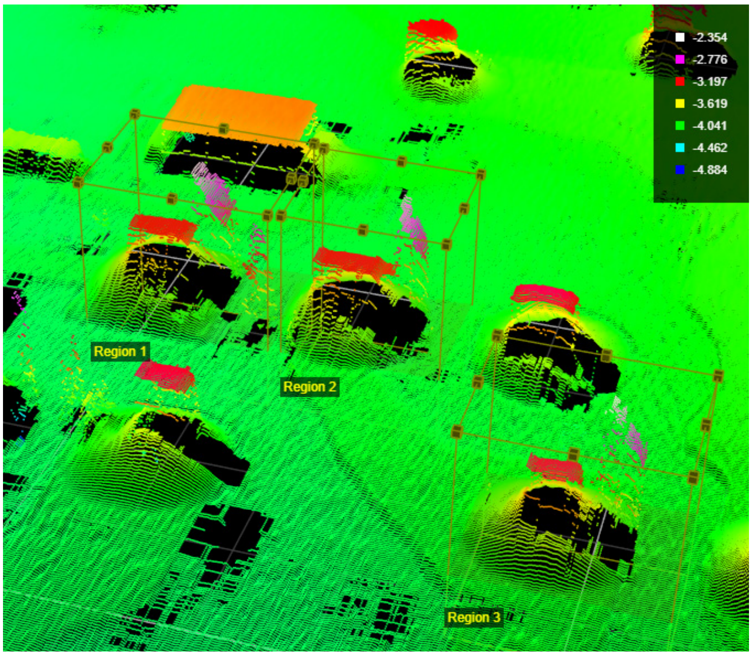
6.13 Direction Filter

Tips

The tool is supported in emulator scenarios.

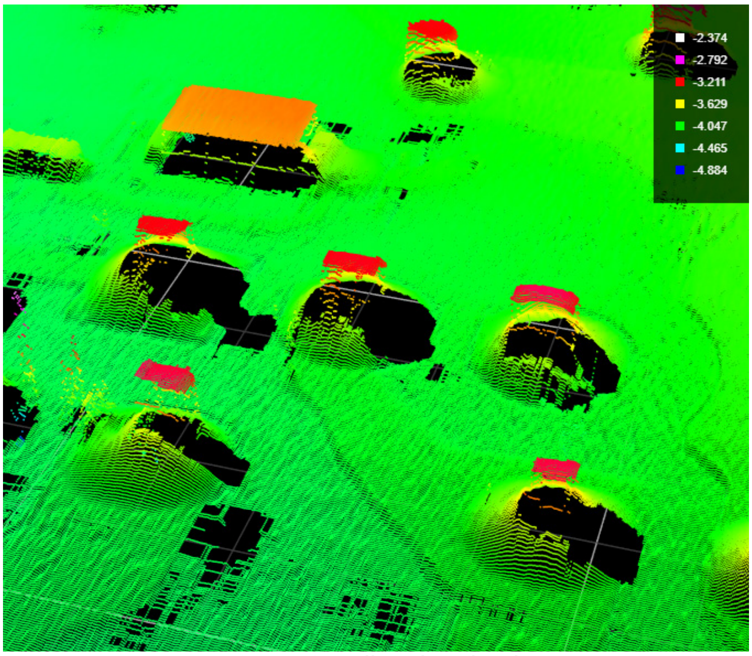
The Surface Direction Filter helps exclude unwanted data points based on their “orientation” (relative to surrounding data points) in 3D space, for example, data points resulting from reflections. The tool can provide better results than median or height based filters. The tool lets you define up to 16 regions, and for each region, configure the characteristics of the data points to exclude.

For example, in the following scan data, noise (in pink) appears to the right of three surface mount components on a PCB. In this case, the "direction" (specifically, the polar angle) of the noise is roughly 75 to 85 degrees, relative to Z.

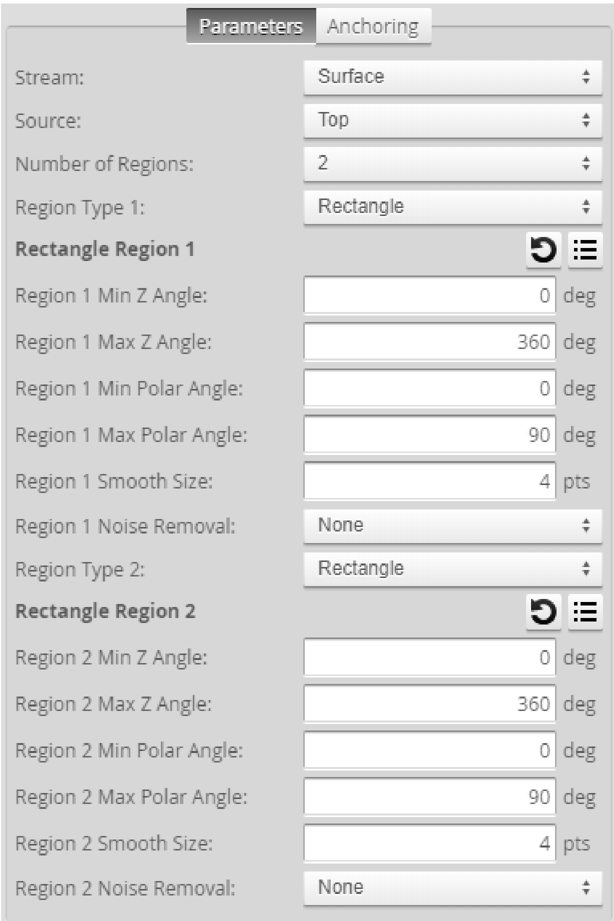


Surface before direction filtering.

In the following scan data, the tool has removed the noise.



Surface after direction filtering.



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.13.1 Measurements, Data, and Settings

[Measurements]

Measurement	Description
[Processing Time]	
The amount of time the tool takes to process.	

[Data]

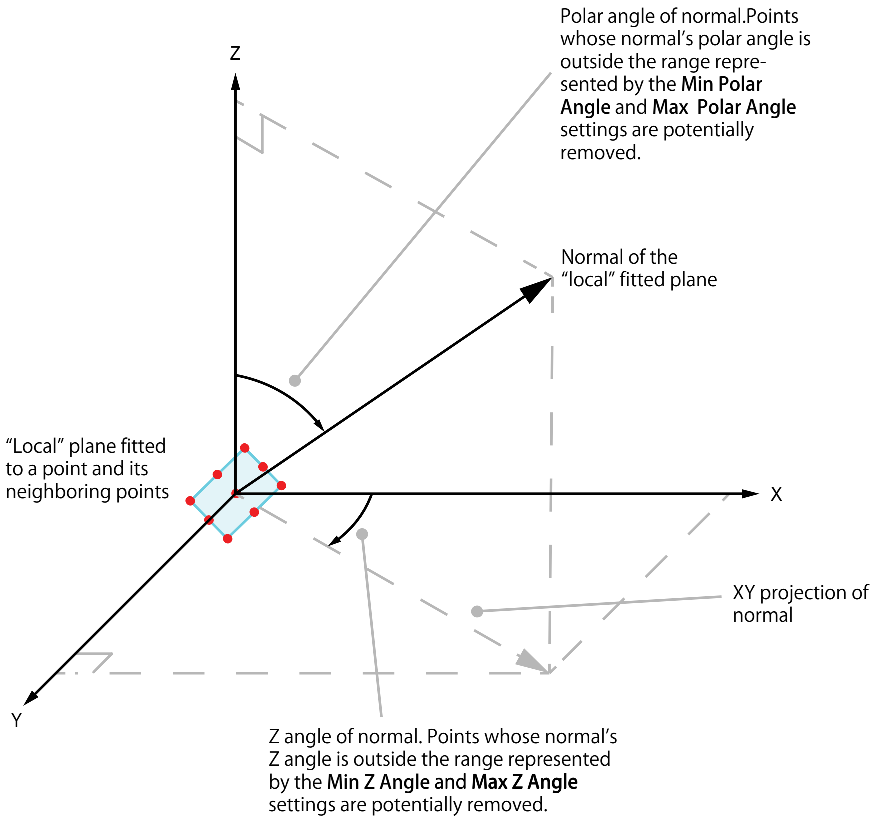
Type	Description
[Filtered Surface]	The surface after filtering.

[Parameters]

Parameter	Description
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool. If you switch from one type of data to another (for example, from section profile data to surface data), currently set input features will become invalid, and you will need to choose features of the correct data type.
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Region Count]	The number of regions the tool applies filtering to. See the parameters below in this table.
[Region {n}]	Lets you configure the size and position of region {n}. See the parameters below in this table. For the region-specific parameters, see 📖 "[Region Filtering Parameters]" on page 487.
[Number of Regions] [Region Type {n}] [Inner Circle Diameter] [Inner Ellipse Major Axis] [Inner Ellipse Minor Axis] [Sector Start Angle] [Sector Angle Range] [Mask Source] [Low Threshold] [High Threshold]	Only displayed on newer instances of this tool. For details on flexible regions and their settings, see 📖 "• Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see 📖 "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

The following illustrates the angle parameters that control which data points are excluded in scan data.

See 📖 "[Region Filtering Parameters]" on page 487.



The number of neighboring points shown above is for illustrative purposes only.

[Region Filtering Parameters]

[Region {n} Min Z Angle] [Region {n} Max Z Angle]	The minimum and maximum acceptable angles around the Z axis of the XY projection of the normal of the surface surrounding a data point, where 0 degrees is defined as positive X and positive rotation is clockwise around the Z axis.
[Region {n} Min Polar Angle] [Region {n} Max Polar Angle]	The minimum and maximum acceptable angles of the normal of the surface surrounding a data point with respect to the Z axis.
[Region {n} Smooth Size]	A mean filter applied to the surface data before calculating the normals in order to avoid abrupt normal changes due to noise.
[Region {n} Noise Removal]	Eliminates noise that can be introduced by the tool's normal calculation.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

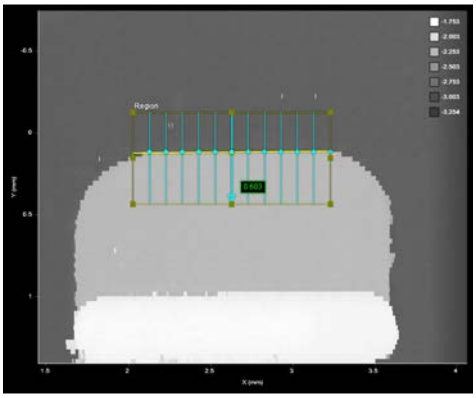
6.14 Edge

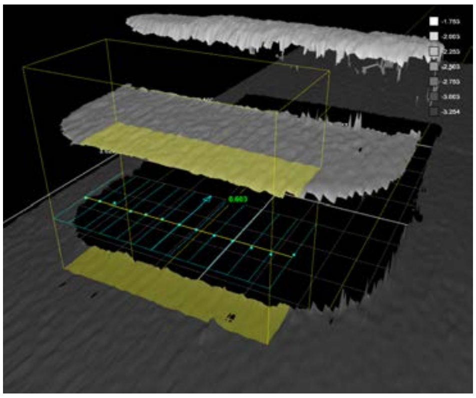
The Edge tool fits a line to a straight edge in the scan data, using either height map or intensity data. The tool can search for an edge using either a step (an abrupt change in the data) or a corner (a contiguous change in the shape of surface). The tool's settings help fit the line when multiple potential edges are in the region of interest. After the tool locates an edge, it returns the position (X, Y, and Z) of the center of the edge line in the region of interest. The tool also returns its angle around the Z axis, the step height between the upper and lower surfaces adjacent to the edge, minimum and maximum error points to either side of the line, and a point count.

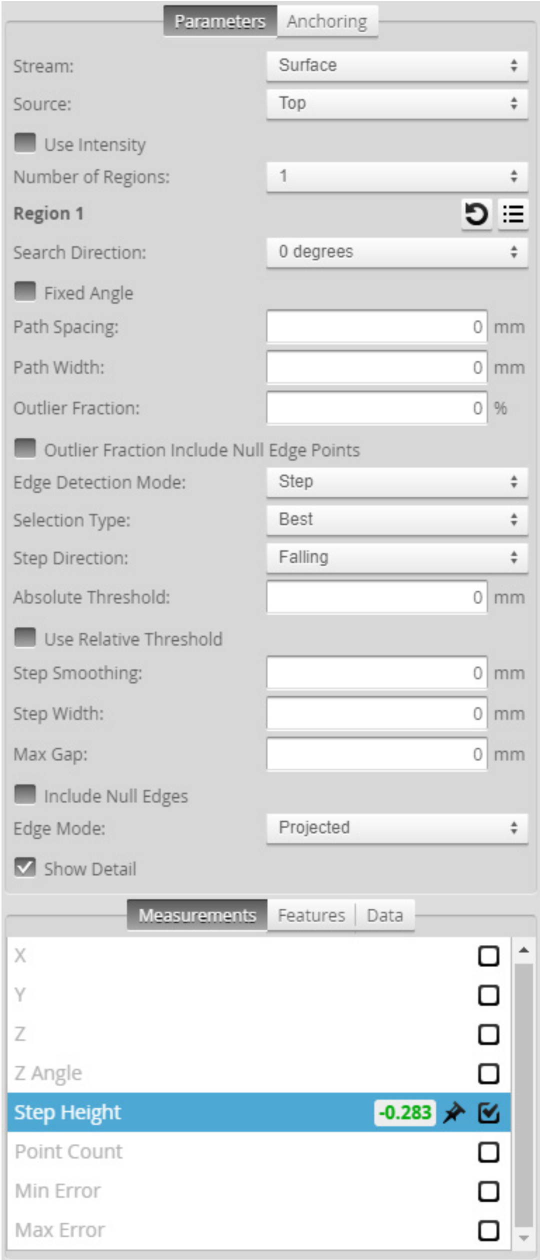
You can use the Z Angle measurement of the edge line with some tools to perform angle anchoring, compensating for minor part rotations around the Z axis, greatly increasing repeatability between part scans; for more information see 📖 "●Measurement Anchoring" on page 254.

The minimum and maximum errors are useful for calculating a straightness value (using a script tool, for example; for more information, see 📖 "6.38 Script" on page 625).

The tool can also generate edge line and center point geometric features that Feature tools can take as input for measurement. For more information on Feature tools, see 📖 "4.7.9 Feature Measurement" on page 301.


2D View


3D View

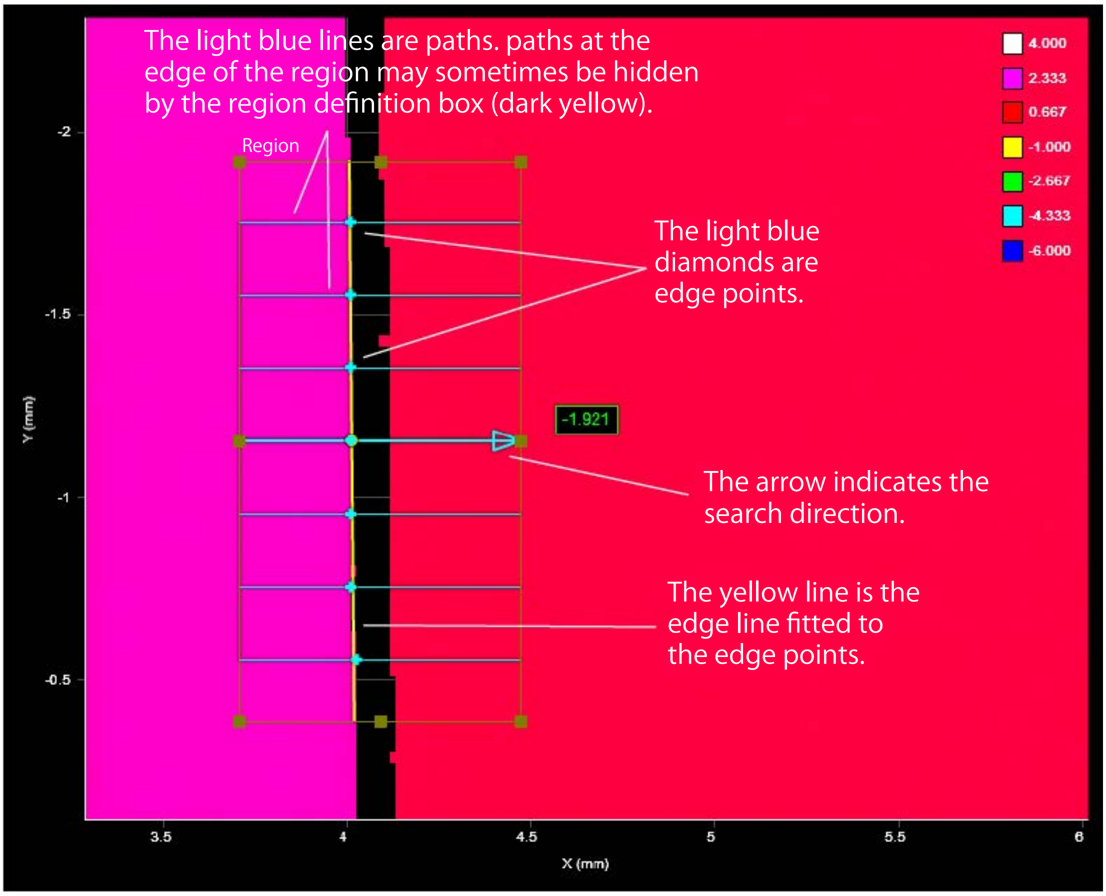


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

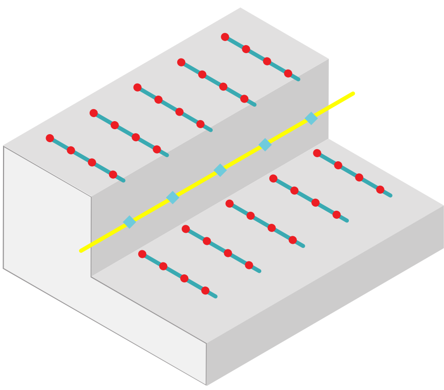
6.14.1 Paths and Path Profiles

To fit an edge line to the scan data, the Surface Edge tool overlays evenly spaced, parallel paths (light blue lines in the interface; see below) in the defined region of interest.

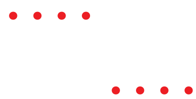


For each path, a profile is generated internally from the height map's data points that fall under or, optionally, near the path. The tool then examines each path profile for steps (changes in height) that meet the criteria set by the tool's settings, such as minimum height, direction (whether it is rising or falling), and so on.

Red dots are data points from the scan data that fall under paths(light blue lines).



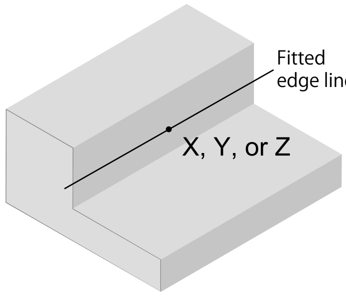
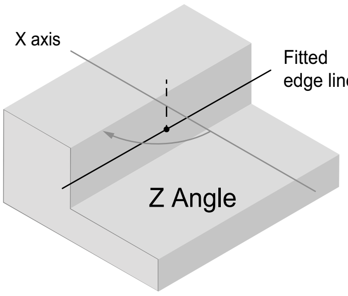
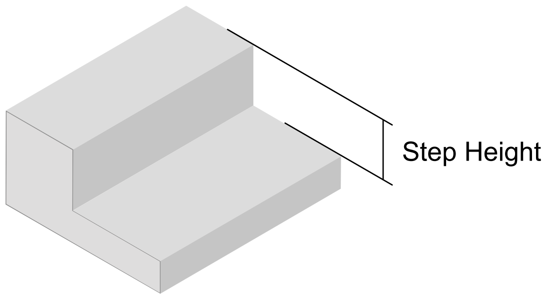
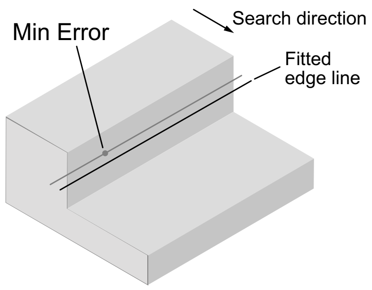
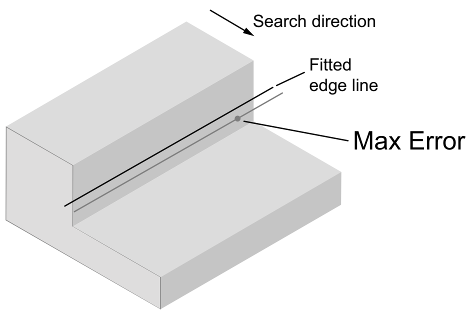
A single path profile extracted from a path.

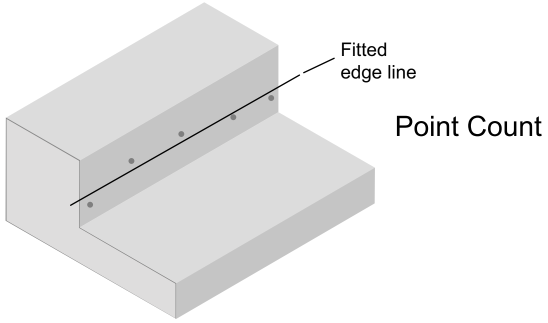


For the step on each path profile that matches the settings, the tool places an edge point between the upper and lower area (light blue diamonds in the interface). The tool then fits a line to those edge points (yellow line in the interface). You can choose the orientation of the paths around the Z axis to accommodate different edge orientations.

6.14.2 Measurements, Features, Data, and Settings

[Measurements]

Measurement	Illustration
[X] Returns the X position of the center point of the fitted edge line.	
[Y] Returns the Y position of the center point of the fitted edge line.	
[Z] Returns the Z position of the center point of the fitted edge line.	
[Z Angle] Returns the rotation, around the Z axis, of the fitted edge line. Rotating the measurement region has no impact on the angle that is returned unless a different edge is detected. Useful for using minor variations in the rotation of an edge on target as an anchor for other measurements. For more information, see 📖 "●Measurement Anchoring" on page 254.	
[Step Height] Returns the height of the step, calculated by averaging the step heights of all of the path profiles. (When [Use Intensity] is enabled, the value returned is the difference in intensity.) This measurement returns Invalid when [Edge Detection Mode] is set to Corner.	
[Min Error[[Max Error] These measurements return the distances of the point furthest before the line (Min Error) and the point furthest after the line (Max Error), based on the search direction specified in the tool. The measurements ignore points excluded using the	

Measurement	Illustration
[Point Count] The number of points used to fit the line. Useful for determining if the number of points is above an acceptable minimum.	

[Features]

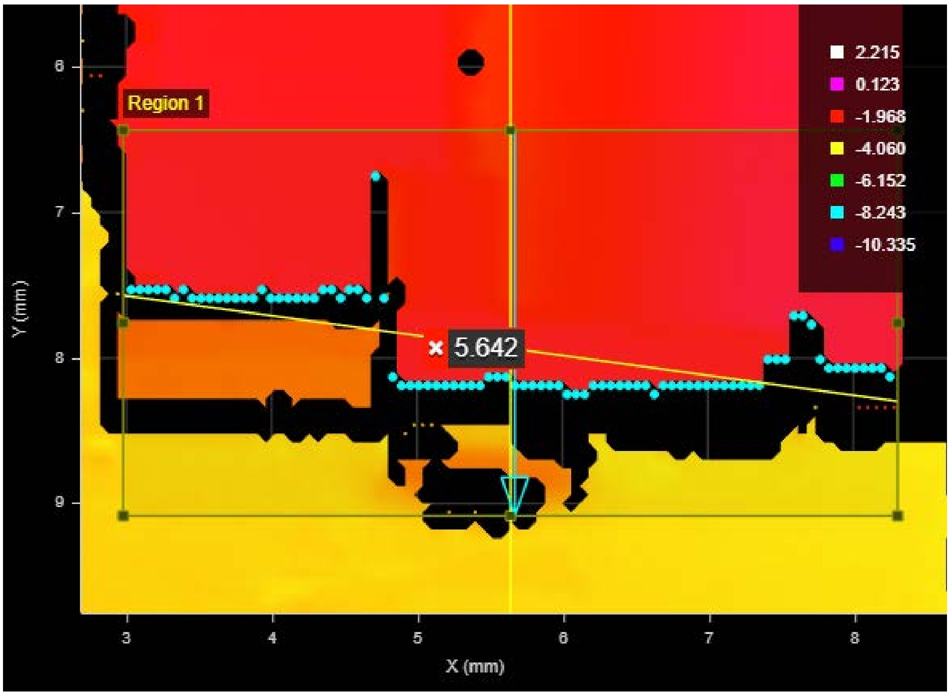
Type	Description
[Edge Line]	The fitted edge line.
[Center Point]	The intersection point of the fitted edge line and the line representing the search direction through the center of the region of interest.
[Edge Plane]	A plane on the XZ axes at the fitted edge line.

Tips

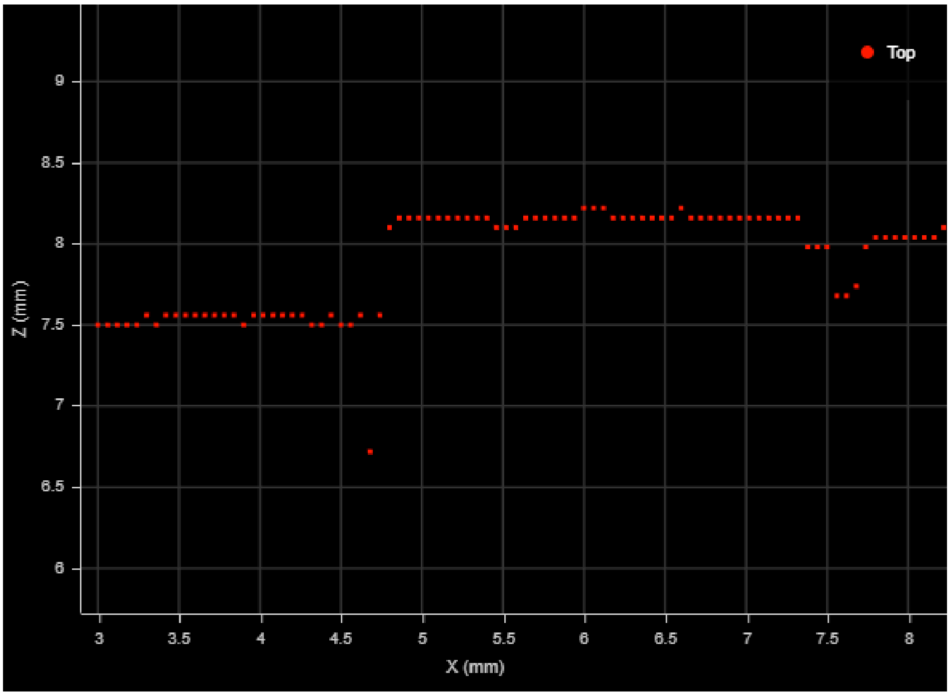
For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Data]

<table>
<tr><th>Type</th><th>Description</th></tr>
<tr><td>[Profile Point Cloud]
[Profile Region {n}]</td><td>A point cloud profile (Profile Point Cloud) and one or more uniform spacing profiles (Profile Region {n}) representing the edge, respectively, made up of the tool's edge points. The XY positions of the edge points on the surface (cyan dots below) are represented as the XZ positions of the profile points, where X => X and Y => Z.
Given the following edge, the resulting profile is shown further below:



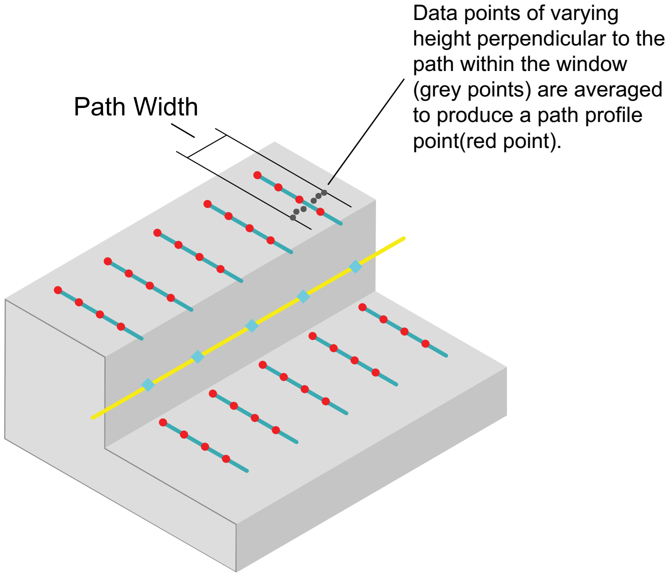
The profile is mirrored vertically when compared to the edge: Note how the single edge point toward the top of Region 1 in the surface data above is at the bottom of the extracted profile (below).



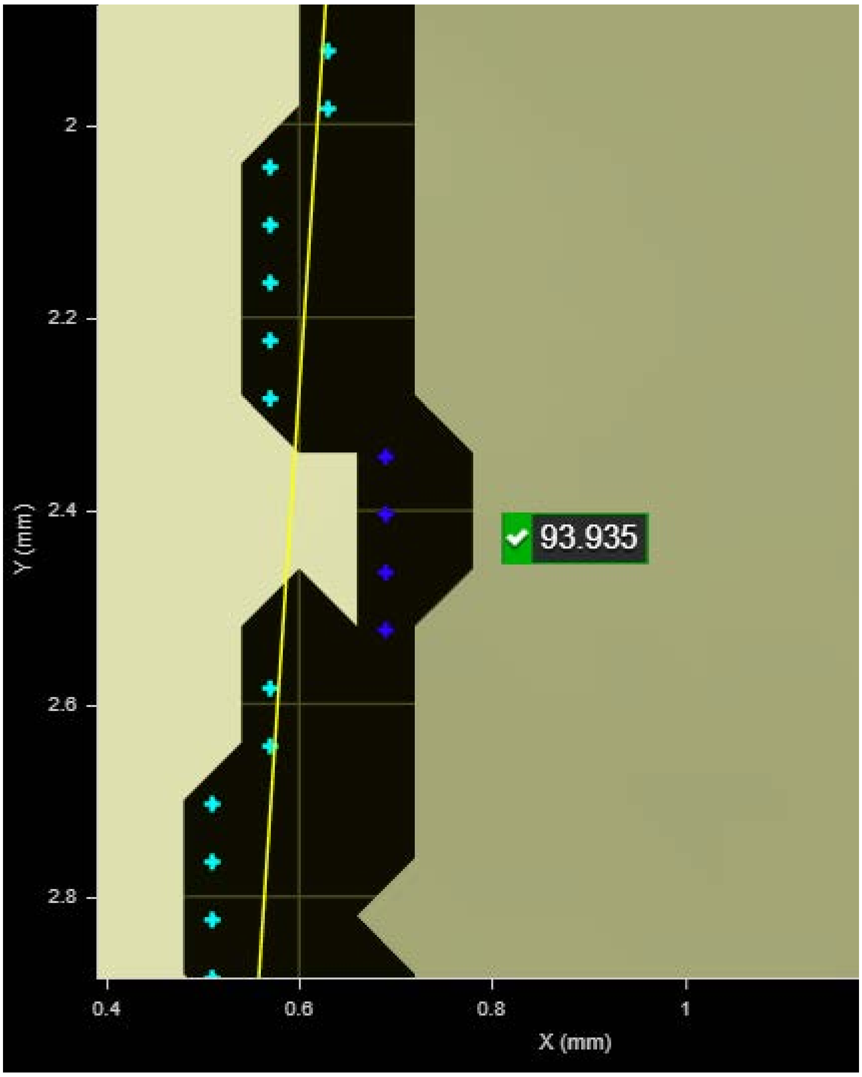
</td></tr>
</table>

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
Number of Regions	The number of regions the tool will use to fit the line. You must configure each region (see "[Region Type {n}]" on page 512). Using multiple regions allows you to fit a line to an edge that is not straight along its entire length or that is not continuous.
[Region {n}]	The region or regions the tool uses to fit a line. For more information, see "●Regions" on page 238. The [Search Direction] setting applies to all of the regions. You can configure the [Z Angle] of each region independently to accommodate the particularities of the feature or target (for example, to exclude unwanted scan data next to one of the regions in the fitting of the line to the edge).
[Search Direction]	The search direction for steps, specified as an orientation around the Z axis, relative to the X axis. Can be 0, 90, 180, or 270 degrees. Choose a value that is roughly perpendicular to the edge on the target. The direction is indicated by a light blue arrow in the data viewer.
[Fixed Angle]	When this option is enabled, the value in [Fixed Angle Value] replaces the value the Z Angle measurement returns. Useful when the angle of the feature is known and noise in the scan data could otherwise cause the measurement to return an incorrect angle.
[Fixed Angle Value]	The value the tool uses to locate the edge and returns for the Z Angle measurement. You must enable [Fixed Angle] to set this value.
[Path Spacing]	Sets the spacing between paths in the measurement region used to extract the profiles that determine the edge. A higher number of paths results in a higher number of edge points, which makes the fitting of the edge line more accurate. However, a higher number of edge points results in a greater tool execution time. When [Path Spacing] is set to 0, the resolution of the scan data is used as the basis for spacing. No paths are displayed in the data viewer in this case.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Path Width]</td><td>The size of the windows perpendicular to the path used to calculate an average for each data point on a path profile. Useful to average out noise along the path caused by reflections, and so on.


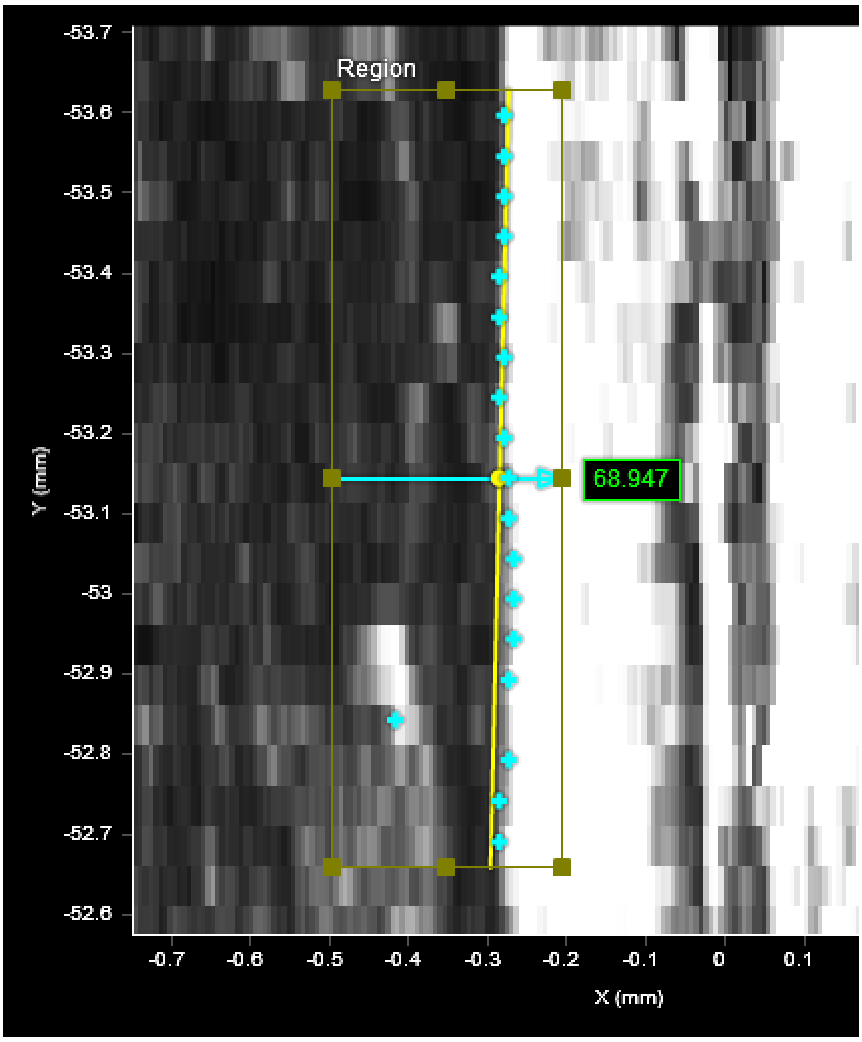
If [Path Width] is set to 0, no averaging is performed (only the data point under the path is used).
For averaging along the path, use [Step Smoothing] (see below).</td></tr>
</table>

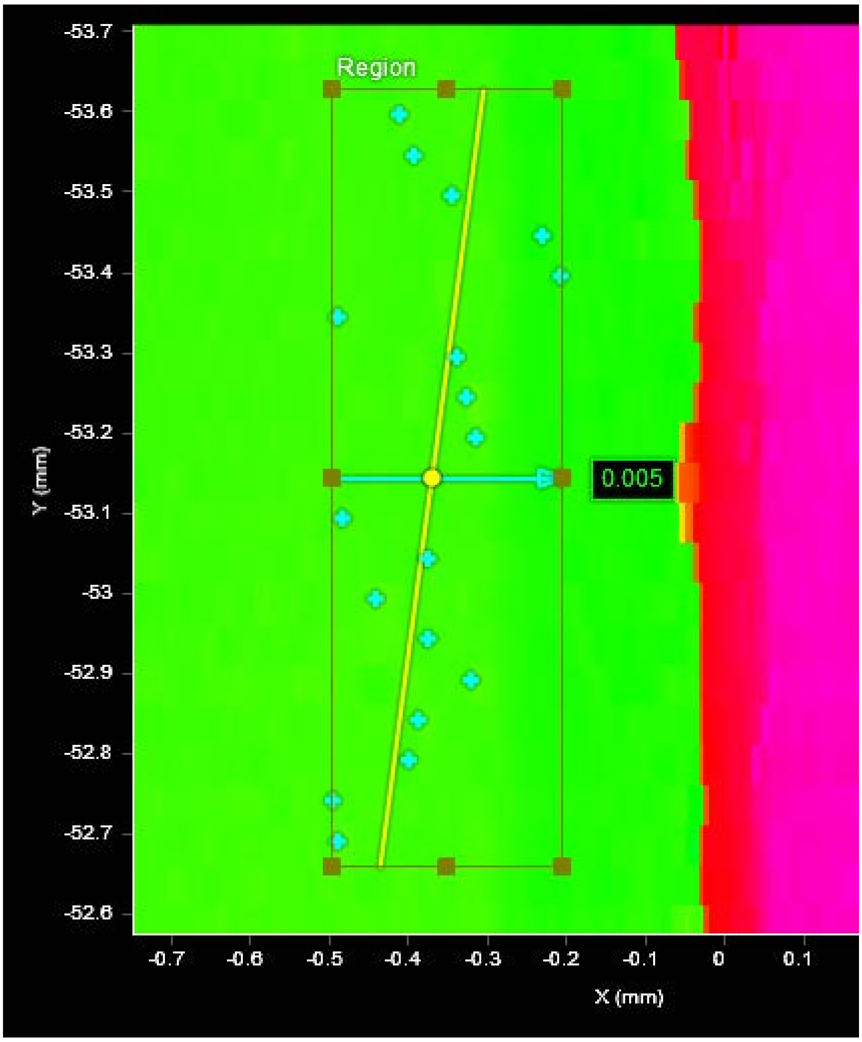
Parameter	Description
[Outlier Fraction]	The percentage of outlier points to exclude. Setting this to a small value can help the tool fit the line better to the edge.  [Outlier Fraction] set to a low value: rejected outlier edge points are dark blue.
[Edge Detection Mode]	One of the following: Step or Corner. [Step]: Searches for steps on each path profile. For additional settings when you choose this mode, see "Step Edge Detection Mode Parameters" on page 498. [Corner]: Searches for slopes on each path profile. When you choose this mode, several of the tool's parameters are hidden.

Parameter	Description
[Selection Type] [Corner Type]	Determines which step (when [Edge Detection Mode] is set to Step) or corner (when [Edge Detection Mode] is set to Corner) the tool uses on each path profile when there are multiple steps or corners in the profile. An edge point is placed on each chosen step or corner. Steps must pass the criteria of the tool's [Absolute Threshold], [Step Direction], and [Relative Threshold] settings (see 📖 "Step Edge Detection Mode Parameters" on page 498). [Best]: Selects the greatest step or corner on each path profile. [First]: Selects the first step or corner on each path profile. [Last]: Selects the last step or corner on each path profile. When [Edge Detection Mode] is set to Corner, the following additional options are available in Corner Type: [Top]: Selects the top-most corner on each path profile. [Bottom]: Selects the bottom-most corner on each path profile.
[Show Detail]	When disabled, hides the light blue path lines and edge points.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

The following parameters are only displayed if you set [Edge Detection Mode] to Step.

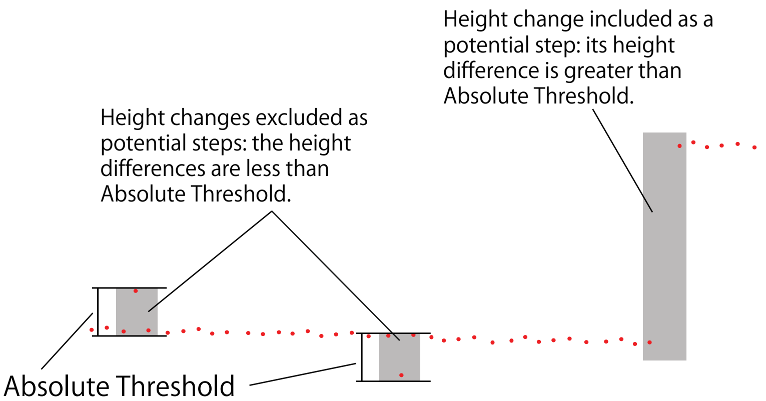
Step Edge Detection Mode Parameters

[Use Intensity]	(This setting is only available when [Acquire Intensity] is enabled in the [Scan Mode] panel; for more information, see "4.4.2 Scan Modes" on page 116.) Uses intensity data rather than height data to find an edge. Useful when color differences on a flat area of a target, which would not be detected using height map data, are distinct, letting you use the detected "line" as an anchor source or perform geometric feature measurements.  [Use Intensity] enabled (intensity view): Surface Edge tool finds the edge using intensity data

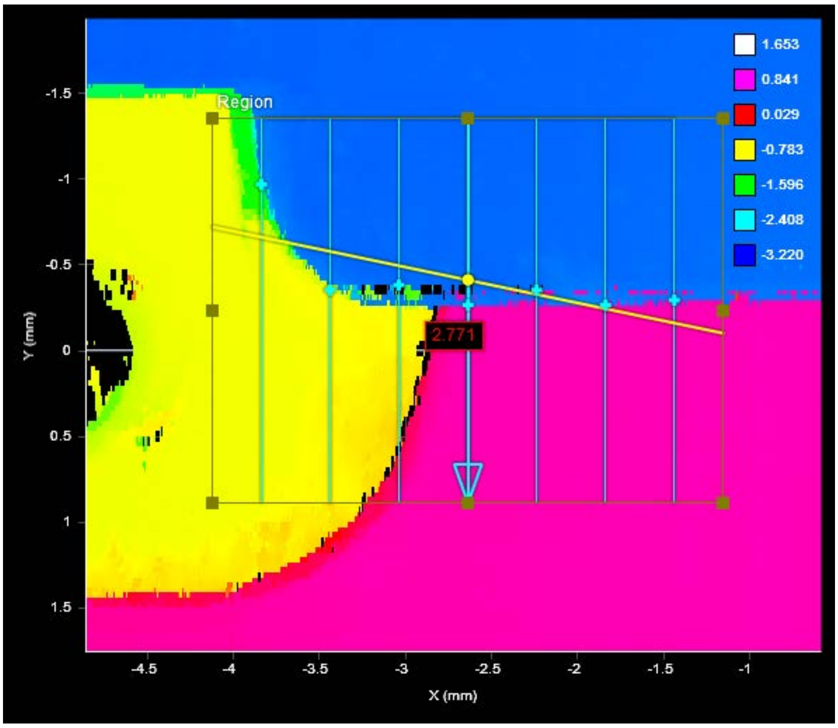
	 [Use Intensity] disabled (heightmap view of the same area): Surface Edge tool unable to find edge using height data.
[Step Direction]	Determines whether the expected step rises or falls along the path. Either [Rising], [Falling], or [Rising] or [Falling].

<table>
<tr>
<td>[Absolute Threshold]</td>
<td>
When [Use Intensity] is disabled, the setting specifies the minimum height difference between points on a path profile for that step to be considered for an edge point.

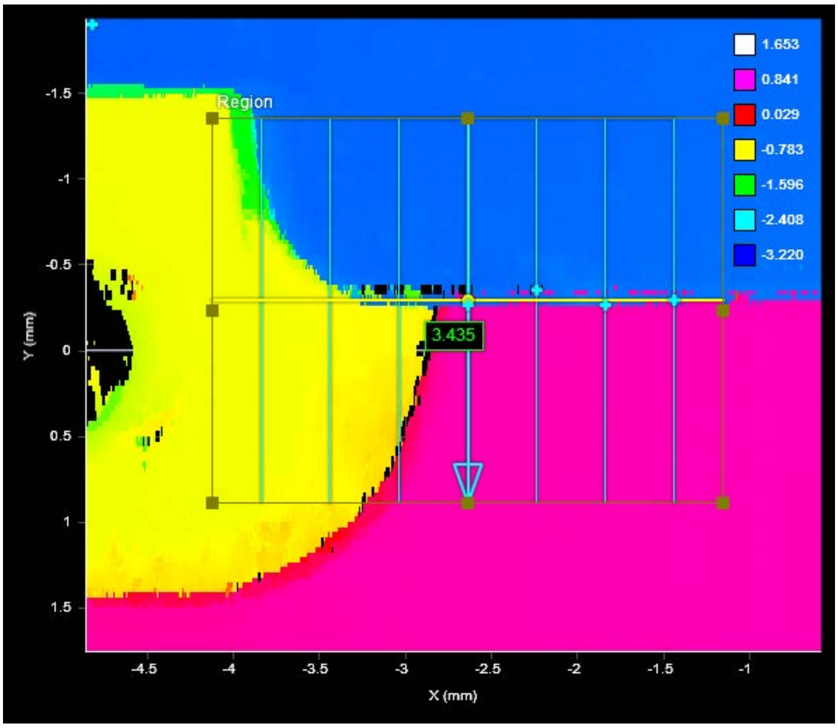
The setting can be used to exclude smaller steps on a part that should not be considered for an edge, or to exclude height differences caused by noise. When used in conjunction with [Relative Threshold], [Absolute Threshold] is typically set to a small value, greater than the general surface roughness.

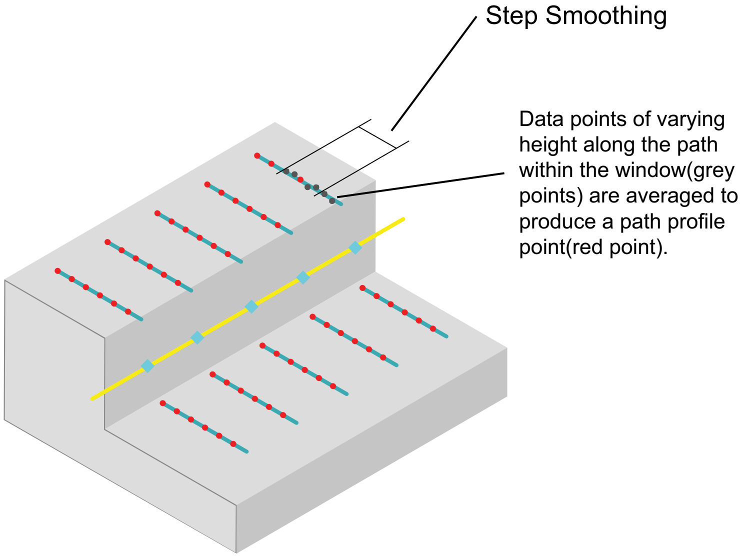
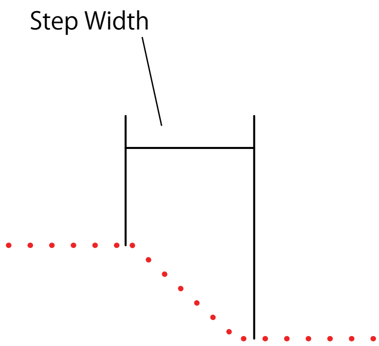


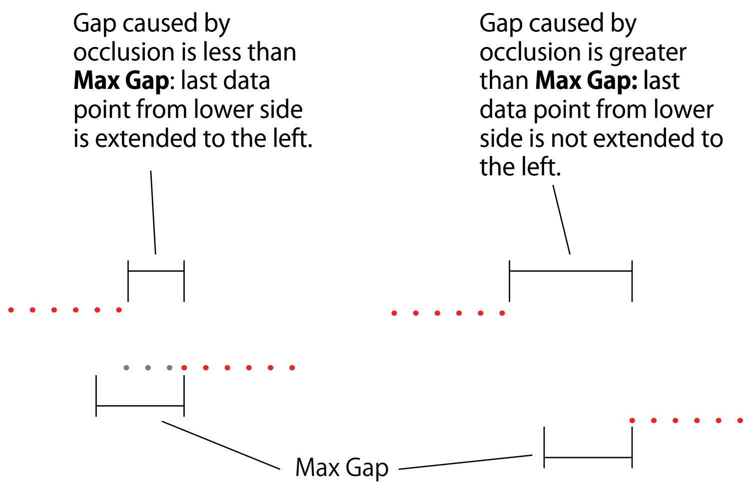
In the image below, when [Absolute Threshold] is left at the default of 0, all steps are included as possible candidates for an edge, and will be used to fit an edge line. The resulting edge line is angled upward to the left.

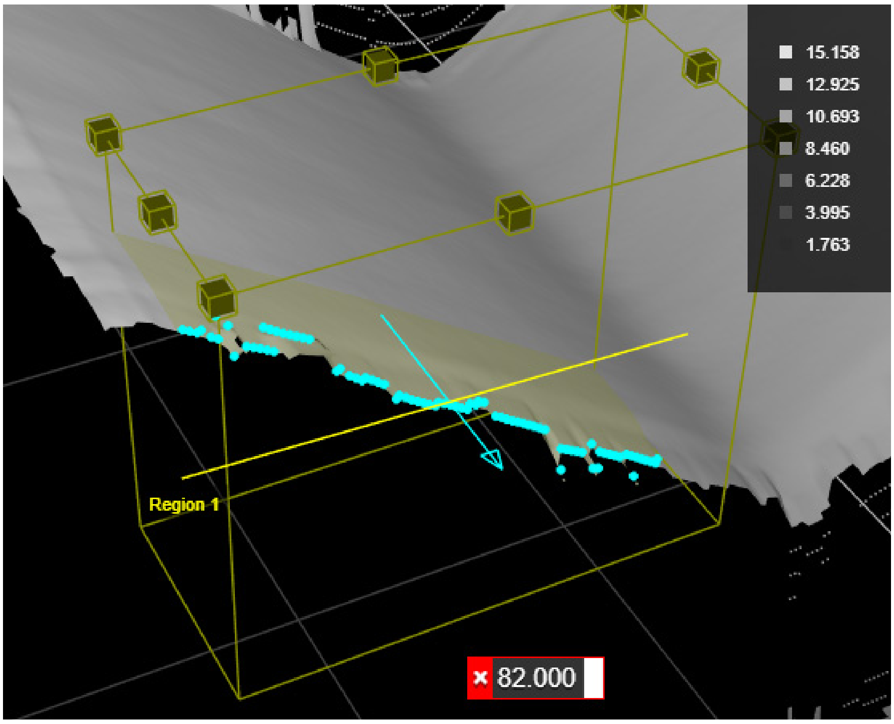


When [Absolute Threshold] is set to 3 with the same data (see image below), steps going from the yellow to pink regions (roughly 1.37 mm) and from the blue to yellow regions (roughly 2 mm) are excluded. Only steps from the blue to pink regions (roughly 3 mm) are included.
</td>
</tr>
</table>

	 When [Use Intensity] is enabled, the setting specifies the minimum difference in intensity. ([Acquire Intensity] must enabled in the Scan Mode panel.)
[Use Relative Threshold]	When this option is enabled, the [Relative Threshold] field is displayed.
[Relative Threshold]	The value for the relative threshold. The tool calculates a relative threshold by scaling the greatest height or intensity difference found on the path profiles by the percentage in Relative Threshold. This lets you configure the tool without knowing the actual step height in advance, and is useful for edges with varying step height. For a height or intensity difference to be considered a valid step, both [Absolute Threshold] and [Relative Threshold] must pass.

[Step Smoothing]	The size of the windows along the path used to calculate an average for each data point on a path profile. The setting is useful for averaging out noise.  If [Step Smoothing] is set to 0, no averaging is performed (only the data point under the path is used). For averaging perpendicular to the path, use [Path Width] (see above).
[Step Width]	The distance, along a path profile, separating the points used to find steps on a path profile.  The setting is useful when you must detect a slope as an edge, rather than a sharply defined edge: setting [Step Width] to a value greater than the width of the edge ensures that the tool measures the height difference between the flat regions on either side of the edge. As a result, the height of the step is accurately measured, and the edge is correctly located. **Tips** Setting [Step Width] wider than necessary can reduce the precision of edge location.

<table>
<tr><td>[Max Gap]</td><td>Fills in regions of missing data caused by an occlusion near the desired edge. Use this setting when continuity on the target is expected. When [Max Gap] is set to a non-zero value, the tool holds and extends the last data point on the low side next to an edge across a gap of null points, up to the distance specified in [Max Gap].

</td></tr>
<tr><td>[Include Null Edges]</td><td>Indicates whether null points (points where no height or intensity value is available, due to dropouts or regions outside of the measurement range) are filled with the value in [Null Fill Value] as a general “background level.” If [Use Intensity] (see above) is enabled, the intensity value in [Intensity Null Fill Value] is also used.
A typical example is a discrete part produced by part detection of an object sitting on a flat background. The background is not visible in the part, so the tool assumes that any null region are at the background level.
Tips
To find edges along a region of null points, you must use either this option and an appropriate value in [Null Fill Value] (and [Intensity Null Fill Value] if [Use Intensity] is enabled) or [Max Gap]. Otherwise, only edges within areas of contiguous data will be detected.</td></tr>
<tr><td>[Null Fill Value]</td><td>The height value (in mm) used to replace null points not filled by [Max Gap] when [Include Null Edges] is enabled.</td></tr>
<tr><td>[Intensity Null Fill Value]</td><td>The intensity value (0-255) used to replace null points when [Include Null Edges] and [Use Intensity] are enabled.</td></tr>
</table>

[Edge Mode]	One of the following: [Projected]: The line fitted to the edge is projected onto the XY plane. This mode is typically used with an edge that is parallel to the XY plane. (Shown on a sloped edge to illustrate its effect.)  [3D]: The line fitted to the edge follows the slope of the edge. This mode is typically used with a sloped edge.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

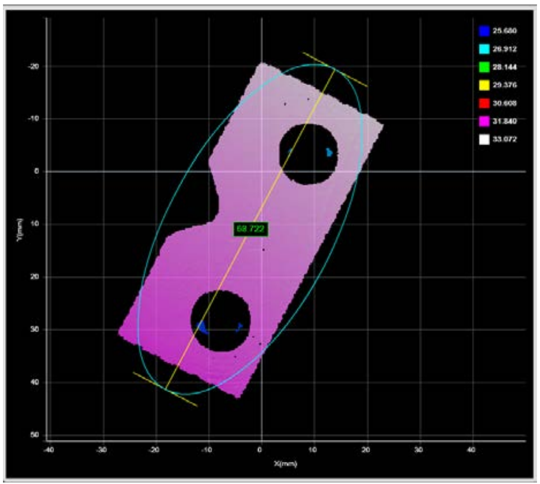
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

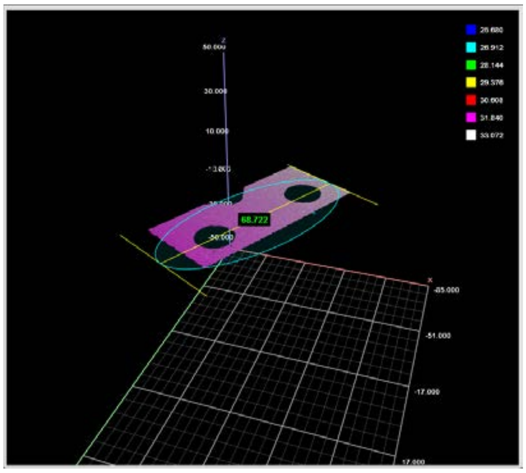
6.15 Ellipse

The Ellipse tool provides measurements for the major and minor axis lengths of an ellipse roughly aligned to the part's shape in the XY plane, and also for the ratio of the major and minor axis lengths and for the orientation angle of the ellipse. The tool is typically used to find the general orientation of a part, for example, potatoes on a conveyor that are longer in one dimension than the other.

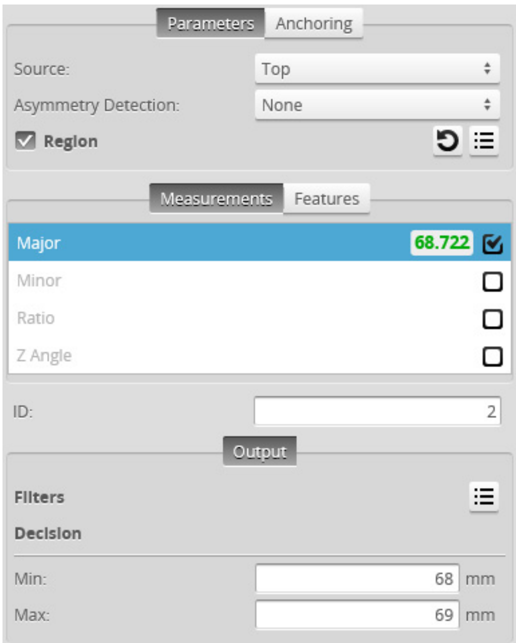
Note that the ellipse fit is not the minimum area ellipse around the data. (Technically, it is the ellipse with matching moments as the data.) For surfaces with no holes, this results in an ellipse approximately the same size and orientation of the part. But for surfaces with holes, the resulting ellipse can be larger than the part.



2D View



3D View

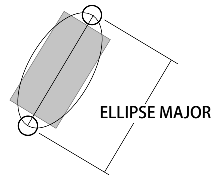
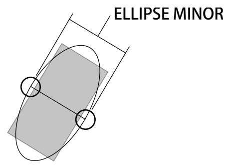
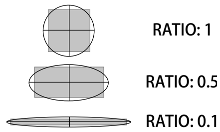
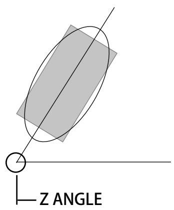


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.15.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Major] Determines the major axis length of an ellipse fitted to the part's area in the XY plane.	
[Minor] Determines the minor axis length of an ellipse fitted to the part's area in the XY plane.	
[Ratio] Determines the minor/major axis ratio of an ellipse fitted to the part's area in the XY plane.	
[Z Angle] Determines the orientation angle of an ellipse fitted to the part's area in the XY plane.	

[Features]

Type	Description
[Center Point]	The center point of the fitted ellipse.
[Major Axis]	A line representing the major axis of the fitted ellipse.
[Minor Axis]	A line representing the minor axis of the fitted ellipse.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Asymmetry Detection]	Resolves the orientation of an object over 360 degrees. The possible values are: 0: None 1: Along Major Axis 2: Along Minor Axis

Parameter	Description
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

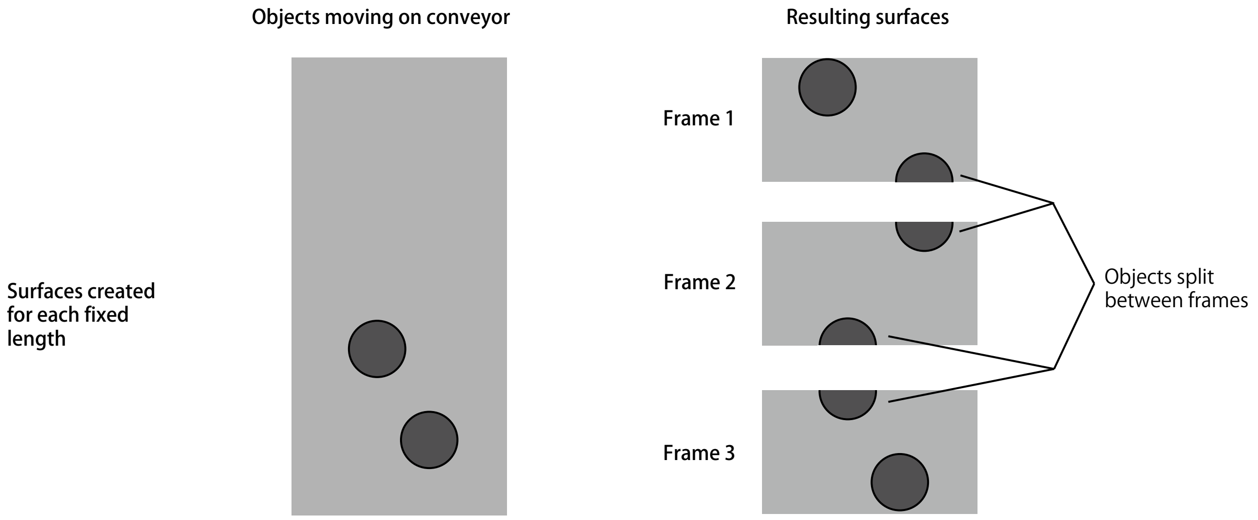
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

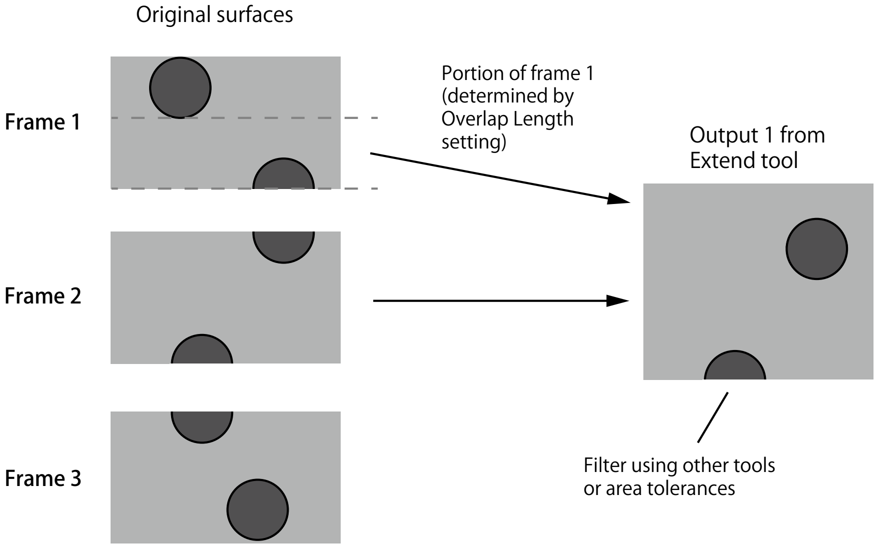
6.16 Extend

Tips
The tool is supported in emulator scenarios.

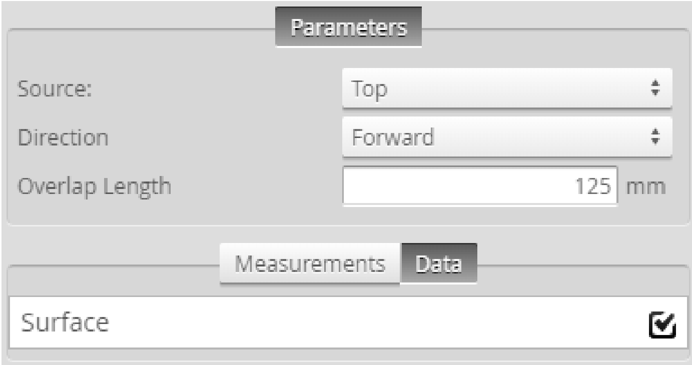
The Extend tool creates a new surface by appending part of the previous frame's data to the current frame's data. The tool outputs the new surface data, which can be used as input by other tools. The tool is especially useful when scans are performed using fixed length surface generation, where parts might be split between two frames. (For more information on surface generation, see "4.4.6 Surface Generation" on page 146.)



The following shows how the tool combines data:



Data is only appended in one direction. Partial objects in the resulting surface output from the tool must be filtered out using downstream tools, for example, excluding them based on the expected area.



Measurement Panel

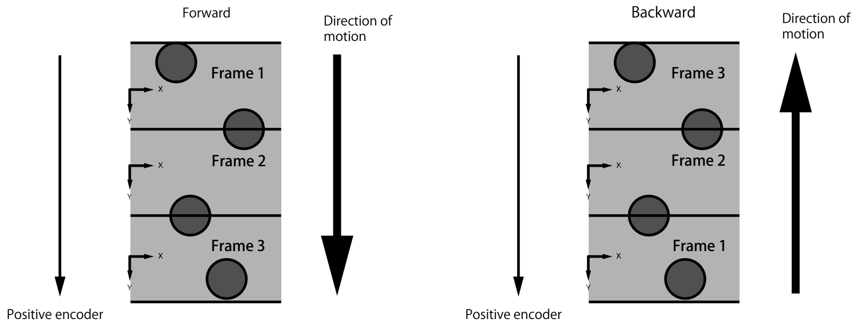
For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.16.1 Data and Settings

[Data]

Type	Description
[Extended Surface]	Data containing an extended surface, available for use as input in the [Stream] drop-down in other tools.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Direction]	Determines whether the previous frame's data is appended above or below the current frame's data.  One of the following. Note that these settings depend on whether the trigger source has been set to Encoder (see 📖 "■Trigger Settings" on page 120). • [Auto]: Choose this when Encoder is selected as the trigger source, in which case the tool will know the direction of travel relative to encoder increase / decrease. • [Forward]: Choose this when the trigger source is not set to Encoder and the direction of motion is the same as the increase of the encoder. • [Backward]: Choose this option when the trigger source is not set to Encoder and the direction of motion is the opposite of the increase of the encoder.
[Overlap Length]	The amount, in millimeters, of the previous frame's data to append to the current frame's data. The combination will be output as tool data. Choose the overlap length to accommodate the size of your scan targets.

Parameter	Description
[Mode]	Determines the mode of the tool. One of the following: • [Normal]: The tool automatically chooses this operation after you have chosen another operation. • [Lock]: Lets you lock the current processing and outputs of the tool. Useful when you need to add another tool that will use this tool's output (for example, a Surface Section tool). If you do not lock the tool, as soon as you add the other tool, the output is cleared, which means you must re-execute the combined output again to configure the additional tool. Be sure to unlock the tool after you have configured any other tools.

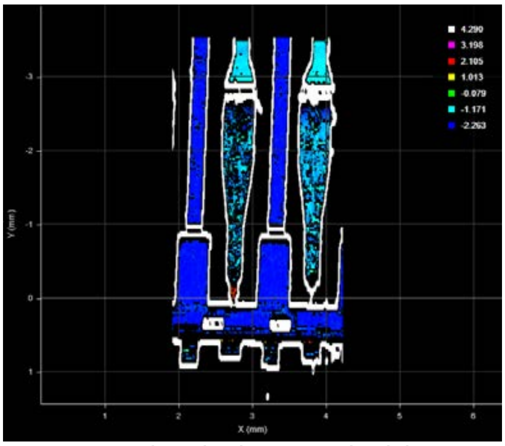
6.17 Filter

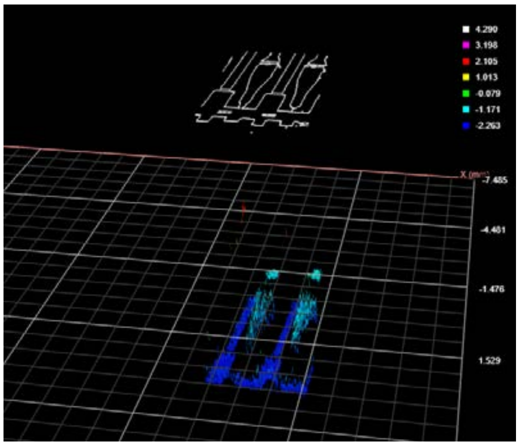
Tips
The tool is supported in emulator scenarios.

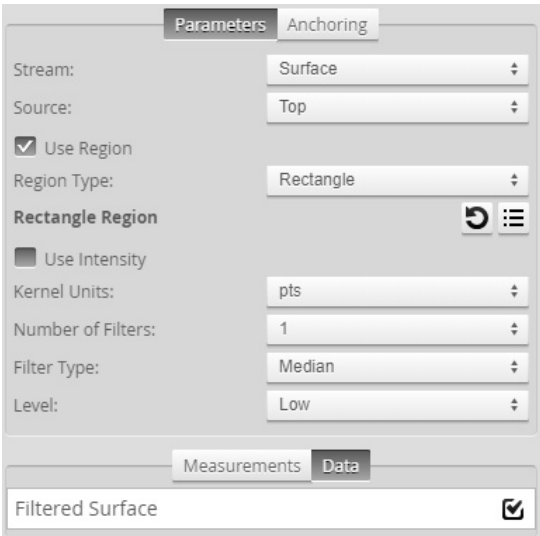
The Filter tool provides several common vision processing filters that you can apply to surface data, as well as a two "cropping" filters that output a subset of the surface data, letting you pre-process scan data to get more repeatable measurements. You can enable up to seven of the filters at once, in any order. Filters in the tool are chained together. Any Surface or Feature tool can use the resulting filtered surface data as input, via the tool's [Stream] drop-down.

For a list of the filters, see 📖 "[Filters]" on page 513.

The Filter tool provides no measurements or decisions, as its only purpose is to output processed surface data.


2D View (Sobel Magnitude)


3D View (Sobel Magnitude)



Tool Setup

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.17.1 Settings and Available Filters

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238. Can only accept Surface scan data (that is, cannot accept data from other tools).
[Region]	The region whose data the tool will apply filters to. Only data within the region is output to other tools.
[Use Region]	When enabled, displays additional settings to let you set a region (see below).
Number of Regions [Region Type {n}] [Inner Circle Diameter] [Inner Ellipse Major Axis] [Inner Ellipse Minor Axis] [Sector Start Angle] [Sector Angle Range] [Mask Source] [Low Threshold] [High Threshold]	When you enable [Use Region], the tool displays additional settings related to the measure region type. For details on flexible regions and their settings, see 📖 "• Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see 📖 "●Regions" on page 238.
[Use Intensity]	If enabled, the tool uses intensity data instead of heightmap data. Only available if Acquire Intensity is enabled on the Scan page during the scan; for more information, see 📖 "4.4.2 Scan Modes" on page 116.
[Kernel Units]	Specifies whether filters use data points ([pts]) or millimeters ([mm]).
Number of Filters	Specifies the number of filters you want to chain together. You can specify up to seven filters.
[Filter Type]	For each filter, specifies the type of filter. For more information on the available filters, see 📖 "●Filters" on page 253.
[Level]	The kernel size used by the Median filter. High is a 5x5 square kernel. Low is a 3x3 square kernel.
[Threshold]	The threshold that the filter uses. (Not available on all filters.)
[Symmetry]	One of the following: Symmetrical, Horizontal, or Vertical. (Not available on all filters.)
[Kernel Size]	The kernel size that the filter uses. (Not available on all filters.)

The following filters are available in the Filter tool.

[Filters]

Name	Description
[Median]	A median filter.
[Gaussian]	A Gaussian filter.
[Open]	Erosion followed by dilation.
[Close]	Dilation followed by erosion.
[Erode]	Applies an erosion filter. Lets you specify the direction of the erosion; one of the following: • [Horizontal] • [Vertical] • [Symmetrical]
[Dilation]	Applies a dilation filter. Lets you specify the direction of the dilation; one of the following: • [Horizontal] • [Vertical] • [Symmetrical]
[Morph Gradient]	Applies a morphological gradient. The difference between dilation and erosion.
[Sobel Magnitude]	Applies a Sobel magnitude filter. Lets you specify the direction of the filter; one of the following: • [Horizontal] • [Vertical] • [Symmetrical]
[Laplacian]	Applies a Laplacian filter. Useful for detecting areas of distinct edges. Uses the following kernel: $\begin{array}{\|c\|c\|c\|} \hline 0 & -1 & 0 \\ \hline -1 & 4 & -1 \\ \hline 0 & -1 & 0 \\ \hline \end{array}$
[Negative]	Inverts the height or intensity values in the scan data.
[Equalize]	Normalizes the norm or value range of an array.
[Binarize]	Sets height values to a fixed value for each point that is present in the data. Can be used with a region Z offset to threshold points above/below a Z value. With intensity data, sets any point over
[Percentile]	Limits the scan data to points between the values you set in [High Percentile] and [Low Percentile], which are displayed when you choose this option.
[Relative Threshold]	Crops scan data based on user-specified minimum and a maximum heights. Use [Reference Region] to set the heights relative to a reference region.
[Crop only]	Crops the scan data to the user-defined region.

Name	Description
[Mask With Input]	Uses the surface input into the tool as a mask on the data. Any points in the filtered data will be set to null if the input surface is null at the same location. For example, the Gaussian filter can extend data along the edges, adding data in areas that contain null values. This filter would remove data that the Gaussian filter introduces, preserving the null values. This filter should follow any filter that introduces this kind of unwanted data.
[Fill Gap]	Fills gaps in data up to the maximum distance in [Max Gap X] and [Max Gap Y]. Gap filling fills in missing data caused by occlusions using information from the nearest neighbors. Gap filling also fills gaps where no data is detected, which can be due to the surface reflectivity, for example dark or specular surface areas, or to actual gaps in the surface. The value represents the maximum gap width that the sensor will fill. Gaps wider than the maximum width will not be filled. Gap filling works by filling in missing data points using either the lowest values from the nearest neighbors or linear interpolation between neighboring values (depending on the Z difference between neighboring values), in the specified X or Y window. The sensor can fill gaps along both the X axis and the Y axis. X gap filling works by filling in the gaps within the same profile. Y gap filling works by filling in gaps in the direction of travel at each X location. If both X and Y gap filling are enabled, missing data is filled along the X and Y axes at the same time, using the available neighboring data. Note that the algorithms the Fill Gap filter in Surface Filter and Gap Filling on the Scan page are the same.

[Data]

Type	Description
[Filtered Surface]	The filtered data, available for use as input in the [Stream] drop-down in other tools.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.18 Flatness

Tips

The tool is supported in emulator scenarios.

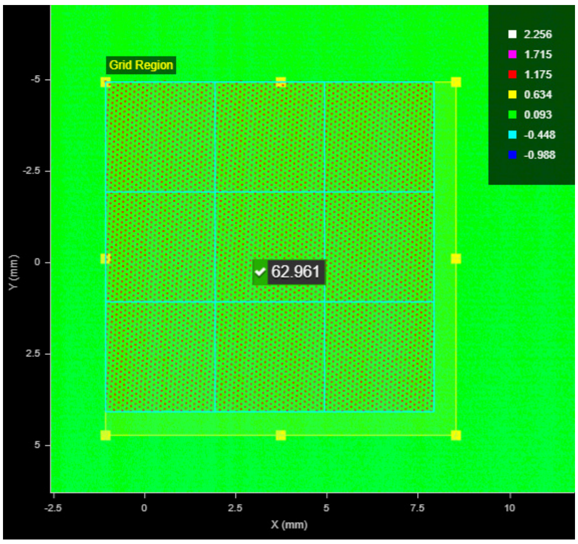
The Flatness tool returns various measurements related to the flatness of one or more regions on the surface of your target. The tool is ideal for general fit and finish inspection.

The tool lets you set a grid over a specific region, or more flexibly with multiple individual regions manually. In each case, "local" minimum and maximum heights, as well as flatness indicators (maximum - minimum), are returned (for grid cells or individual regions, depending on the tool's settings). In addition, "global" minimum, maximum, and flatness measurements, that combine data from all flatness measurement areas, can also be returned. The tool measures the maximum and minimum distances from a different best-fit plane for each local measurement, and from another plane fit to all data for the "global" measurements.

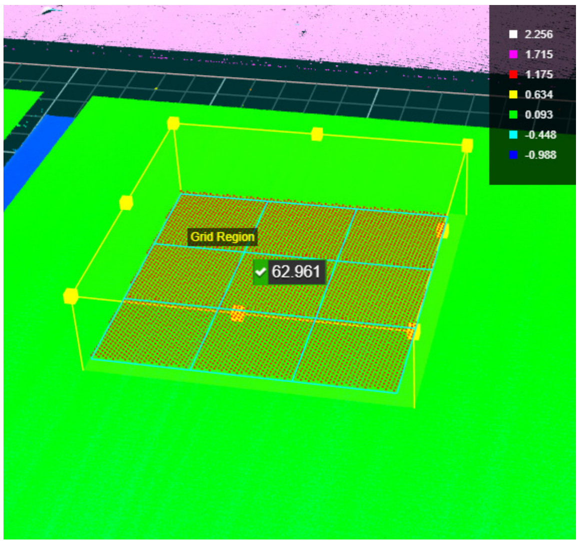
You can control how many data points the tool uses in its calculations to account for noise or smooth data, or otherwise exclude unwanted data.

Tips

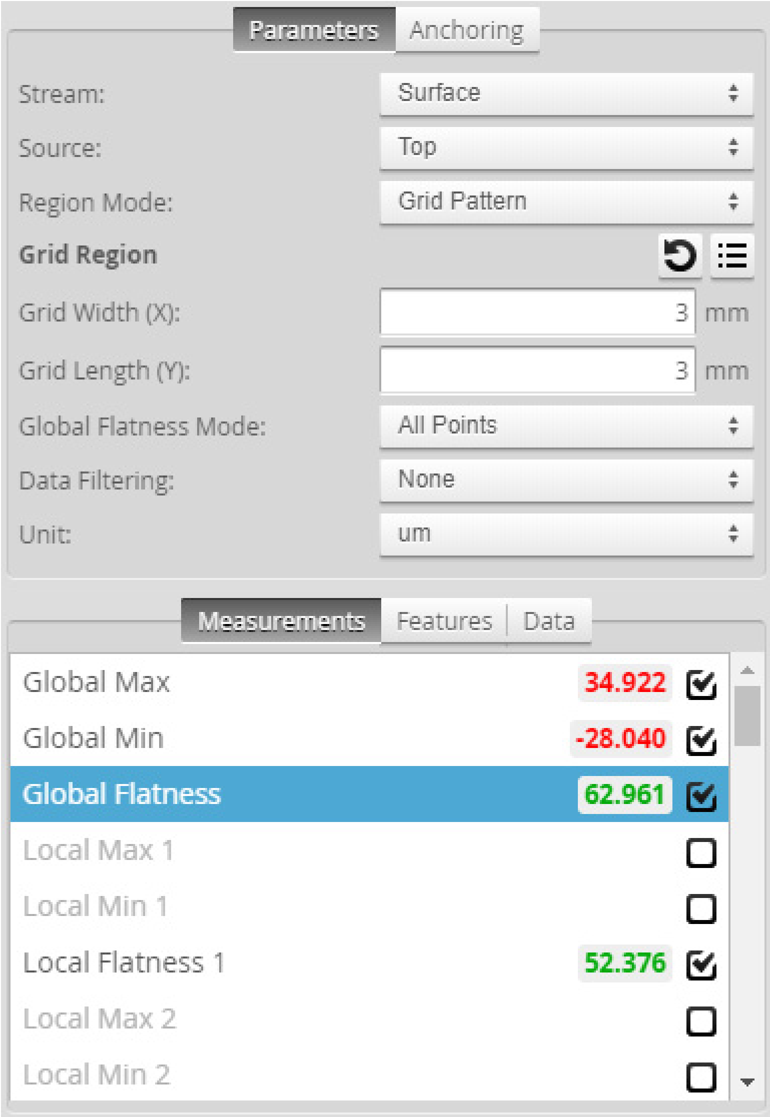
When you configure the tool to use a grid that contains more than 15 cells, only the first 15 local measurements are displayed in the web interface. Flatness results for cells beyond 15 cells are however available in the tool data.



2D View



3D View



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.18.1 Measurements, Features, Data, and Settings

[Measurements]

Measurement
[Global Max] [Global Min] [Global Flatness] The maximum distance, minimum distance, and flatness (maximum - minimum) calculated using the valid data points from all the cells in the grid (when [Region Mode] is set to [Grid Pattern]), or all the individual regions (when [Region Mode] is set to [Flexible]).
[Local Max {n}] [Local Min {n}] [Local Flatness {n}] The maximum distance, minimum distance, and flatness (maximum - minimum) calculated using the valid data points from a specific grid cell (when [Region Mode] is set to [Grid Pattern]), or an individual regions (when [Region Mode] is set to [Flexible]). Clicking a local measurement in the list of measurements selects the corresponding cell or region in the data viewer.

[Features]

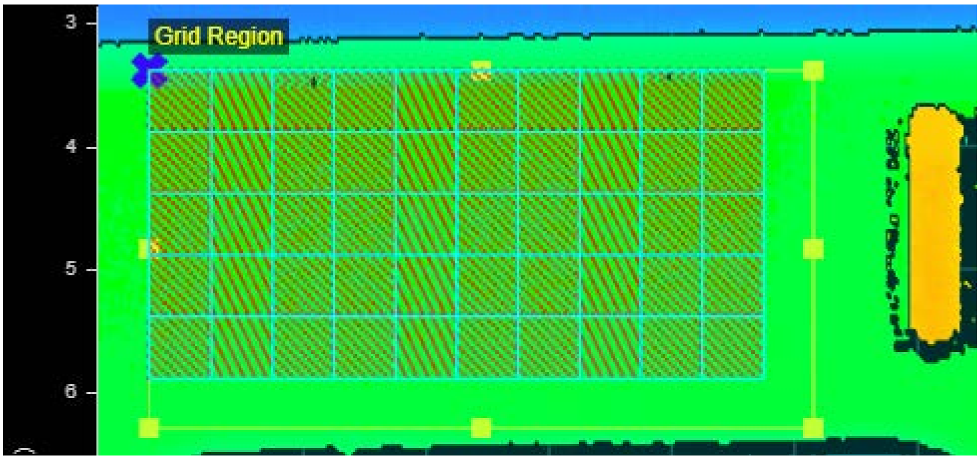
Type	Description
[Global Plane]	The plane fitted to the valid data points from all the cells in the grid (when [Region Mode] is set to [Grid Pattern]), or all the individual regions (when [Region Mode] is set to [Flexible]).
[Local Plane {n}]	The plane fitted to the valid data points from grid cell {n} (when [Region Mode] is set to [Grid Pattern]), or those from region {n} (when [Region Mode] is set to [Flexible]). Clicking a local plane in the list of features selects the corresponding cell or region in the data viewer.

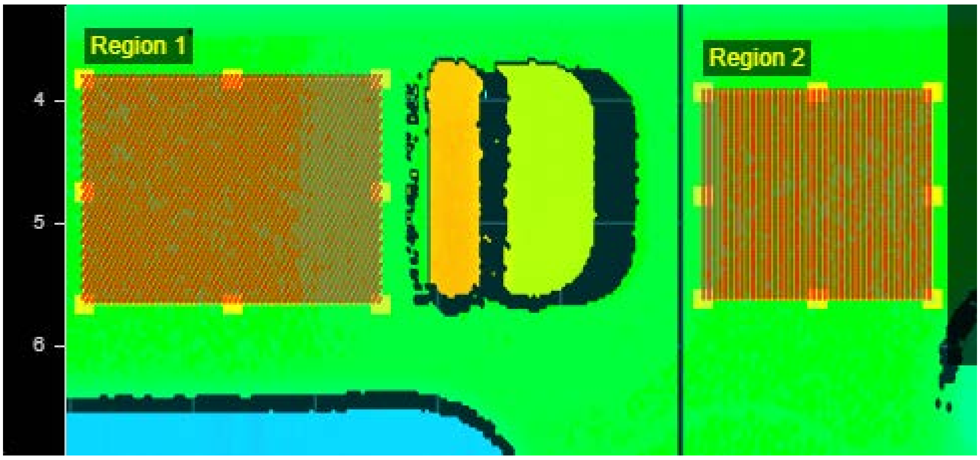
[Data]

Type	Description
[Output Measure-ment]	Data containing the measurement results. The web interface only displays up to 15 local measurements. However, if you define the grid and cell size so that you have more than 15 flatness measurement areas, these are included in the tool data. A sample included in the SDK package shows how you can use this output data in an application.

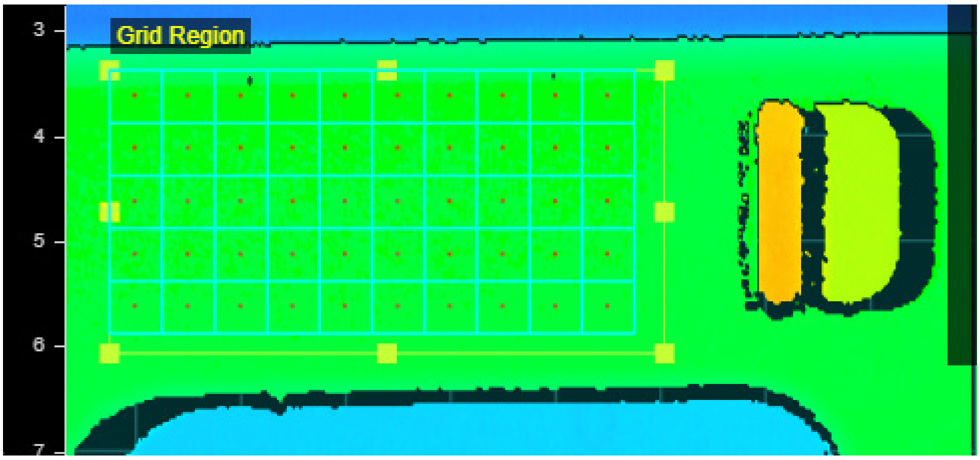
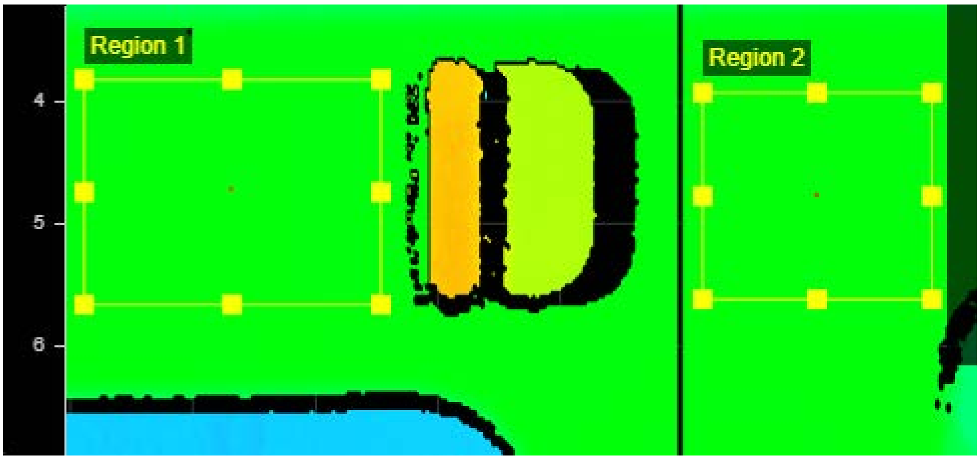
[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measure-ments. For more information, see 📖 "●Source" on page 238.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Region Mode]</td><td>Determines how flatness measurement areas are set up on the target. One of the following:
[Grid Pattern]: The tool determines flatness in a grid you define on the target. This option enables settings that let you set the size and location of a region that contains the grid ([Grid Region] setting), as well as the width and length of the grid cells ([Grid Width] and [Grid Length]). The combination of the values of these settings determines the number of cells in the grid region.


[Flexible]: The tool determines flatness using one or more (up to 15) regions that you define individually on the target.

</td></tr>
<tr><td>[Grid Region] (used with Grid Pattern region mode)</td><td>Determines the size of the grid region. (See details under [Grid Pattern] in [Region Mode] above.)</td></tr>
<tr><td>[Grid Width (X)]
[Grid Length (Y)] (used with Grid Pattern region mode)</td><td>These settings determine the size of the cells in the grid. (See details under [Grid Pattern] in [Region Mode] above.)</td></tr>
<tr><td>Region Number
(used with Flexible region mode)</td><td>Only displayed on older instances of this tool. Newer instances use "flexible regions" (see the parameters below in this table).
The number of regions.</td></tr>
</table>

Parameter	Description
[Region {n}] (used with Flexible region mode)	Only displayed on older instances of this tool. Newer instances use "flexible regions" (see the parameters below in this table). When [Region Mode] is set to [Flexible], for each region, the tool displays a region definition.
Number of Regions [Region Type {n}] [Inner Circle Diameter] [Inner Ellipse Major Axis] [Inner Ellipse Minor Axis] [Sector Start Angle Sector Angle Range] [Mask Source] [Low Threshold] [High Threshold]	Only displayed on newer instances of this tool. When you enable [Use Region], the tool displays additional settings related to the measure region type. For details on flexible regions and their settings, see 📖 "• Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see 📖 "●Regions" on page 238.

Parameter	Description
[Global Flatness Mode]	Chooses which points the tool uses to calculate global flatness. One of the following: [All Points]: The tool uses all points in the measurement area (all flexible regions or the grid pattern in the region). [Single Average Point]: The tool uses an average of the points in the measurement area. When you choose this option, the global measurements require at least four data points to calculate the plane and statistics. This means that if you set [Region Mode] to [Flexible], you must choose a minimum of four regions; if you set Region Mode to Grid Pattern, the size of the grid and the cells must result in at least four cells.  
[Data Filtering]	Lets you filter scan data before the tool performs its calculations. [Percentile]: Limits the data to points between the values you set in [High Percentile] and [Low Percentile], which are displayed when you choose this option. [None]: The tool performs no filtering.
[Unit]	Lets you choose which units the tool uses for measurement results. One of the following: • um (micrometers) • mm (millimeters)
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

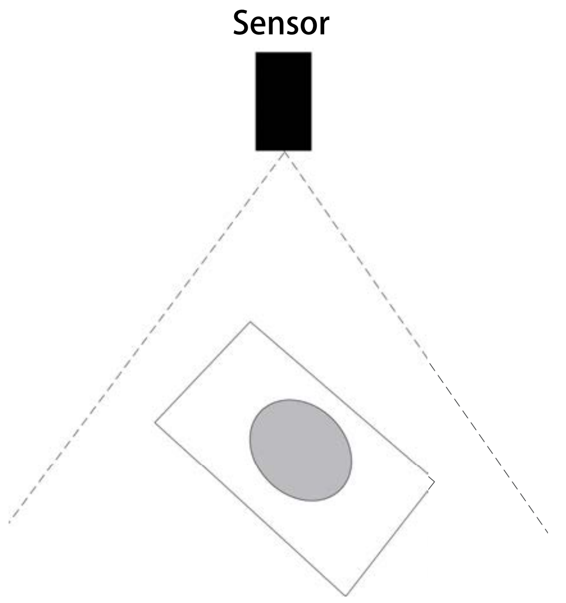
6.19 Hole

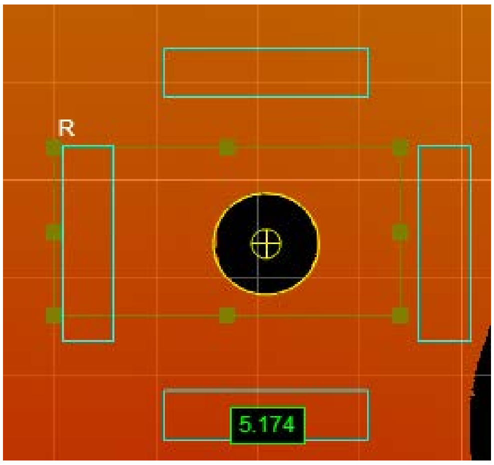
The Hole tool measures a circular opening within a region of interest on the surface and returns its position and radius.

> **Tips**
>
> The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

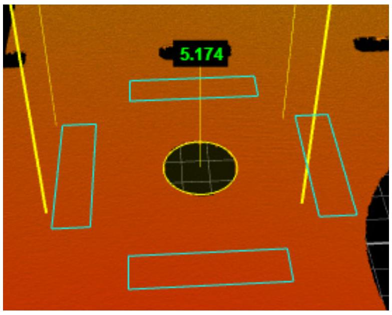
The hole can be on a surface at an angle to the sensor.

The tool uses a complex feature-locating algorithm to find a hold and then return measurements. See "Hole Algorithm" in the SurfaceMeasure1008S Measurement Tool Technical Manual for a detailed explanation of the algorithm. The behavior of the algorithm can be adjusted by changing the parameters in the measurement panel.

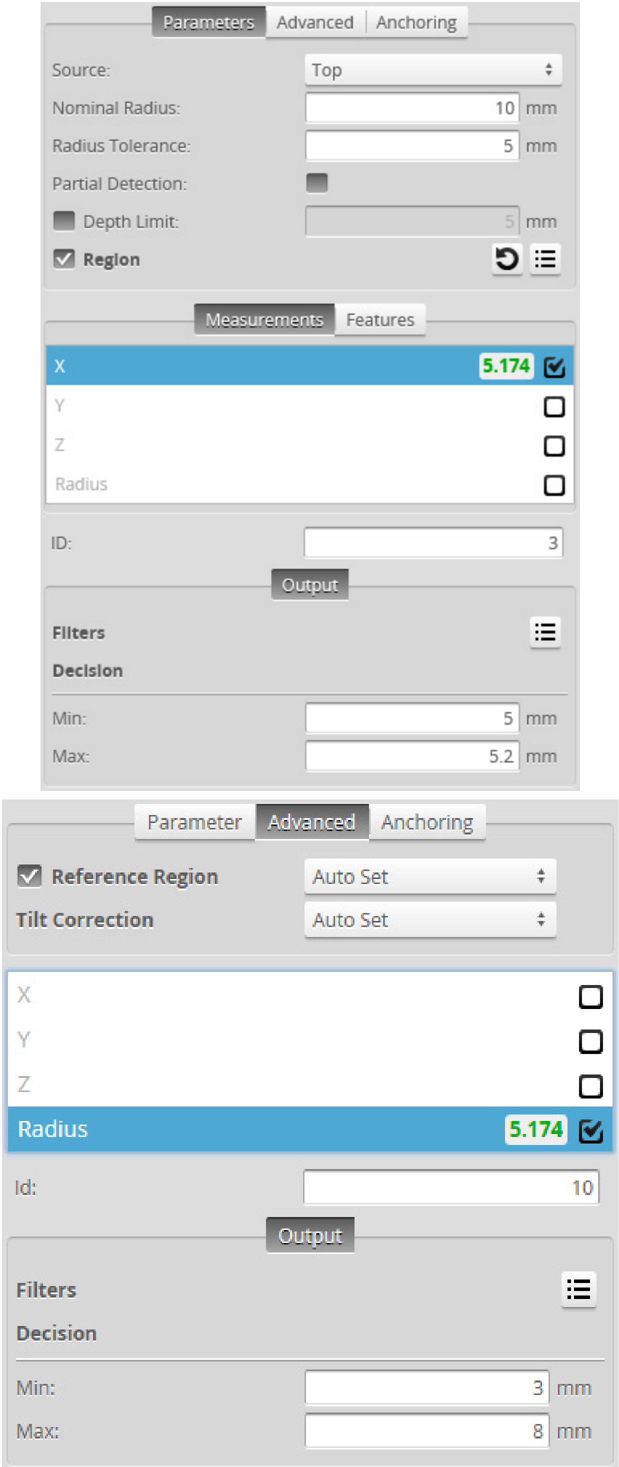




2D View



3D View

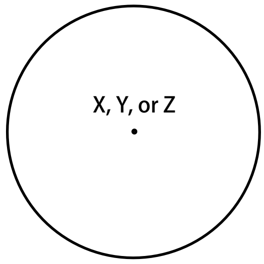
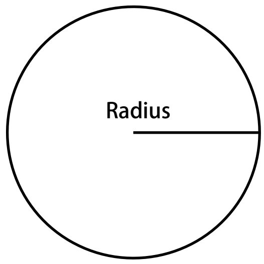


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.19.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Determines the X position of the hole center.	
[Y] Determines the Y position of the hole center.	
[Z] Determines the Z position of the hole center.	
[Radius] Determines the radius of the hole.	

[Features]

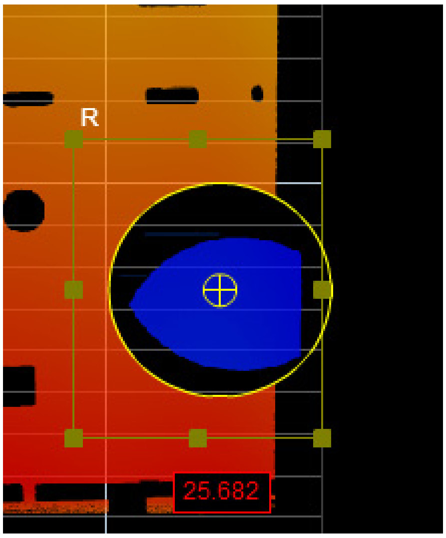
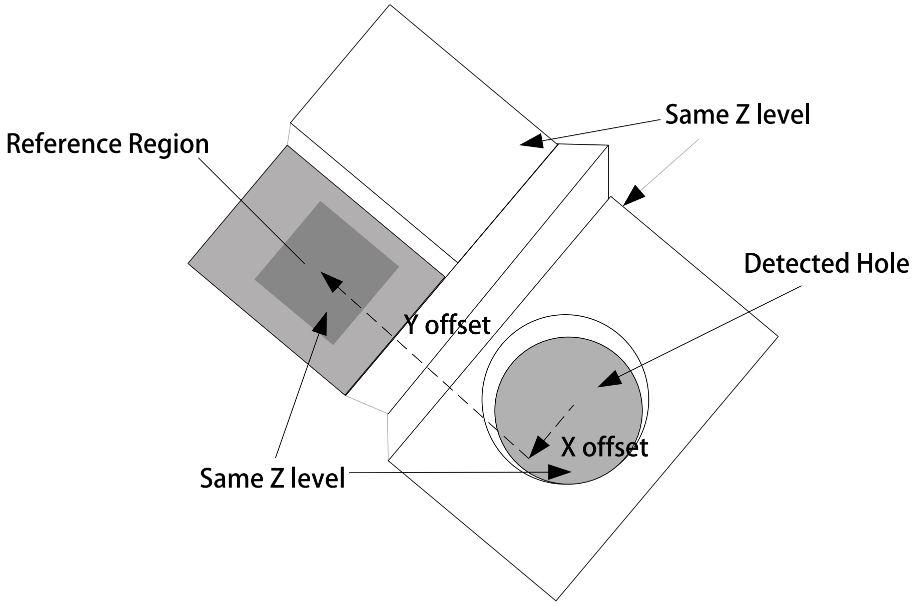
Type	Description
[Center Point]	The center point of the hole. The Z position of the center point is at the Z position of the surrounding surface.

Tips

For more information on geometric features, see "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Nominal Radius]	Expected radius of the hole.
[Radius Tolerance]	The maximum variation from the nominal radius (+/- from the nominal radius).

Parameter	Description
[Partial Detection]	Enable if only part of the hole is within the measurement region. If disabled, the hole must be completely in the region of interest for results to be valid. 
[Depth Limit]	Data below this limit (relative to the surface) is excluded from the hole calculations.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.
[Reference Region] (Advanced Parameters)	The tool uses the reference regions to calculate the Z position of the hole. It is typically used in cases where the surface around the hole is not flat.  When this option is set to [Autoset], the algorithm automatically determines the reference region. When the option is not set to [Autoset], you must manually specify one or two reference regions. The location of the reference region is relative to the detected center of the hole and positioned on the nominal surface plane. When [Reference Region] is disabled, the tool measures the hole's Z position using all the data in the measurement region, except for a bounding rectangular region around the hole.

Parameter	Description
[Tilt Correction] (Advanced Parameters)	Tilt of the target with respect to the alignment plane. [Autoset]: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes. [Custom]: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below).
[X Angle] [Y Angle] (Advanced Parameters)	The X and Y angles you must specify when [Tilt Correction] is set to [Custom]. You can use the Surface Plane tool's X Angle and Y Angle measurements to get the angle of the surrounding surface, and then copy those measurement's values to the [X Angle] and [Y Angle] parameters of this tool. For more information, see Plane.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

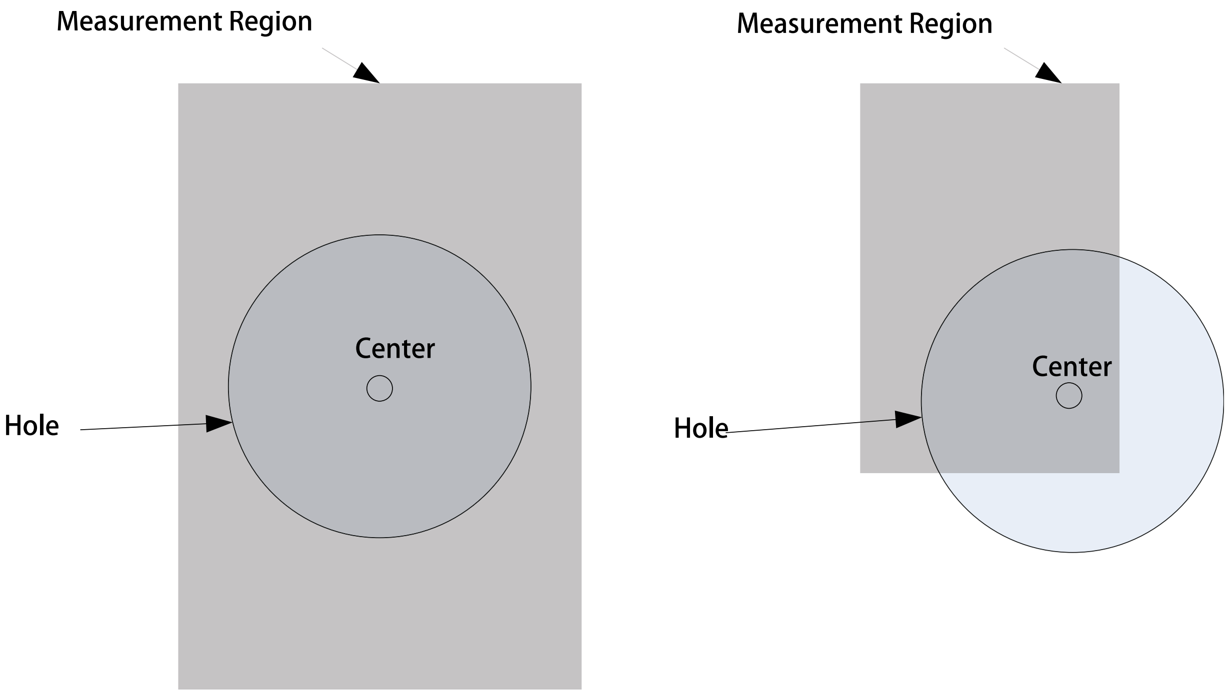
Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

6.19.2 Measurement Region

The center of the hole must be inside the measurement region, even if the Partial Detection option is enabled.

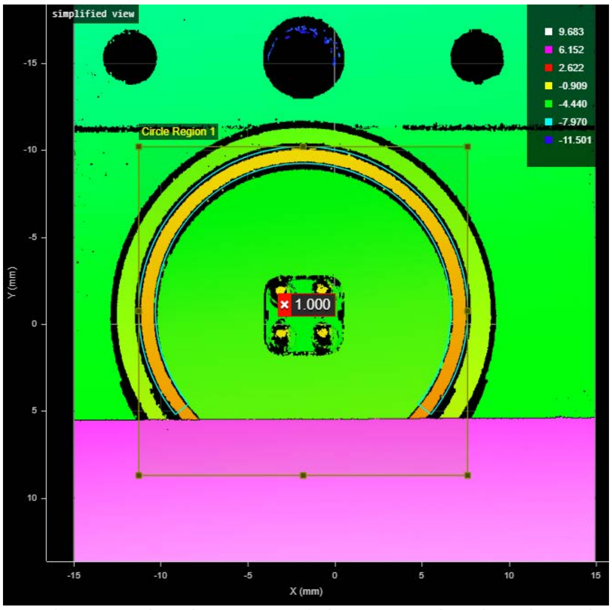


6.20 Mask

The Surface Mask tool lets define up to 16 regions to extract data from a surface. Each region's size, position, and shape (circular, elliptical, polygonal, and rectangular) can be individually configured, and regions can overlap. The tool can also exclude inner data of circular and elliptical regions, letting you extract rings of surface data. Extracted data is output in a single surface.

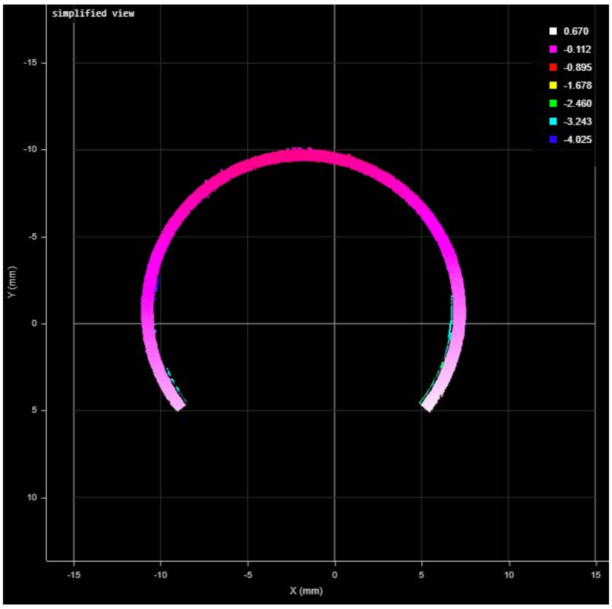
The resulting surface can then be further processed or measured by other tools.

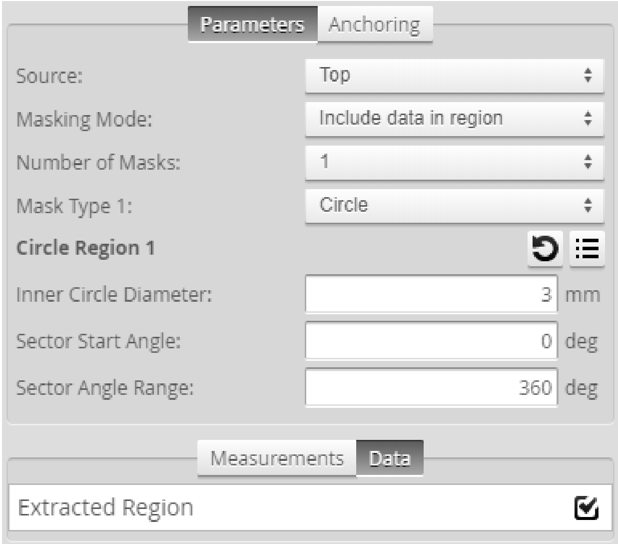
For example, given the following scan data:



A circle region box containing a partial ring (cyan)

The image below shows the extracted data. The extracted surface data can then be further processed by other tools, or measurements can be applied to the surface data.





Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.20.1 Measurements and Settings

[Measurements]

Type	Description
[Processing Time]	The amount of time the tool takes to process.

[Data]

Type	Description
[Extracted Region]	The surface containing the extracted region or regions.

[Parameters]

Parameter	Description
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool. If you switch from one type of data to another (for example, from section profile data to surface data), currently set input features will become invalid, and you will need to choose features of the correct data type.
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Masking Mode]	The masking mode the tool uses. One of the following: [Include data in region]: Data in the mask is included [Exclude data in region]: Data in the mask is excluded.

Parameter	Description
[Number of Masks] [Mask Type {n}] [Region Type {n}] [Inner Diameter] [Sector Start Angle] [Sector Angle Range] [Inner Major Axis] [Inner Minor Axis] [Mask Source] [Low Threshold] [High Threshold] [Vertex Count]	When you enable [Use Region], the tool displays additional settings related to the measure region type. For details on flexible regions and their settings, see 📖 "• Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see 📖 "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

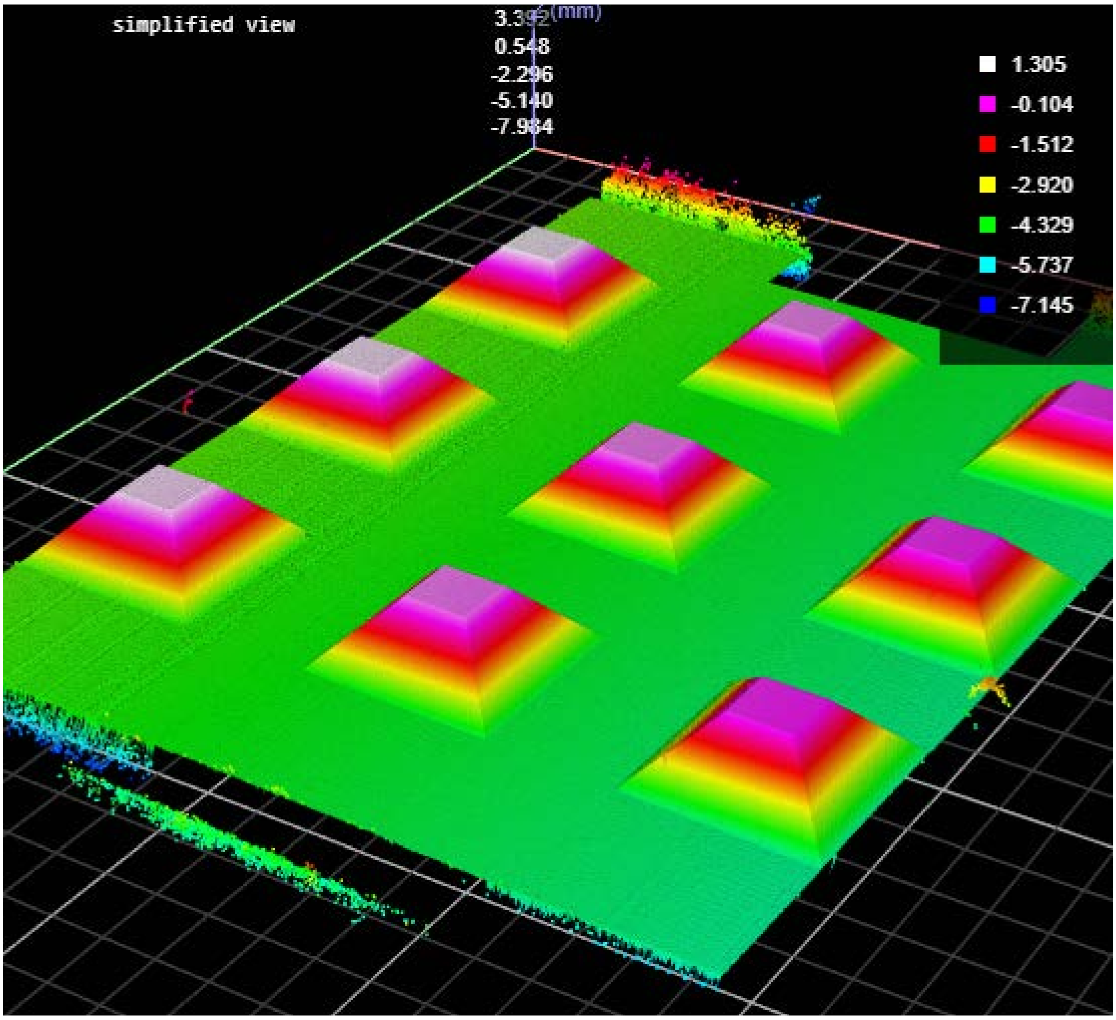
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

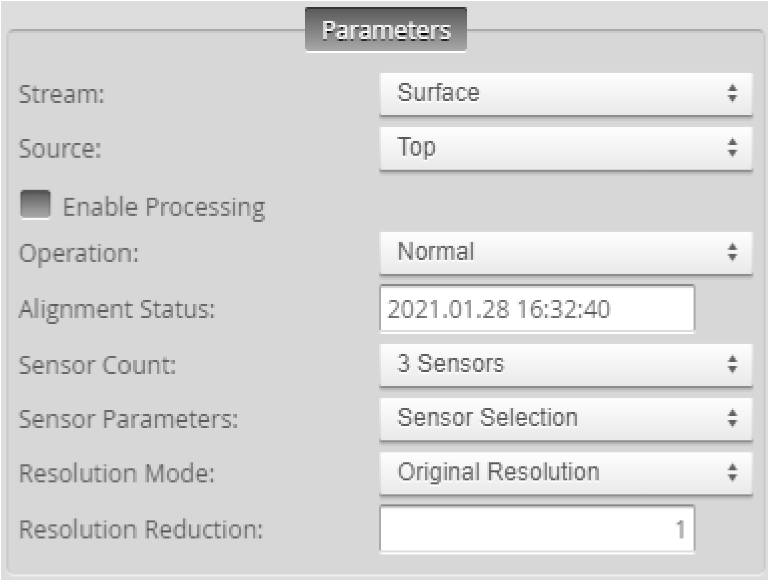
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.21 Merge Wide

Tips
The tool is supported in emulator scenarios.

The Surface Merge Wide tool takes in an XML transformation file produced by the Surface Align Wide tool (see "●Measurement Anchoring" on page 254), and combines scan data from multiple sensors into a single surface. You can use any built-in or GDK-based Surface measurement tool to perform measurements on the resulting merged Surface scan data.





[Measurements]

Measurement
[Processing Time]
The time the tool takes to run.

[Data]

Type	Description
[Processed Surface]	The Surface data resulting from combining the scan data of the individual sensors. Any Surface measurement tool can perform measurements on the data.

[Parameters]

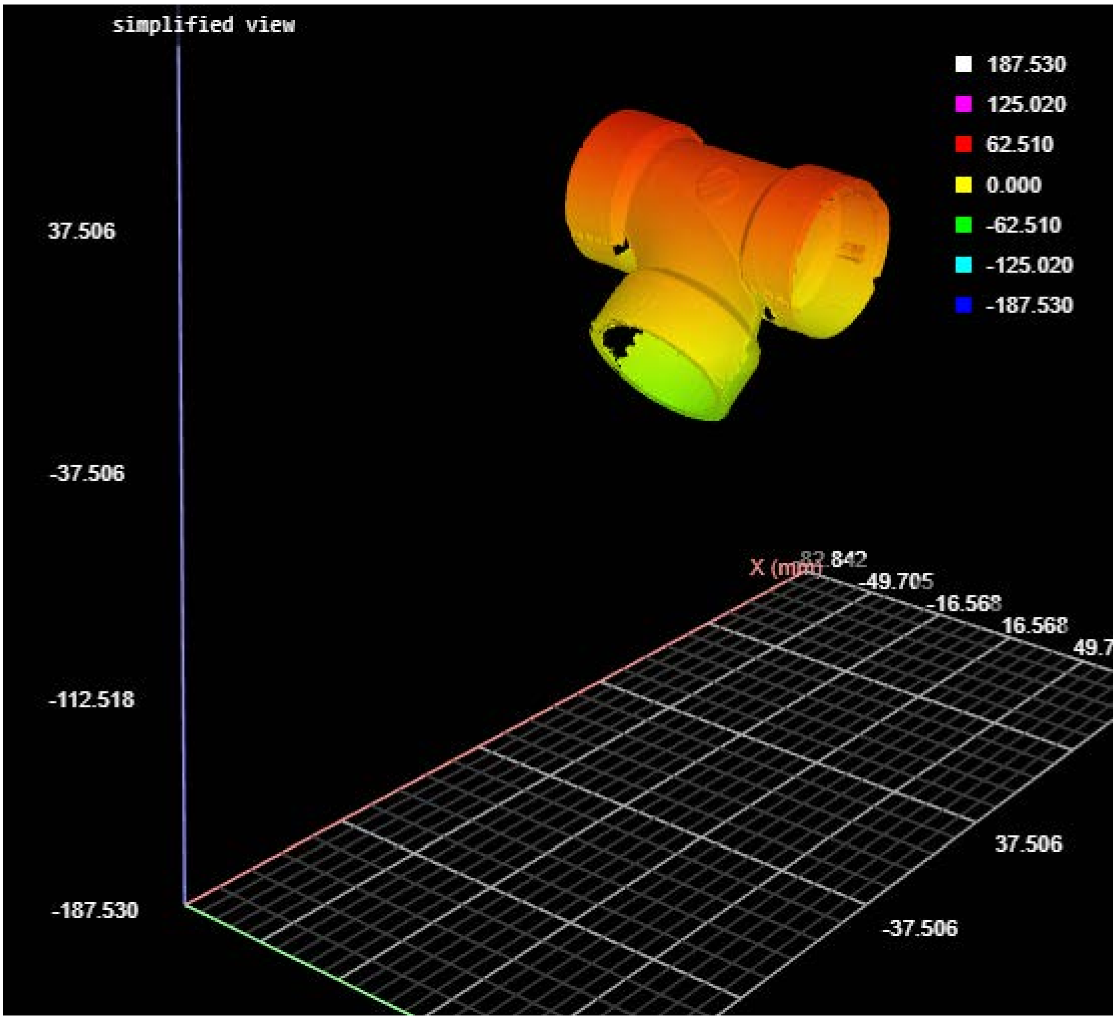
Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Enable Processing]	Causes the tool to start merging data from the individual sensors. Make sure to properly configure the tool before enabling this option.
[Operation]	Actions that apply to the XML initialization file the tool will use to perform merging. An initialization file must first be created by Surface Align Wide (see "■Wide Layouts" on page 198. XML files are located in C:\GoTools\SurfaceAlign. One of the following: • [Normal]: The tool automatically chooses this operation after you have chosen another operation. • [Load]: Displays a list of initialization files you can load. After you select a file, the tool loads it and displays a message in the log. • [Save]: Saves the sensor alignment information to an XML file, using the name you provide in the Configuration Name field that displays when you choose this option. This lets you save the alignment information if you have made manual changes to the sensor positions or orientations using the Sensor Parameters settings. • [Delete]: Deletes the initialization file you select.
[Alignment Status]	Indicates whether the tool has aligned the sensors. Either "Not Aligned" or the date of the alignment.

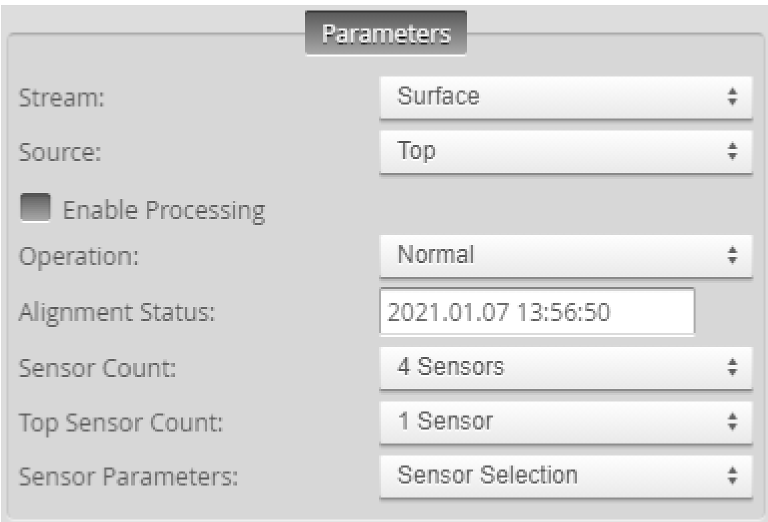
Parameter	Description
[Sensor Count]	Indicates the number of sensors in the system.
[Sensor Parameters]	A drop-down that lets you display the settings of a specific sensor. You do not usually need to change these settings, as they are set when you load the XML file produced using the Operation drop-down. The values are intended for diagnostics only. For information on the parameters, see "[Sensor Parameters]" on page 207.
[Resolution Mode]	Determines whether the tool scales the X or Y resolution so that they are the same (a 1:1 ratio), or leaves the X and Y resolutions as the original. One of the following. • [Optimal (uniform)] Brings the X/Y resolution ratio to 1:1 while preserving the pixel area. Best for random rotation around Z. Provides a balance between the highest and lowest possible resolutions, requiring an average amount of memory and processing time compared to the [High Oriented (uniform)] or [Low Oriented (uniform)] options. • [High Oriented (uniform)] Interpolates the lower resolution to match the higher resolution (between X and Y) in the input. Choose this option when increased resolution is preferred over speed and low memory usage. (This can result in a very high resolution output, creating a lot of data for subsequent tools to process. This can in turn result in slower processing.) • [Low Oriented (uniform)] Decimates the higher resolution to match the lower resolution (between X and Y) in the input. Choose this option when speed and low memory usage is preferred over resolution. (It can result in significant data quality reduction with large Z rotations if the X and Y resolutions of the input are very different.) • [Original Resolution] Keeps the original X and Y resolution of the scan. Use this option only when you expect little or no Z rotation. Otherwise, with X/Y resolution ratios that are not 1:1, large rotation around Z results in severe data quality reduction. • [Customized] Lets you set a custom resolution mode using the Scale X and Scale Y parameters this option displays.
[Resolution Reduction]	Reduces the lateral resolution of the heightmap to reduce processing time.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253. Not typically used with this tool.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251. Not typically used with this tool.

6.22 Mesh

Tips

The tool is supported in emulator scenarios.





The Surface Mesh tool takes in an XML transformation file produced by the Surface Align Ring tool (see 📖 "■Ring Layouts" on page 203), and stitches scan data from multiple sensors into a single mesh, which is typically a 360-degree scan. (That is, when sensors are in a ring configuration.) You can apply some measurements directly to the resulting Mesh scan data, or you can use the Mesh Projection tool to extract a surface from any angle of the Mesh data, and apply any of the other Surface measurement tools to the extracted surface.

Note that the tool's settings (most of which are visible only if you select a sensor from the [Sensor Parameters] drop-down) are populated by loading the XML transformation file produced by Surface Align Ring.

Tips

Always make sure that you select Top & Bottom in [Source] when using this tool.

[Measurements]

Measurement
[Detected Sensor Count] The number of sensors detected in the system.
[Processing Time] The time the tool takes to run.

[Data]

Type	Description
[Mesh]	The Mesh data resulting from combining the scan data of the individual sensors. This data output can be taken as input by the Mesh tools (see 📖 "4.7.8 Mesh Measurement" on page 288). Use Mesh Projection or Mesh Plane to extract Surface data from this output, which can then be measured using any Surface measurement tool.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Enable Processing]	Causes the tool to start processing scan data from individual sensors, combining it into a Mesh data output. Make sure to load the XML

Parameter	Description
[Operation]	Actions that apply to the tool's XML initialization files. XML files are located in C:\GoTools\SurfaceAlign. One of the following: • [Normal]: The tool automatically chooses this operation after you have chosen another operation. • [Load]: Displays a list of initialization files you can load. After you select a file, the tool loads it and displays a message in the log. The settings in the file, such as the number of sensors and their X and Y origin, are updated in the tool's parameters. • [Save]: Saves the sensor alignment information to an XML file, using the name you provide in the Configuration Name field that displays when you choose this option. This lets you save the alignment information if you have made manual changes to the sensor positions or orientations using the Sensor Parameters settings. • [Delete]: Deletes the initialization file you select.
[Alignement Status]	Indicates whether the tool has aligned the sensors. Either "Not Aligned" or the date of the alignment.
[Sensor Count]	Indicates the number of sensors in the system.
[Sensor Parameters]	A drop-down that lets you display the settings of a specific sensor. These parameters are set by loading an XML initialization file by choosing Load in the [Operation] drop-down.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253. Not typically used with this tool.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251. Not typically used with this tool.

6.23 OCR

Tips

This tool requires GoMax or PC-based acceleration.

For more information on GoMax, see the GoMax user manual.

For more information on PC-based acceleration, see 📖 "7 SurfaceMeasure1008S Acceleration" on page 627.

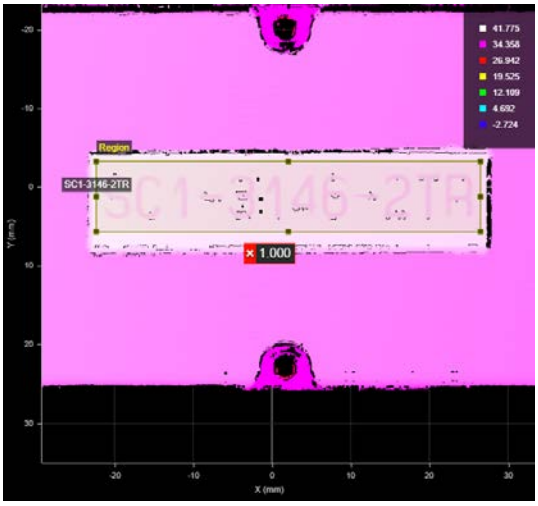
The Surface OCR (optical character recognition) tool lets you extract a string of text from surfaces, using either heightmap or intensity scan data. The tool is font-independent and already trained. The tool therefore lets you implement OCR without the need for a separate 2D camera system.

You can use the String Encoding tool to extract the string and pass it as output to a PLC; for more information, see 📖 "6.32 String Encoding" on page 587. The extracted string is also available via the SDK; for information on the SDK, see 📖 "11.1 GoSDK" on page 947 and the SDK reference documentation.

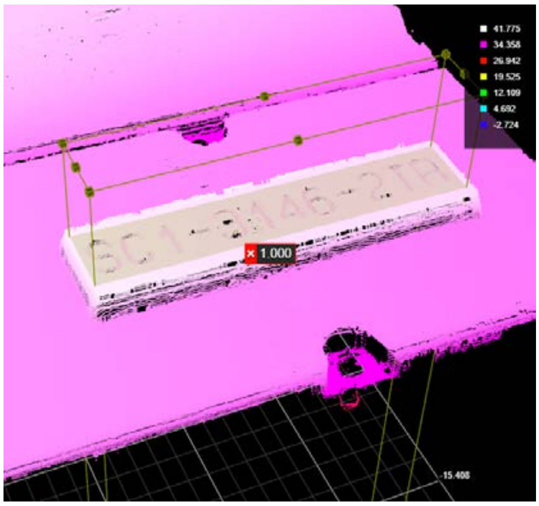
The tool does not support multi-line character recognition, and the text must be rotated so that it is human-readable from left to right along the X axis.

Tips

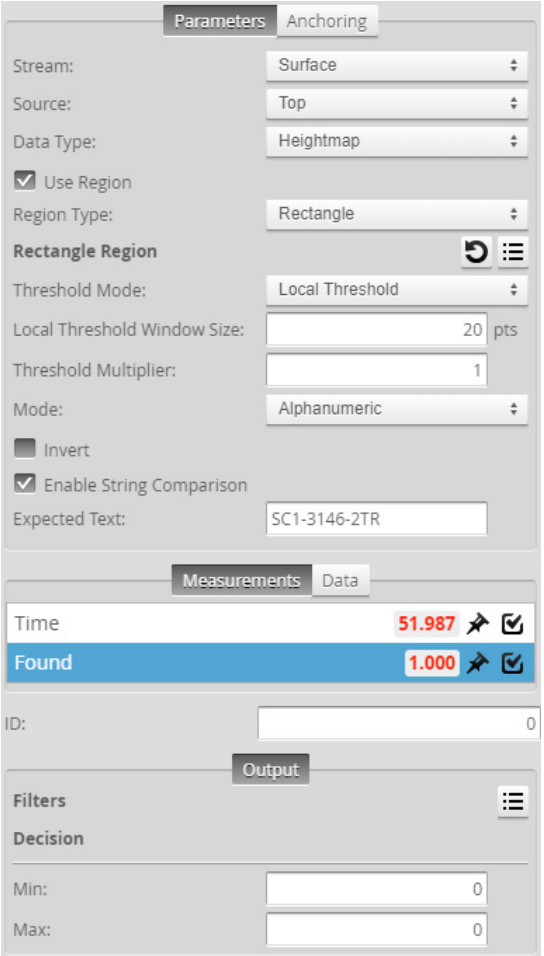
When configuring the tool, use the Diagnostic Image data output, on the [Output] tab, to help set the thresholding parameters correctly.



2D View



3D View



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.23.1 Measurements and Settings

[Measurements]

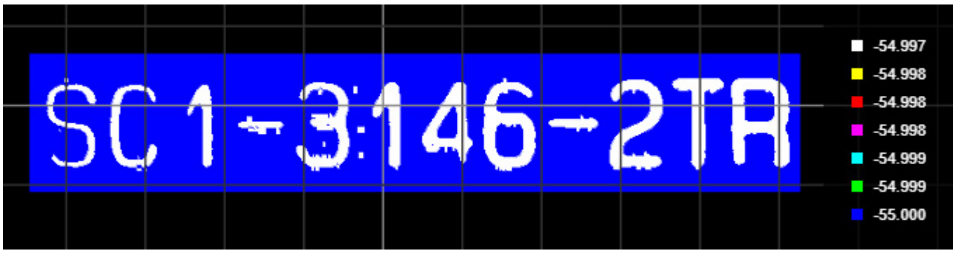
Measurement
[Time] The amount of time the tool takes to process.
[Found] Whether the extracted text is identical to the text in [Expected Text].

[Data]

Type	Description
[Diagnostic Image]	The data the tool uses to perform optical character recognition.
[Output String]	A string containing the recognized text. (This data is not currently visualized in the data viewer.)

[Parameters]

Parameter	Description
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool.
[Source]	The sensor that provides data for the tool's measurements.
[Data Type]	The type of data the tool uses ([Heightmap] or [Intensity]).
[Use Region]	Only displayed on older instances of this tool. Newer instances use "flexible regions" (see the parameters below in this table). Indicates whether the tool uses a user-defined region. If this option is not checked, the tool uses data from the entire active area.
[Region]	Only displayed on older instances of this tool. Newer instances use "flexible regions" (see the parameters below in this table). The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Number of Regions] [Mask Type {n}] [Region Type {n}] [Inner Diameter] [Sector Start Angle] [Sector Angle Range] [Inner Major Axis] [Inner Minor Axis] [Vertex Count] [Mask Source] [Low Threshold] [High Threshold]	Only displayed on newer instances of this tool. When you enable [Use Region], the tool displays additional settings related to the measure region type. For details on flexible regions and their settings, see 📖 "• Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see 📖 "●Regions" on page 238.
[Threshold Mode]	Determines the threshold the tool uses to identify characters relative to the background data. One of the following: [Default] – The default used by tesseract with OTSU adaptive thresholding method. Use this mode if the scan data has been pre-processed to remove any tilt of the surface on which you want to perform OCR, for example using Surface Transform; for more information, see 📖 "6.35 Transform" on page 609. [Local Threshold] – The tool varies the threshold for each pixel based on the minimum and maximum values within a moving window over the region, using the specified window size and multiplier (see below). This method can compensate for intensity and height gradients. [Manual Threshold] – The tool uses a single, fixed threshold for the entire region (see Manual Threshold below).
[Local Threshold Window Size]	The window size the tool uses for local thresholding. The window size should generally be larger than the size of the characters being detected. Displayed when [Threshold Mode] is set to [Local Threshold].

Parameter	Description
[Threshold Multi-plier]	The multiplier the tool uses for local thresholding. Typically set to a value close to 1. Displayed when [Threshold Mode] is set to [Local Threshold].
[Manual Thresh-old]	The manual threshold the tool uses, expressed as a percentage, converted to a 0-255 range, relative to minimum and maximum values within the region. Displayed when [Threshold Mode] is set to [Manual Threshold].
[Mode]	Limits the characters the tool will recognize. Choose the mode based on the expected types of characters in the target. One of the following: [Alphanumeric] – Only attempts to recognize alphanumeric characters. [Numeric] – Only attempts to recognize numeric characters. [Whitelist] – Only attempts to recognize the characters in the [Whitelist] parameter that this option displays. [Blacklist] – Will not attempt to recognize characters in the [Blacklist] parameter that this option displays.
[Whitelist] [Blacklist]	The whitelist or blacklist of characters that the tool will attempt to recognize or ignore, respectively. These parameters are case sensitive. The list of characters is a simple string of characters. One of these parameters is displayed when [Mode] is set to [Whitelist] or [Blacklist].
[Invert]	Swaps intensity values in the data the tool uses to perform OCR. Use this if you need to perform OCR on light text on a dark background. (The OCR library the tool uses expects dark text on a light background.) For heightmap data, the tool swaps the "high" and "low" values. For example, in the second image below, the height values used for the text and the surrounding surface (the highest and lowest values in the heightmap legend to the right) are swapped when compared to the first, non-inverted data.   This parameter is not available when [Threshold Mode] is set to Default.
[Enable String Comparison]	Enables string comparison.
[Expected Text]	The string the tool compares the extracted text to. The parameter is case-sensitive and does not support wild cards or truncation.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measure-ment tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.24 Opening

The Opening tool locates rounded, rectangular, and rounded corner openings. The opening can be on a surface at an angle to the sensor.

Tips

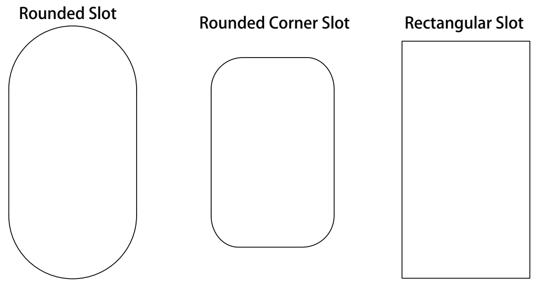
The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

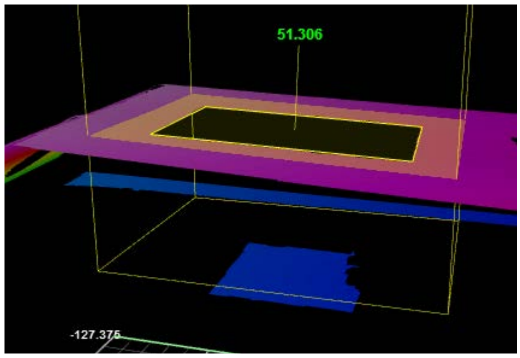
The tool uses a complex feature-locating algorithm to find a hold and then return measurements. See "Opening Algorithm" in the SurfaceMeasure1008S Measurement Tool Technical Manual for a detailed explanation of the algorithm. The behavior of the algorithm can be adjusted by changing the parameters in the measurement panel.

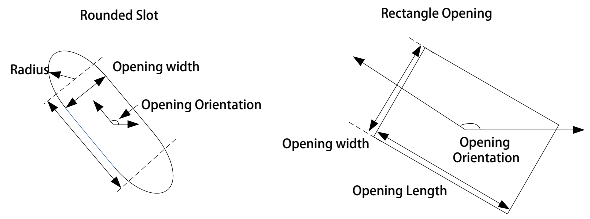
The algorithm can separate out background information that appears inside the opening. It can also detect a slot that only partially appears in the data.

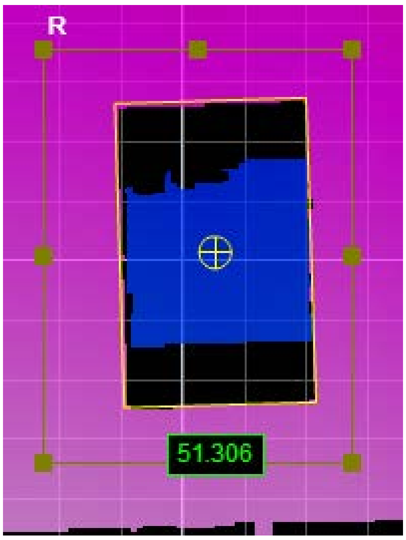
The shape of the opening is defined by its type and its nominal width, length, and radius.

The orientation defines the rotation around the normal of the alignment plane.

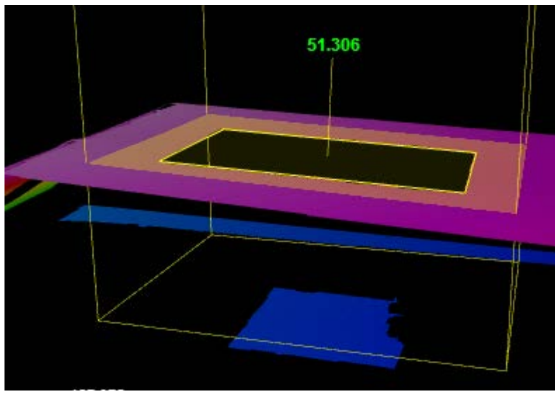




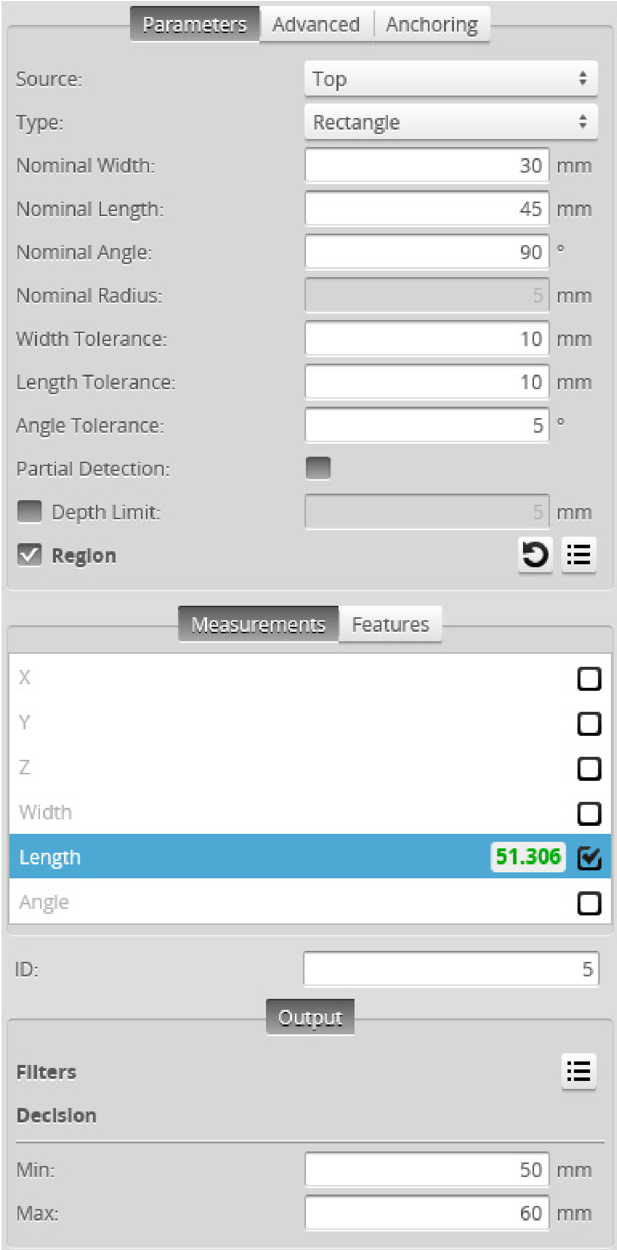


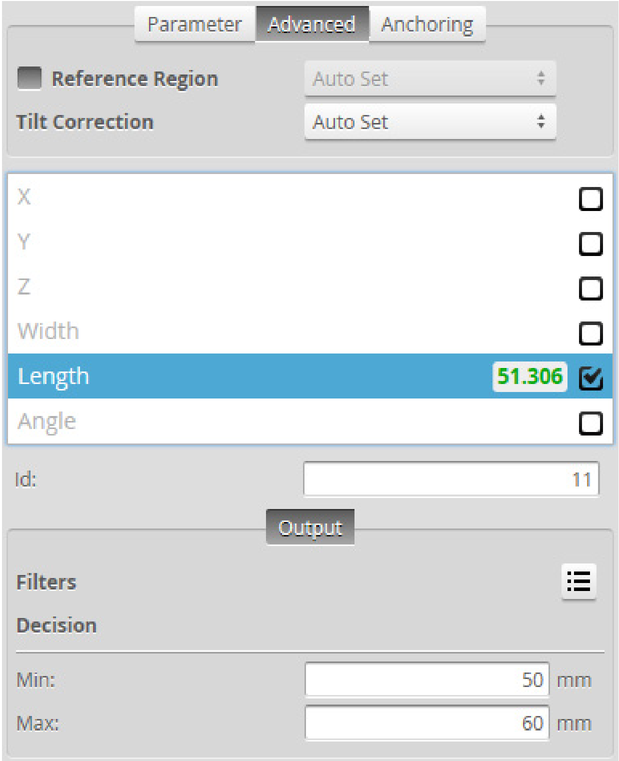


2D View



3D View


Parameters
Advanced
Anchoring
Source:
Top
Type:
Rectangle
Nominal Width:
30
mm
Nominal Length:
45
mm
Nominal Angle:
90
°
Nominal Radius:
5
mm
Width Tolerance:
10
mm
Length Tolerance:
10
mm
Angle Tolerance:
5
°
Partial Detection:
Depth Limit:
5
mm
Region
Measurements
Features
X
Y
Z
Width
Length
51.306
Angle
ID:
5
Output
Filters
Decision
Min:
50
mm
Max:
60
mm

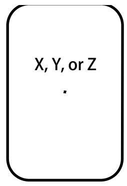
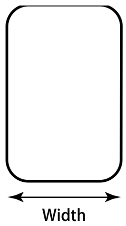
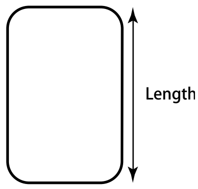
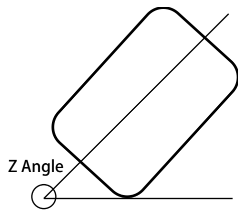


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.24.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Determines the X position of the opening's center.	
[Y] Determines the Y position of the opening's center.	
[Z] Determines the Z position of the opening's center.	
[Width] Determines the width of the opening.	
[Length] Determines the length of the opening.	
[Z Angle] Determines the angle (rotation) around the normal of the alignment plane.	

[Features]

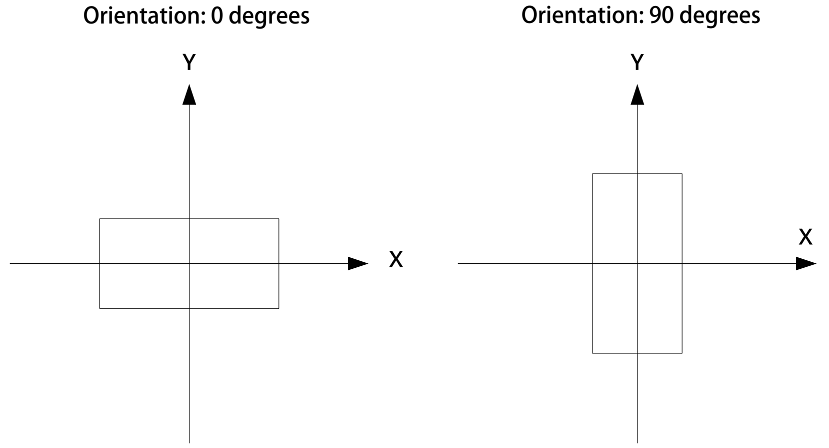
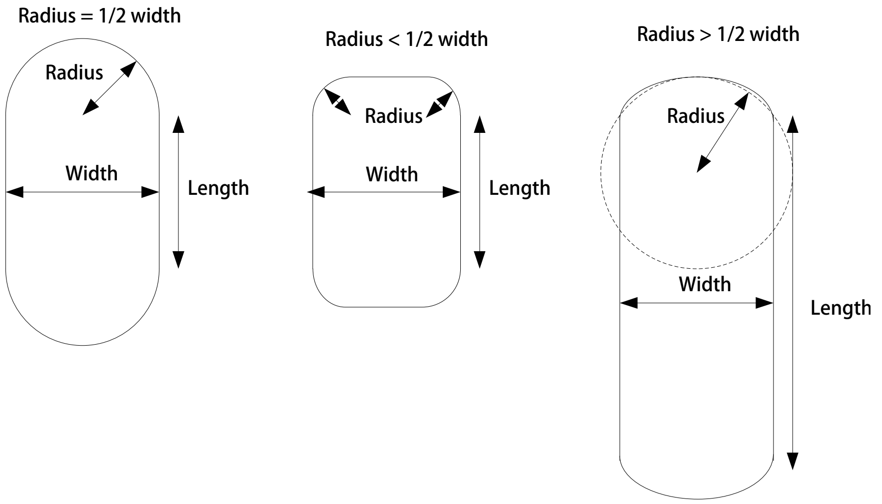
Type	Description
[Center Point]	The center point of the opening. The Z position of the center point is at the Z position of the surrounding surface.

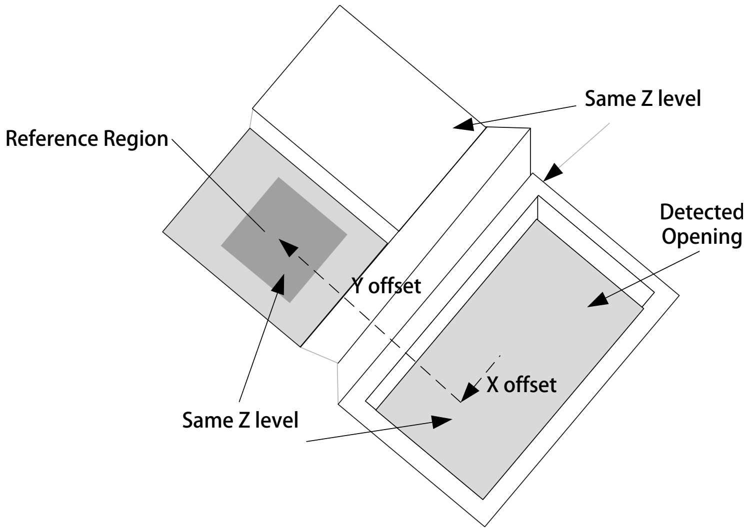
Tips

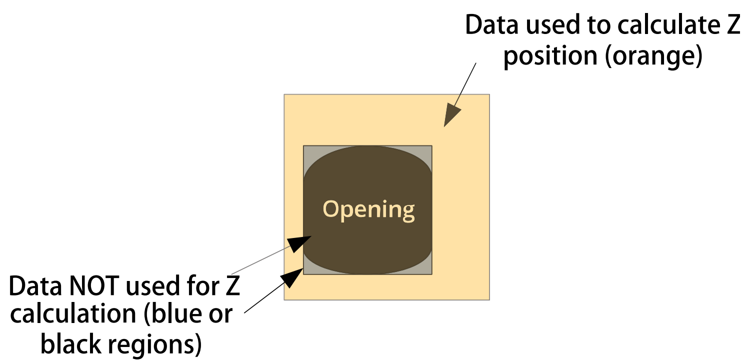
For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Type]	Rounded Slot, Rectangle.
[Nominal Width]	Nominal width of the opening.
[Nominal Length]	Nominal length of the opening.

Parameter	Description
[Nominal Angle]	Nominal angle of the opening. The default orientation is the length of the opening along the X axis.  The diagram above illustrates the case where the surface is not tilted. When the surface is tilted, the orientation is defined with respect to the normal of the surface, not with respect to the X-Y plane
[Nominal Radius]	Nominal radius of the opening ends. If the opening type is set to rectangular, the radius setting is disabled. The opening has an oval shape if the radius is equal to ½ of the width. The opening is a rounded rectangle when the radius is less than ½ of the width. 
[Width Tolerance]	The maximum variation from the nominal width (+/- from the nominal value).
[Length Tolerance]	The maximum variation from the nominal length (+/- from the nominal value).
[Angle Tolerance]	The maximum variation from the nominal orientation (+/- from the nominal value).
[Partial Detection]	Enable if only part of the opening is within the measurement region. If disabled, the opening must be completely in the region of interest for results to be valid.
[Depth Limit]	Data below this limit (relative to the surface) is excluded from the opening calculations.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Reference Regions]
(Advanced Parameters)</td><td>The tool uses the reference regions to calculate the Z position of the opening. Reference regions are relative to the center location of the feature. This option is typically used in cases where the surface around the opening is not flat.


When the Reference Regions setting is disabled, the tool measures the opening's Z position using the all data in the measurement region, except for a bounding rectangular region around the opening.


With one or more reference regions, the algorithm calculates the Z positions as the average values of the data within the regions.
When you place the reference region manually, all of the data is used, whether the data is inside or outside the opening. You should place the reference region carefully.</td></tr>
<tr><td>[Tilt Correction]
(Advanced Parameters)</td><td>Tilt of the target with respect to the alignment plane.
[Autoset]: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes.
[Custom]: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below).</td></tr>
<tr><td>[X Angle]
[Y Angle]
(Advanced Parameters)</td><td>The X and Y angles you must specify when [Tilt Correction] is set to [Custom].
You can use the Surface Plane tool's X Angle and Y Angle measurements to get the angle of the surrounding surface, and then copy those measurement's values to the [X Angle] and [Y Angle] parameters of this tool. For more information, see Plane.</td></tr>
<tr><td>[Filters]</td><td>The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.</td></tr>
<tr><td>[Decision]</td><td>The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.</td></tr>
</table>

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

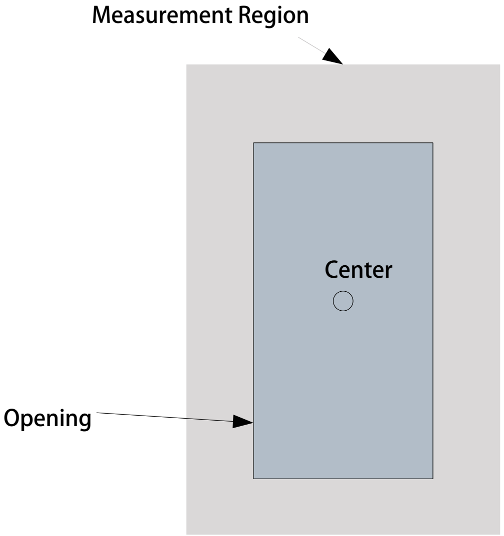
Tips

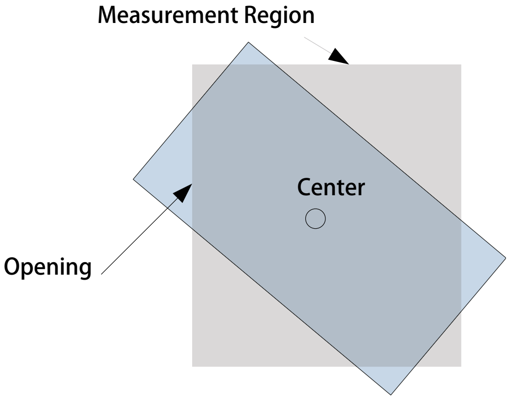
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

6.24.2 Measurement Region

The center and the two sides and ends of the opening must be within the measurement region, even if [Partial Detection] is enabled.





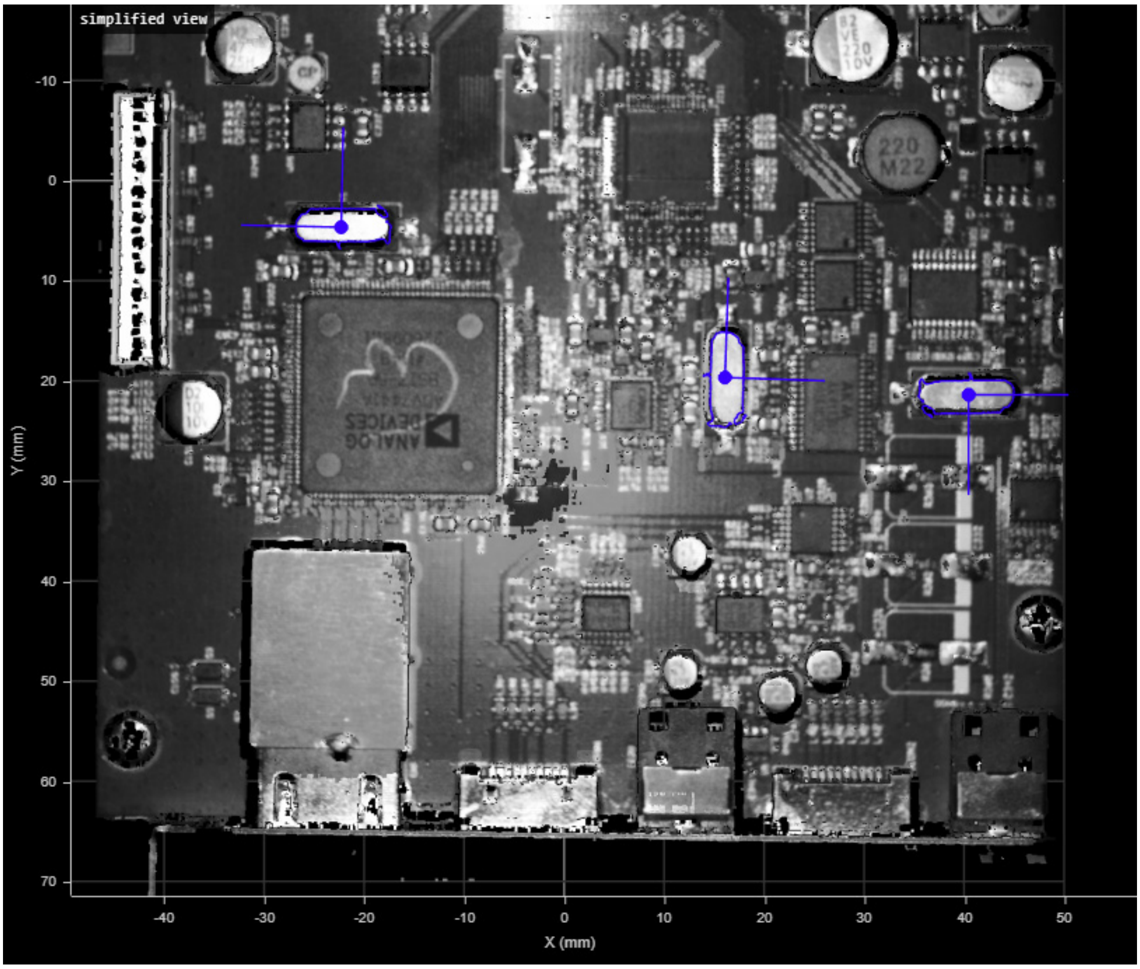
6.25 Pattern Matching

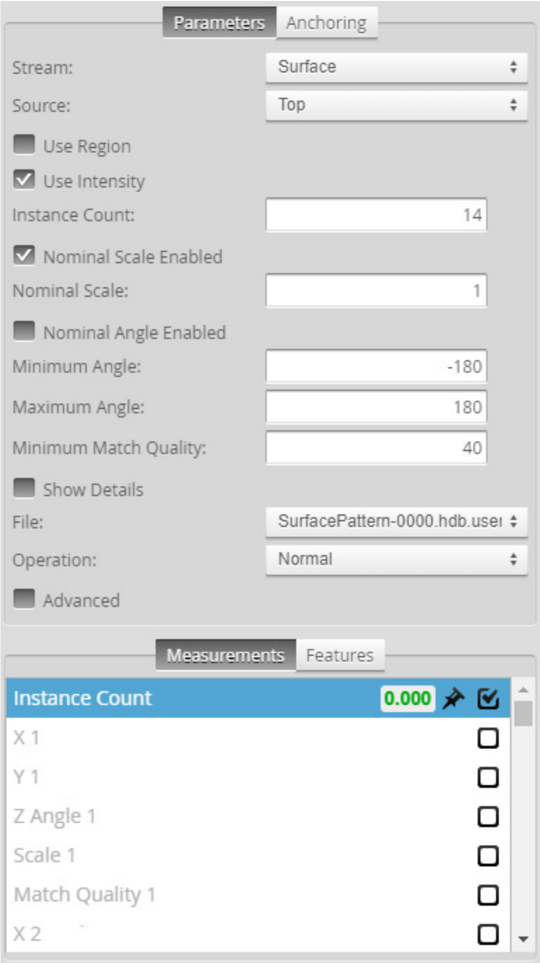
Tips
The tool is supported in emulator scenarios.

The Surface Pattern Matching tool locates parts and features by comparing 2D contours (on the XY plane) found in scan data to pattern models you have defined; note that the tool does not use height data in its algorithms. Models represent contour-based “golden parts” or “golden features.” (Models can be modified in the provided standalone model editor; for more information, see 📖 "12.3 Pattern Editor" on page 982.) For comparing full parts in 3D, use the Mesh Template Matching tool instead (see 📖 "■Template Matching" on page 298).

The tool can process multiple occurrences of a part or feature in a frame of scan data. For each matching part or feature (called an instance), the tool returns an X and Y position and a rotation, which can be used to anchor other measurements. The tool also returns a point and a line geometric feature for each instance, which you can use in conjunction with Surface Transform tools to shift and rotate scan data to reliably position the target; this can be used as an improved way of performing the part matching that is available on the [Model] page. Finally, the tool returns a match quality that you can use as a general conformity measure for matching instances (for example, checking for dents in a target), as well as a count of located instances.

Tips
In order to create a template for a feature on a target, you typically need to enable the [Use Region] checkbox to limit the tool to the contours related to that feature. After that, when running the tool to find instances of the feature, you should either modify the region to limit it to areas of the target that might contain the feature you are looking for or disable [Use Region] so that the tool can locate instances of the feature in all of the scan data. You can also use the [Use Region] parameter when creating a template to limit it to a unique portion of an outer edge of a target.

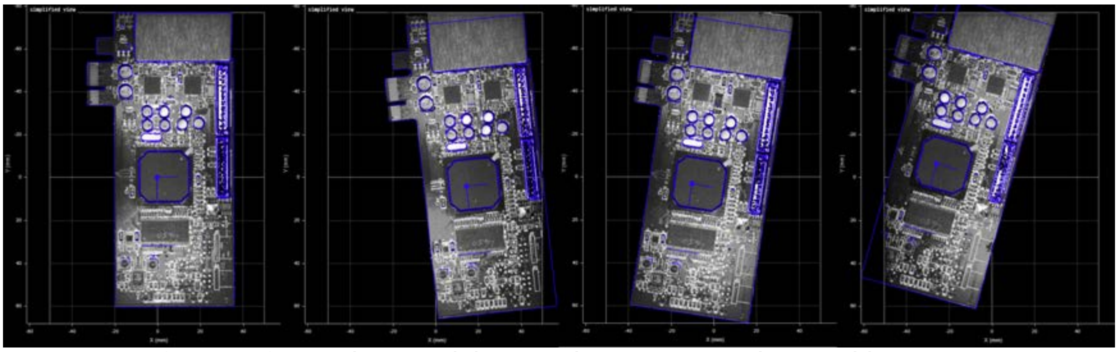

simplified view
Y (mm)
X (mm)



Measurement Panel

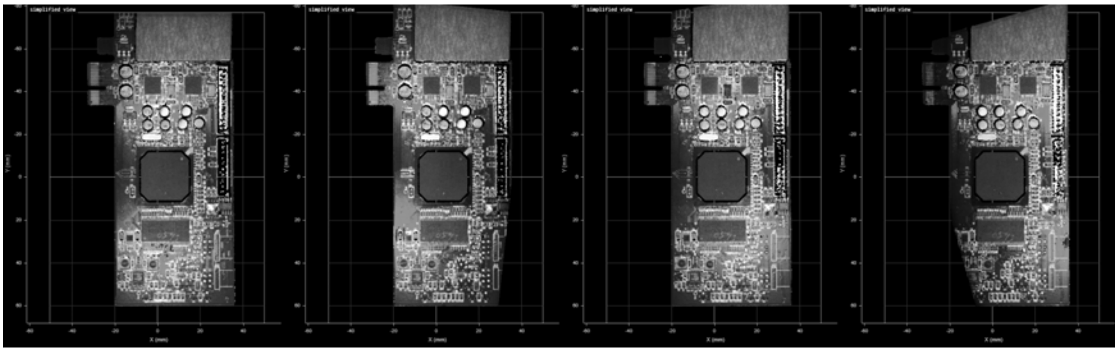
For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

Note that when you use the geometric features with a Surface Transform tool to transform the scan data from frame to frame, you can often avoid the need to anchor other measurements, because the transforms ensure that any features you are interested are always in the same location. This can save considerable setup time and reduce the complexity of an application. For example, in the following frames of scan data, in which a PCB shifts from frame to frame, a Surface Pattern Matching tool successfully locates the entire PCB using its outer contours and the contours of various components on the PCB, as indicated by a dark blue outline. Note the “missing” data in the second and fourth frames, on the lower right and left edges, respectively: the tool still locates the PCB, despite the occlusions.



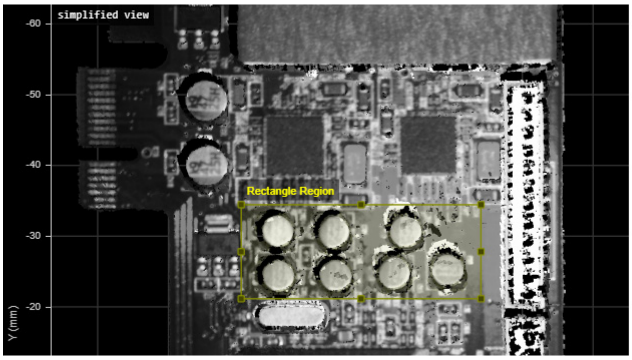
Four frames of scan data. Dark blue outline represents the matching template.
The first frame was used to create the template.

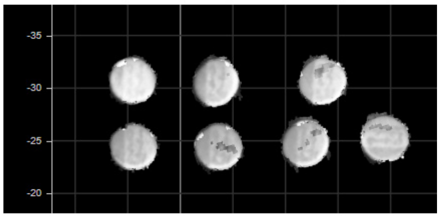
When the tool's Point and Line geometric features are passed to a Surface Transform tool, the transformed scan data ensures that, for example, the set of seven mid-sized capacitors above the main IC are always in the same location and orientation.



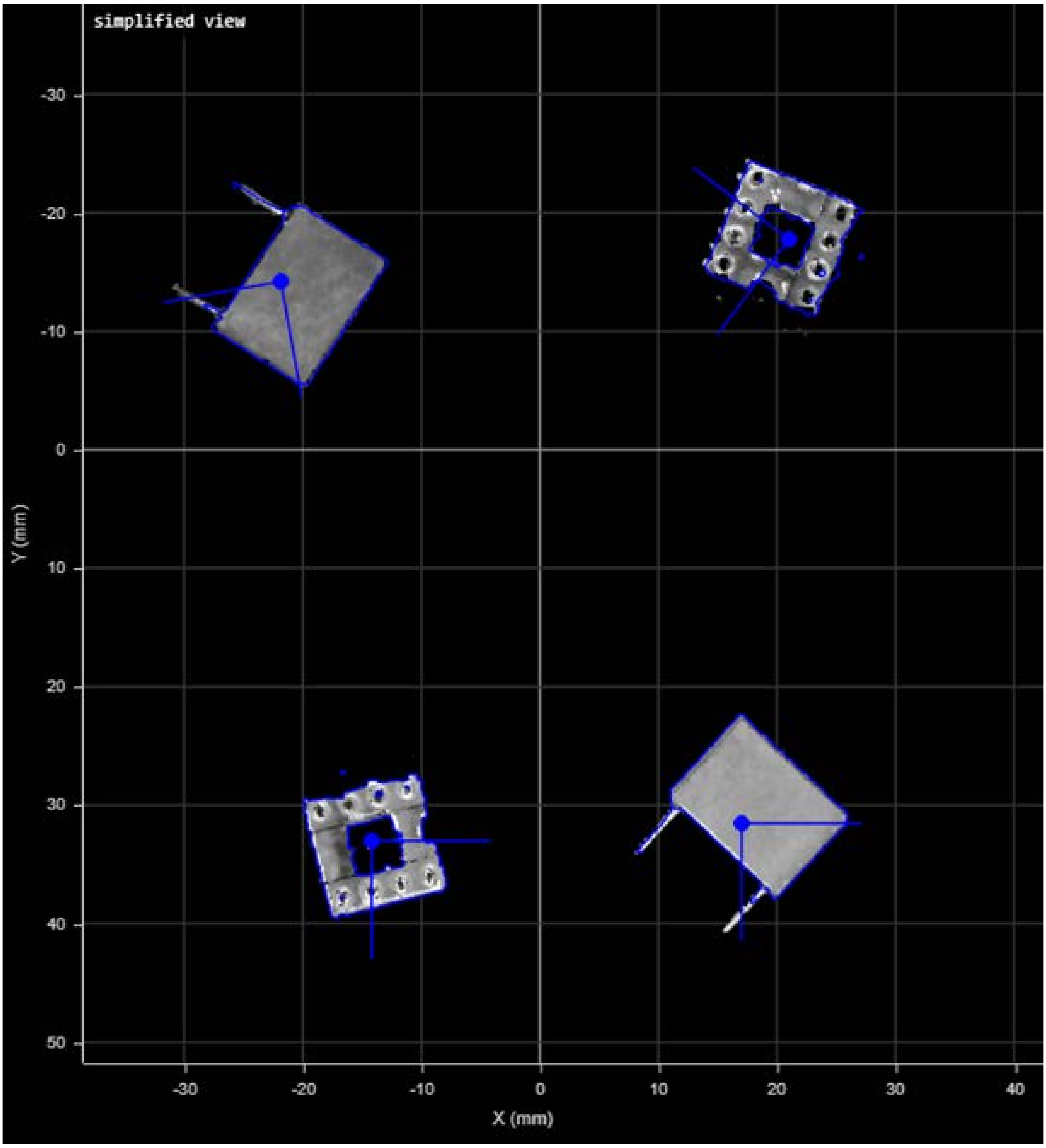
Transformed scan data of the four frames.

Other measurement tools can then be placed over the capacitors, without needing to anchor them. In the following image (the fourth frame, which was significantly shifted and rotated), a Surface Filter tool isolates the capacitors based on height. Subsequent tools can perform measurements on the isolated data to verify that all capacitors are present, are seated properly, and so on.



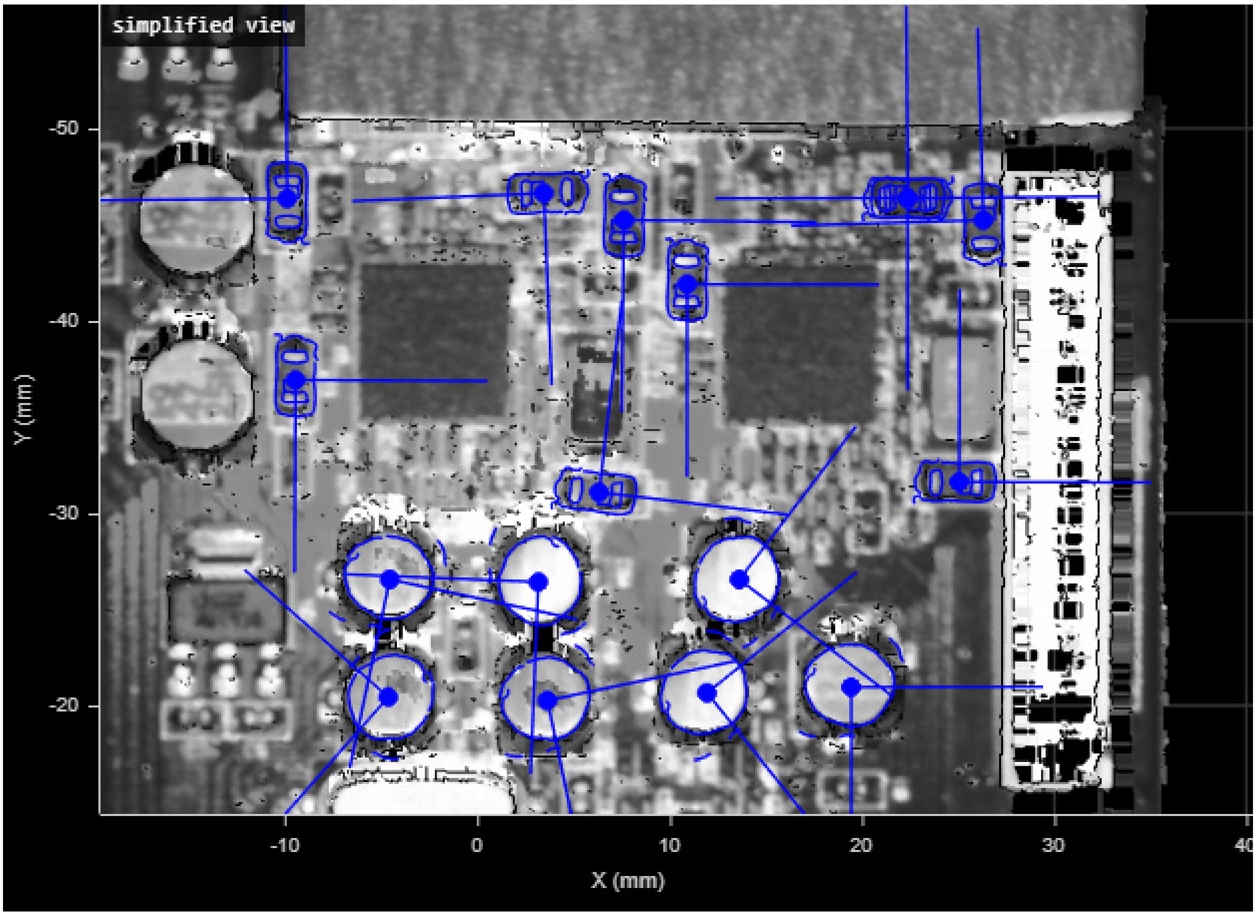


By adding multiple Surface Pattern Matching tools to a job and defining different templates for each, you can match multiple types of features or parts, for example, matching different parts moving on a conveyor.



Two copies of the Surface Pattern Matching tool matching parts using two different templates (one for the sockets, another for the capacitors). If used in conjunction with Part Detection, each part would be in an individual frame, matching templates as necessary.

Or you can match different types of features on a single target:



Rectangular surface mount components (two orientations) matching one template. Circular capacitors matching another template (matched orientations are arbitrary, because a circular contour is matched). In this case, intensity was used for template creation and matching.

- Creating a Template

To create a template:

1 **Scan a part that is typical (no damage, all features are present, etc.).**

2 **If you need to perform pattern matching on a feature on the part, enable [Use Region] and position the region over the feature.**

3 **In the [Operation] drop-down, choose Create.**

» The tool creates a model and saves it either to the PC (if the sensor is accelerated) or to the sensor.

After creating a template, configure the tool's parameters (see below) for use during production runs.

6.25.1 Measurements, Features, and Settings

[Measurements]

Measurement
[Instance Count] Returns the number of parts or features matching the loaded template up to the value set in the Instance Count parameter.
[X {n}] [Y {n}] The X and Y position of the center of matched instance {n}.
[Z Angle {n}] The angle of matched instance {n} relative to the sensor's coordinate system.
[Scale {n}] The scale of matched object {n} relative to the loaded template.
[Match Quality {n}] Percentage of matched model contours for the selected object instance. Match quality ranges from 0 to 100, with 100 being the best quality. A value of 100 means 100% of the model contours were successfully matched to the actual contours detected in the scan data. Use the [Minimum Match Quality] parameter to set the minimum acceptable value.

[Features]

Type	Description
[Point]	A point representing the center of the region used when creating a template and the template's default reference point. (Note that the reference point of a template can be changed in the model editor.)
Line	A line parallel to the X axis passing through the Point feature.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Use Region]	Determines whether the tool uses a user-defined region to search for matching instances, or, when first creating a template, whether the tool limits establishing template contours to the data in the ROI.
[Use Intensity]	Determines whether the tool uses intensity instead of heightmap data to locate instances or create templates.
[Instance Count]	The maximum number of instances the tool will locate.
[Nominal Scale Enabled]	If enabled, displays the [Nominal Scale] setting and the tool uses the user-defined nominal scale. Otherwise, the tool displays [Minimum Scale] and [Maximum Scale] settings and uses the user-defined range. (See below.)

Parameter	Description
[Nominal Scale]	The scale factor the tool requires to recognize an instance. Displayed when [Nominal Scale Enabled] is enabled.
[Minimum Scale] [Maximum Scale]	The maximum and minimum scale factors allowed for the tool to recognize an instance, respectively. Displayed when [Nominal Scale Enabled] is disabled.
[Nominal Angle Enabled]	If enabled, displays the [Nominal Angle] setting and the tool uses the user-defined nominal angle. Otherwise, the tool displays [Minimum Angle] and [Maximum Angle] settings and uses the user-defined range. (See below.)
[Nominal Angle]	The angle the tool requires to recognize an instance. Displayed when [Nominal Angle Enabled] is enabled.
[Minimum Angle] [Maximum Angle]	The maximum and minimum angles allowed for the tool to recognize an instance, respectively. Displayed when [Nominal Angle Enabled] is disabled.
[Minimum Match Quality]	Minimum percentage of template contours that must match in the scan data for the tool to consider the object instance as valid.
[Show Details]	Toggles whether to overlay a blue outline over scan data representing the currently loaded template's contours.
[File]	A drop-down containing the currently available templates.
[Operation]	The operation to perform on the currently selected template in the File drop-down. One of the following: [Normal]: The default value after having performed another operation. [Create]: Creates a new template based on the current frame of scan data. Delimited to the region if [Use Region] is enabled. [Load]: Loads the currently selected template. [Save]: Saves contour data to the currently selected template, overwriting its contour data. [Delete]: Deletes the currently selected template.
[Advanced]	Displays the following additional advanced parameters. [Recognition Level] The "effort" the tool will expend on recognizing an instance in scan data. Ranges from Fast to Accurate (that is, there is a trade-off between accuracy and speed). Only used during pattern matching (and not during pattern template creation). [Positioning Level] How accurately the tool determines the position of the instance. Ranges from Fast to Accurate. Only used during pattern matching (and not during pattern template creation). [Add Border] Consider a drop to NULL, outside the region, as an edge. Use this when performing part detection or when there is no data around the part. If there is nothing in the region, then there will be nothing in the template either.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

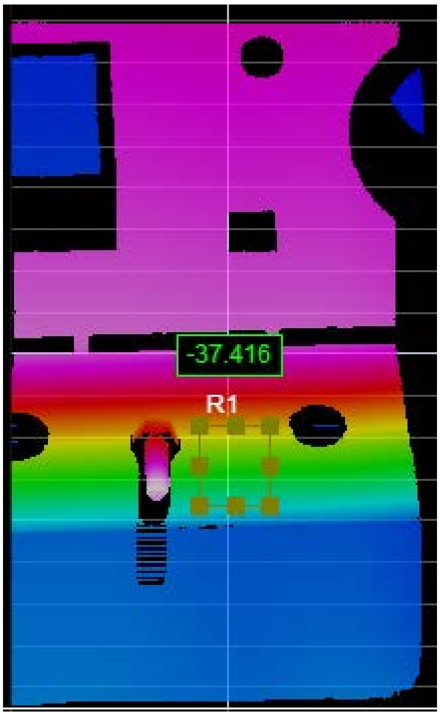
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.26 Plane

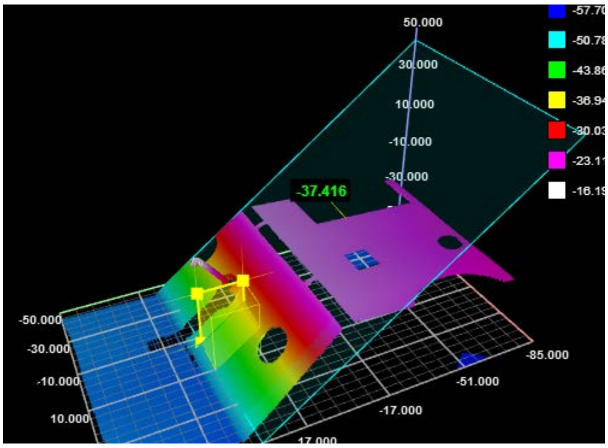
The Plane tool provides measurements that report a plane's position and orientation (X Angle, Y Angle, Z Offset, Normal, Distance), as well as the maximum and average deviations from the plane.

The Z offset reported is the Z position at zero position on the X axis and the Y axis.

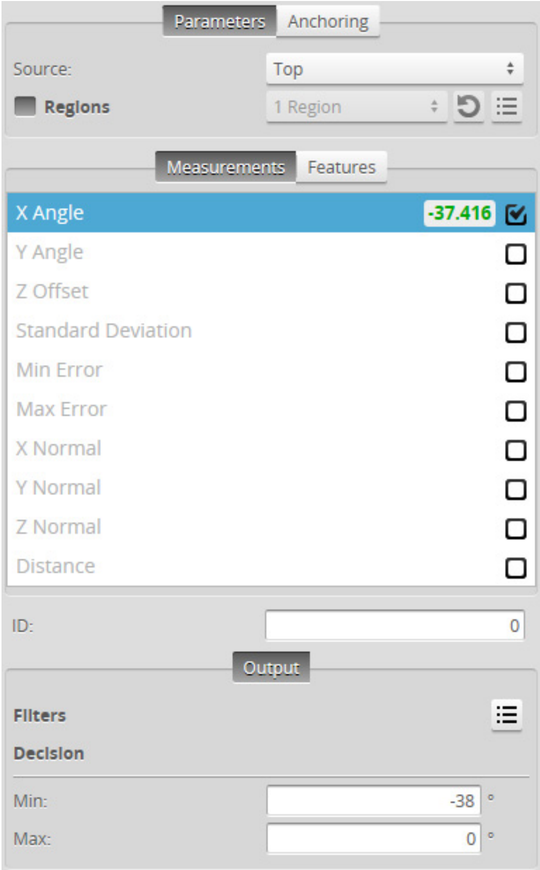
The results of the Angle X and Angle Y measurements can be used to manually customize the tilt angle in the Hole, Opening, and Stud tools.



2D View



3D View

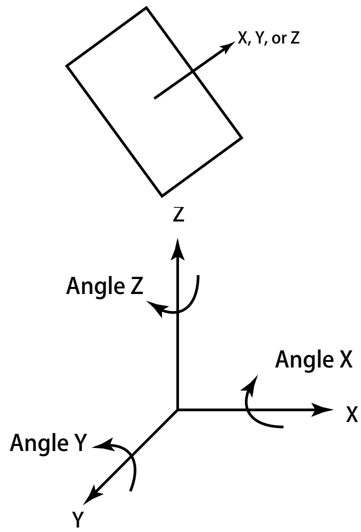


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.26.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Angle X] Determines the X angle of the surface with respect to the alignment target.	
[Angle Y] Determines the Y angle of the surface with respect to the alignment target.	
[Offset Z] Determines the Z value of intersection of the plane and the Z axis.	
[Standard Deviation] Measures the standard deviation of the points of the surface from the detected plane within the specified region or regions.	
[Min Error] Measures the minimum error from the detected plane (the maximum distance below the plane, perpendicular to the plane) within the specified region or regions.	
[Max Error] Measures the maximum error from the detected plane (the maximum distance above the plane, perpendicular to the plane) within the specified region or regions.	
[X Normal] Returns the X component of the surface normal vector.	
[Y Normal] Returns the Y component of the surface normal vector.	
[Z Normal] Returns the Z component of the surface normal vector.	
[Distance] Distance from the origin to the plane.	

[Features]

Type	Description
[Plane]	The fitted plane.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Regions]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

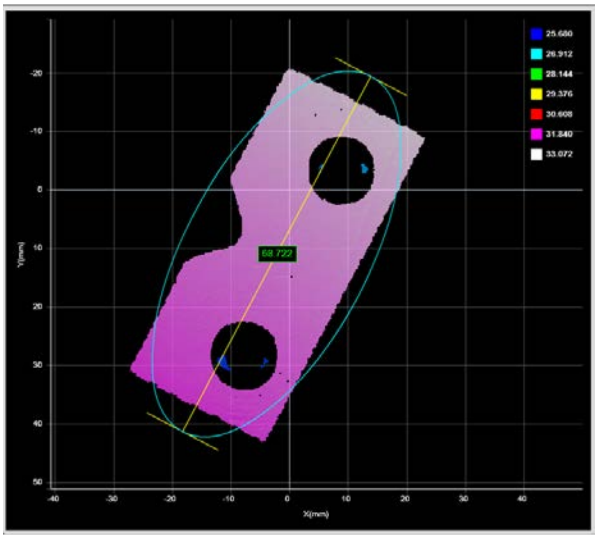
Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

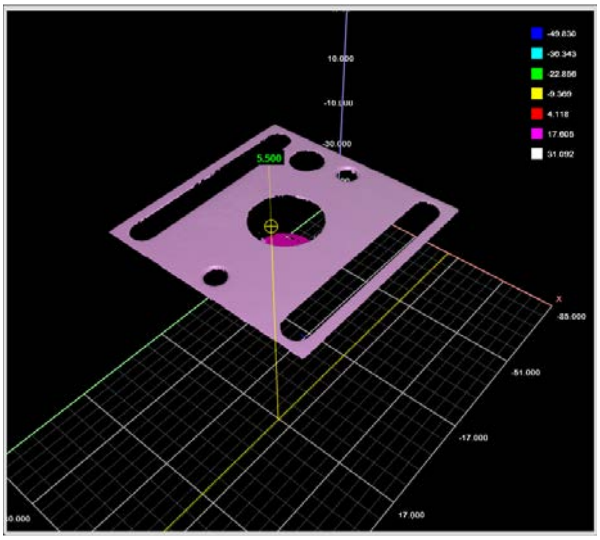
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.27 Position

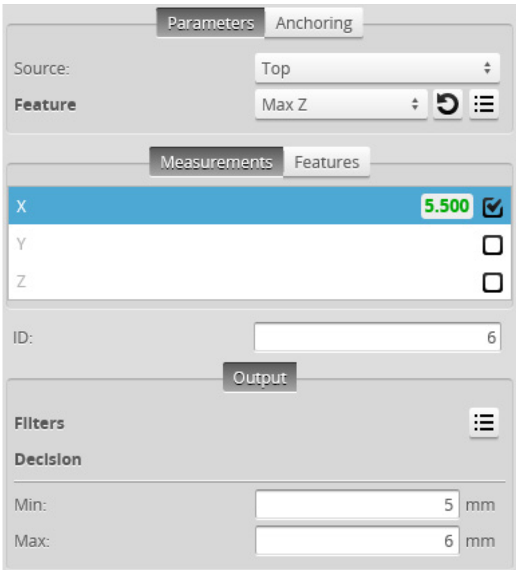
The Position tool reports the X, Y, or Z position of a part. The feature type must be specified and is one of the following: Average (the mean X, Y, and Z of the data points), Median (median X, Y, and Z of the data points), Centroid (the centroid of the data considered as a volume with respect to the z = 0 plane), Min X, Max X, Min Y, Max Y, Min Z, or Max Z.



2D View



3D View

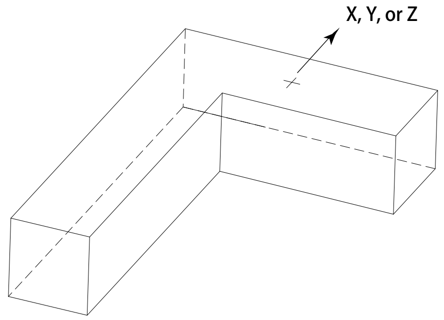


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.27.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[X] Determines the X position of the selected feature type.	
[Y] Determines the Y position of the selected feature type.	
[Z] Determines the Z position of the selected feature type.	

[Features]

Type	Description
[Center Point]	The returned position.

Tips

For more information on geometric features, see "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Feature]	The feature the tool uses for its measurements. One of the following: • [Average] • [Median] • [Centroid] • [Max X] • [Min X] • [Max Y] • [Min Y] • [Max Z] • [Min Z] To set the region of a feature, adjust it graphically in the data viewer, or expand the feature using the expand button (☰) and enter the values in the fields. For more information on regions, see "●Regions" on page 238.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

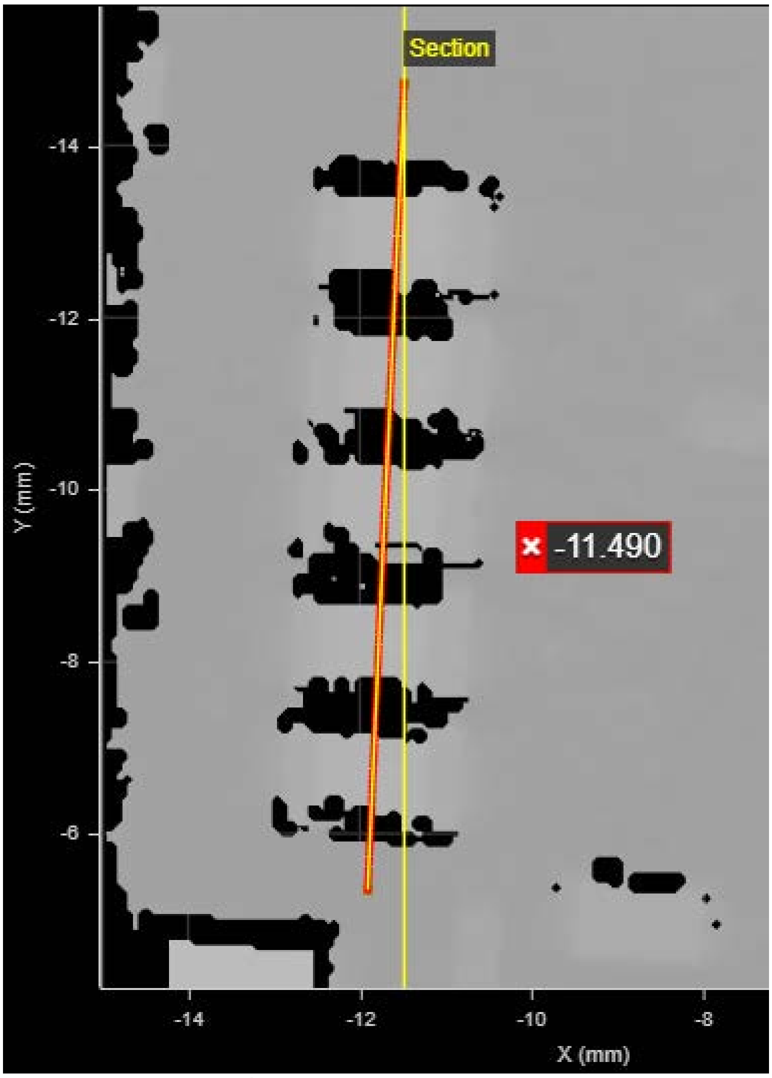
Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

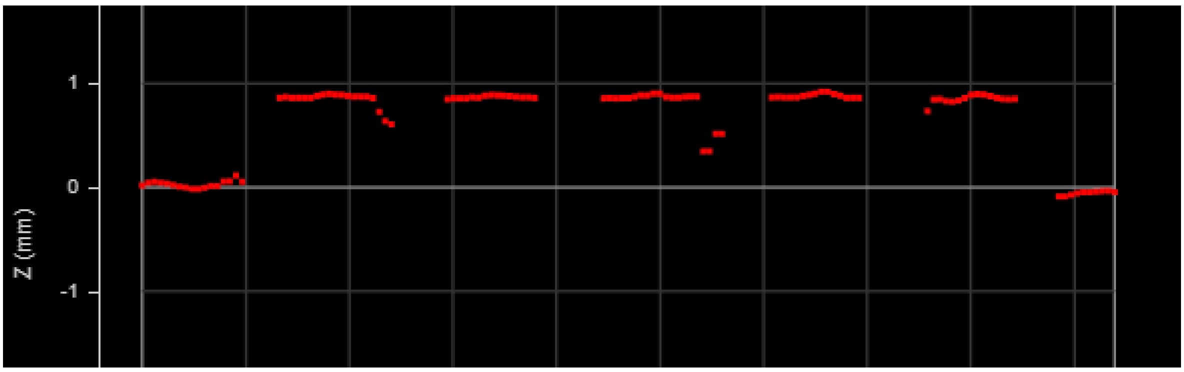
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.28 Section

The Surface Section tool lets you define a line on a surface (a "section") from which the tool extracts a profile. You can apply any Profile tool to the resulting profile (see "5 Profile Measurement" on page 343). Note that a section can have any XY orientation on the surface, but its profile is parallel to the Z axis.



A section over a row of components



The resulting profile

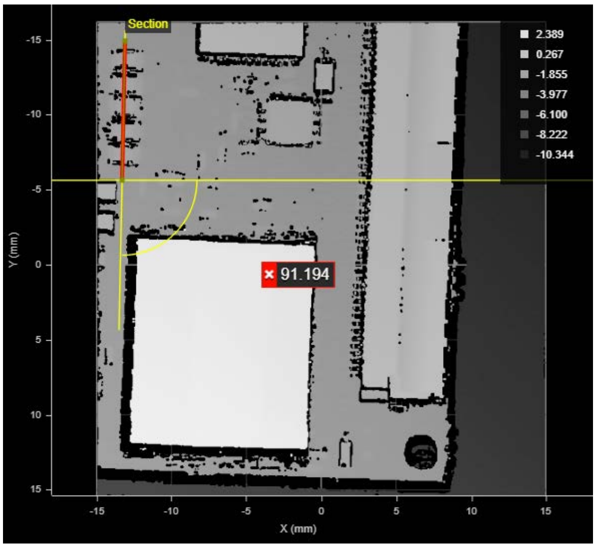
Note that profiles extracted from surfaces start at the point defined as the X/Y Start of the section. Profiles are always displayed horizontally, with X increasing to the right. The origin of extracted profiles is the beginning of the section, and not relative to the surface from which they are extracted.

The Surface Section tool provides functionality similar to sections you can define on the Models page (see "4.6 Models" on page 209). However, the Surface Section tool has a few advantages.

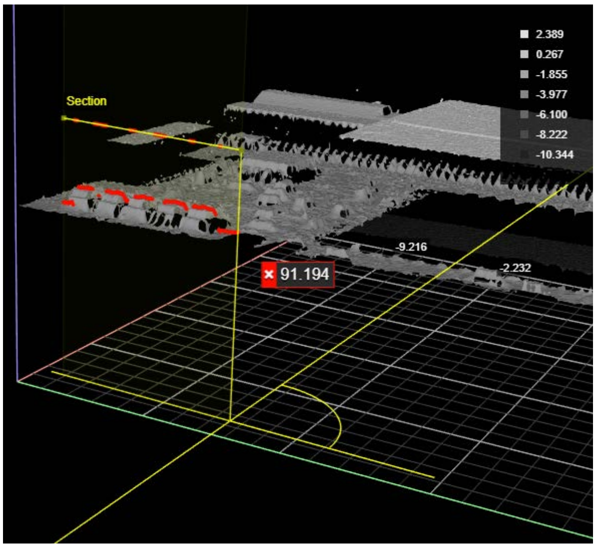
One advantage of the Surface Section tool is that you can anchor the tool to some other easily identifiable feature on the scan target, which "shifts" the section in relation to that feature: this increases repeatability.

Another advantage is that unlike sectioning generated from the Model page, the Surface Section can take any surface as input, such as a combined surface (using Surface Extend or Stitch), a transformed surface (using Surface Transformation), a filtered / corrected (Surface Filter and Surface Vibration Correction), and so on.

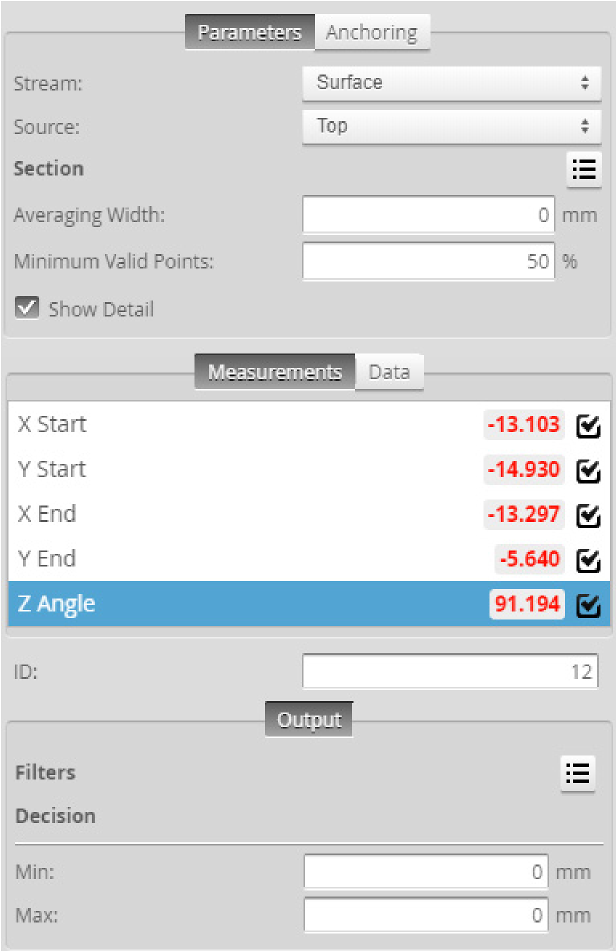
Finally, the Surface Section tool provides measurements useful for calculating the global X/Y coordinates of the resulting profile, using a Script tool see "6.38 Script" on page 625. Even if you don't use anchors or the measurements, Mitutoyo recommends using the Surface Section tool over model-based sections.



2D View



3D View



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.28.1 Measurements, Data, and Settings

[Measurements]

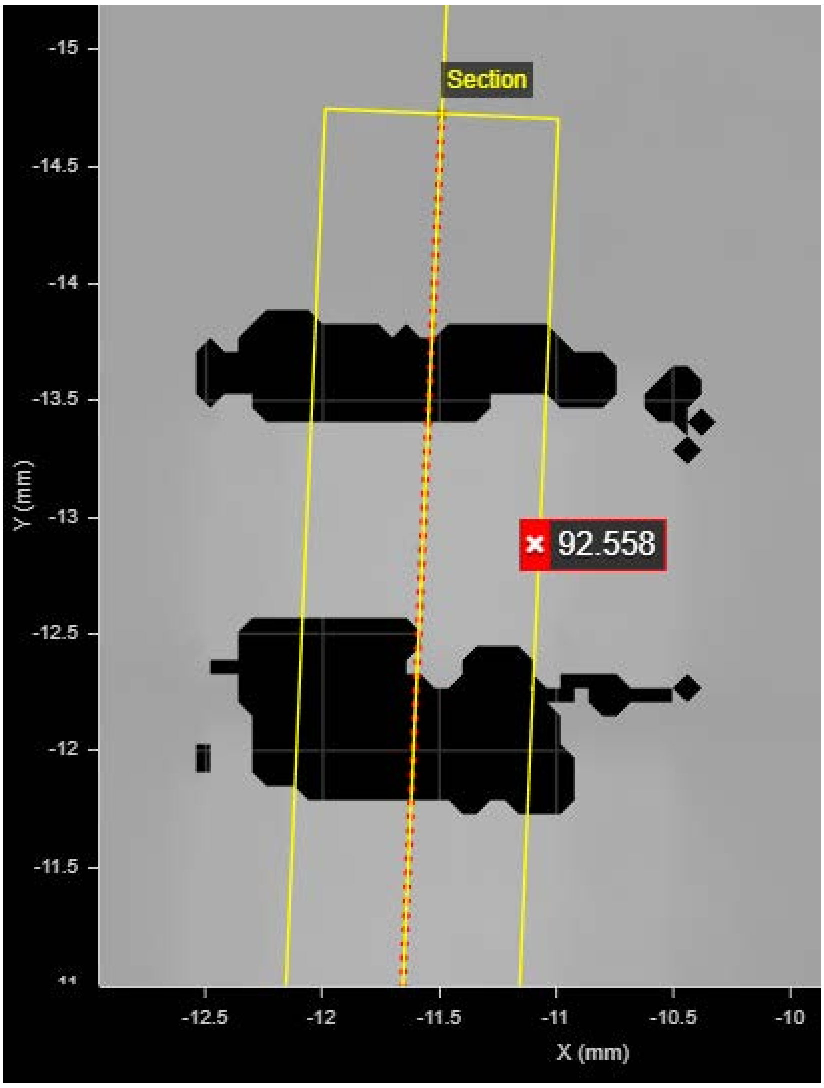
Measurement	
[X Start] [Y Start]	These measurements return the X and Y position of the start of the section, respectively.
[X End] [Y End]	These measurements return the X and Y position of the end of the section, respectively.
[Z Angle]	Returns the rotation of the section around the Z axis.

[Data]

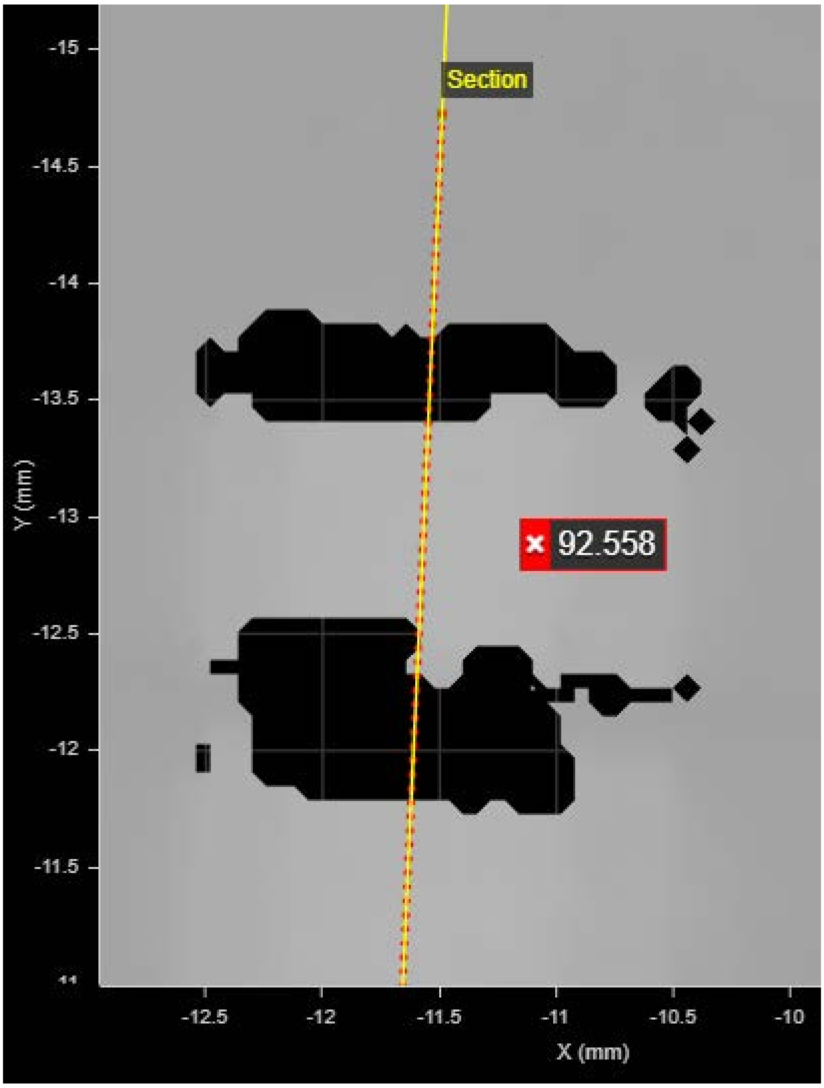
Type	Description
[Profile]	The profile the tool extracts from the surface. Available to profile tools for profile measurement.

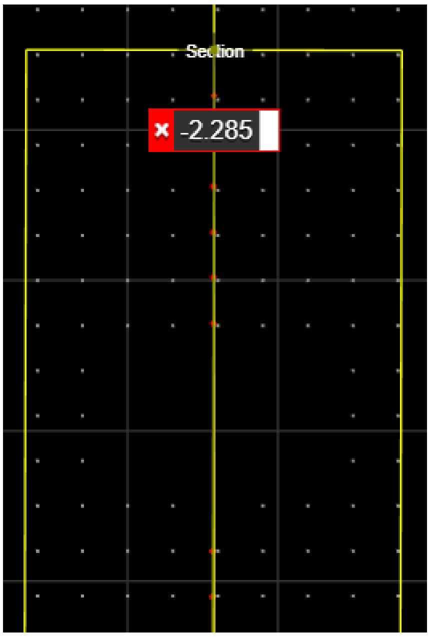
[Parameters]

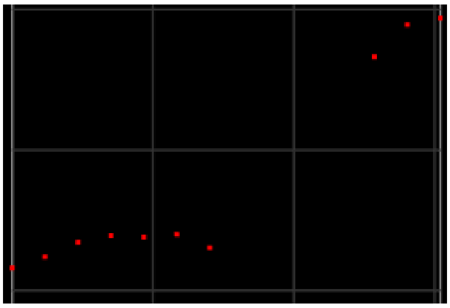
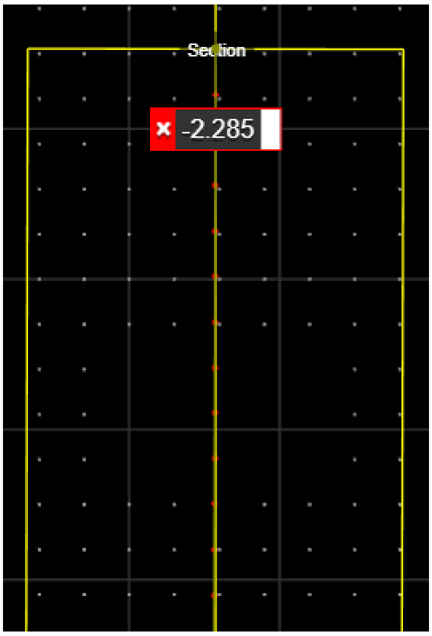
Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Section]	Contains the coordinates of the two points that define the section.  [Point] The point to configure (1 or 2). [X], [Y], [Z] The coordinates of the point selected in [Point].

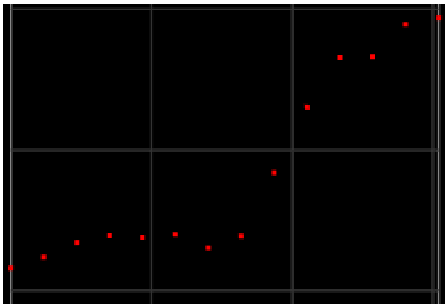
<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Averaging Width]</td><td>The width, in millimeters, of a window in which averaging of data points perpendicular to the section occurs. Use this to compensate for noise around the section.
In the following, [Averaging Width] is set to 1. The red dots, representing the data points of the extracted profile, are the result of averaging the neighboring points along a line perpendicular to the section. When non-zero, this setting works in conjunction with the [Minimum Valid Points] setting (see below).


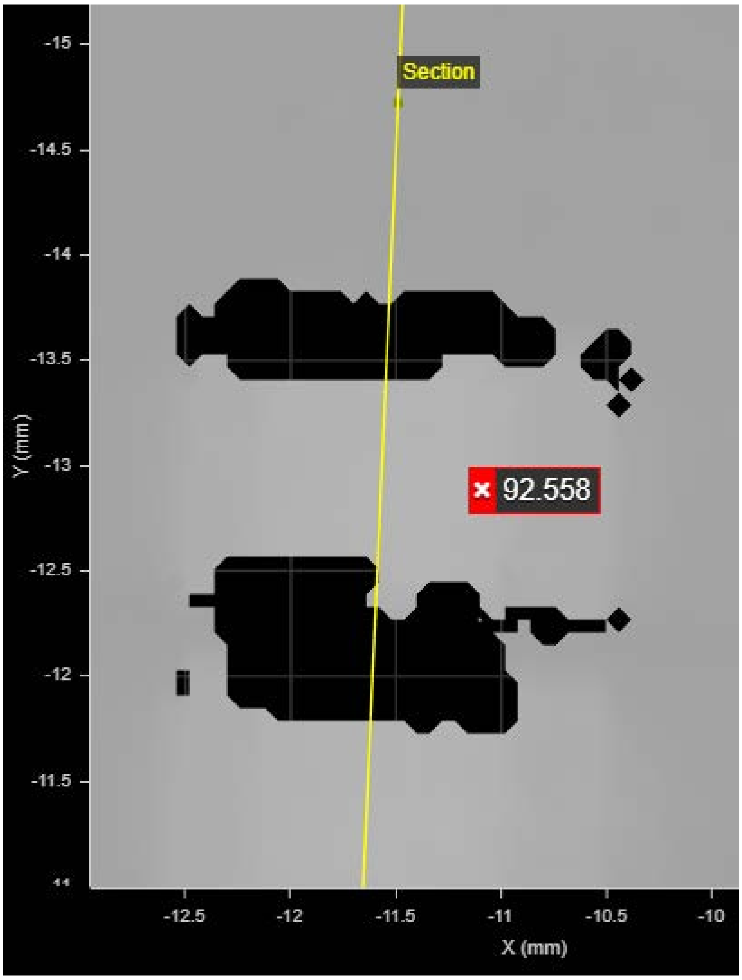
When set to 0, only data points directly under that section are used in the profile.</td></tr>
</table>

Parameter	Description
	

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Minimum Valid Points]</td><td>
When [Averaging Width] is non-zero, the minimum percentage of neighboring points across the averaging width (perpendicular to the section) that need to be valid for a point to be output on the resulting profile.
With the following Surface scan data (zoomed in and with the data viewer set to show individual data points), [Minimum Valid Points] has been set to 100%. As a result, no data points are output to the profile in the area that lacks valid data points (see profile to the right).



But with the following scan data, [Minimum Valid Points] has been set much lower, to 10%. As a result, the three or four data points to each side of the void are enough for an average to be calculated, and points are included in that area in the profile.



</td></tr>
</table>

Parameter	Description
[Show Detail]	Determines whether data points (in red) are displayed under the section in the data viewer. If this setting is disabled (as shown below), only the yellow line representing the defined section is displayed. 
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.29 Segmentation

> **Tips**
> The tool is supported in emulator scenarios.

The Segmentation tool separates surface data into "segments," based on the tool's parameters. Segments can be touching and overlapping to a certain degree. The Segmentation tool is especially useful in the food industry, for example to identify food items that are too small or too big, or items that are damaged.

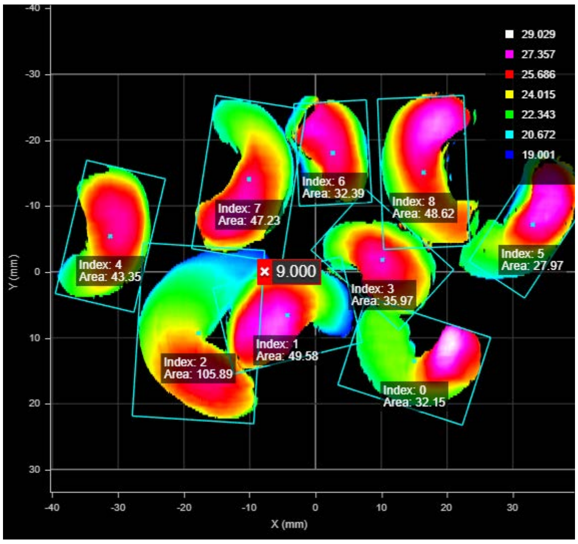
For each segment, the tool returns the X and Y position of its center, its length and width, and its area, as well as several more global measurements, such as maximum / minimum width or length, etc. For a complete list, see below.

The Segmentation tool can also be used as a second stage of processing after part detection. For example, part detection could be used to detect a tray (containing parts), and the Segmentation tool could then separate the parts within the tray. For information on part detection, see 📖 "4.4.7 Part Detection" on page 149. For a comparison of part detection, Surface Blob, and Surface Segmentation, see 📖 "6.1 Isolating Parts from Surface Data" on page 421.

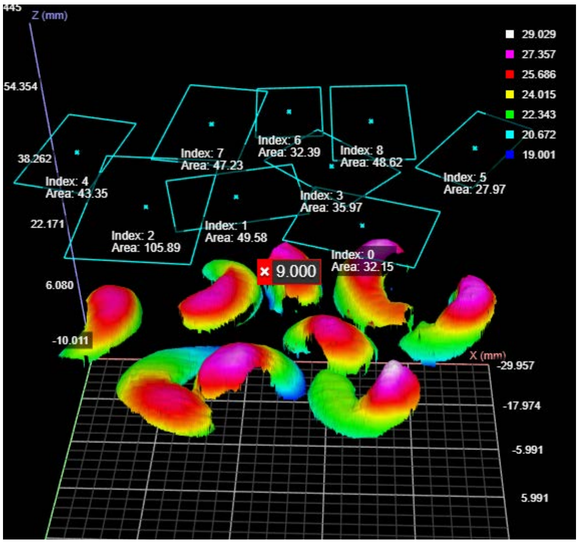
> **Tips**
> The Segmentation tool cannot handle large overlaps.

> **Tips**
> The Segmentation tool does not perform template matching.

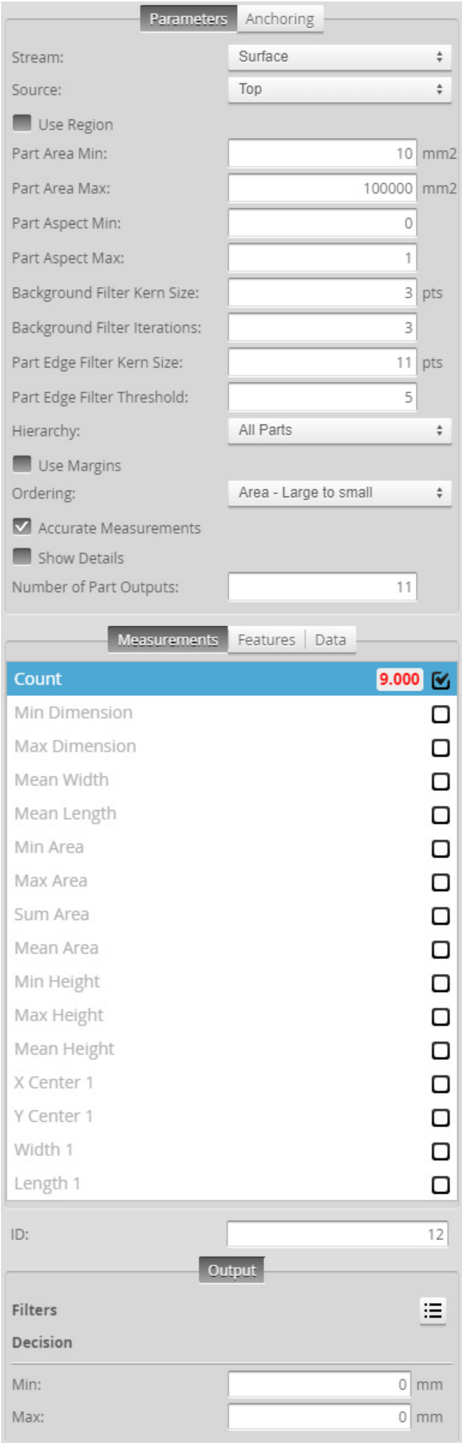
> **Tips**
> To reduce processing time, consider using the decimation filter. For more information on this filter, see 📖 "●Filters" on page 253.



2D View



3D View



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.29.1 Measurements, Data, and Settings

[Measurements]

Measurement	Description
[Count]	Returns the total number of segments identified, based on the tool's parameters.
[Min Dimension] [Max Dimension]	The minimum and maximum dimensions among all of the identified segments.
[Mean Width] [Mean Length]	The mean width and length of the segments, respectively.
[Min Area] [Max Area]	The minimum and maximum area among all of the identified segments.
[Sum Area]	The sum of the areas of the segments.
[Mean Area]	The mean area of the segments.
[Min Height] [Max Height]	The minimum and maximum heights among all of the identified segments.
[Mean Height]	The mean height of the segments.
[X Center {n}] [Y Center {n}]	The X and Y positions of the center of a part segmented from the surface. The [Number of Part Outputs] setting determines the number of measurements listed in the [Measurements] tab.
[Length {n}] [Width {n}]	The length and width of a part segmented from the surface. These are always the major and minor axis of a part, respectively. The [Number of Part Outputs] setting determines the number of measurements listed in the [Measurements] tab.
[Area {n}]	The area of a part segmented from the surface. The area is calculated using the contour of the part and resampling. For this reason, areas calculated using the Surface Volume tool will produce different measurements; for more information, see "[Area]" on page 624.

[Features]

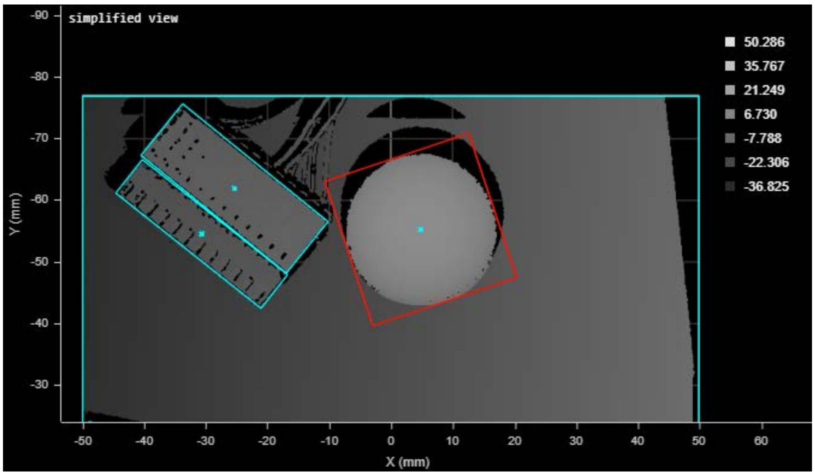
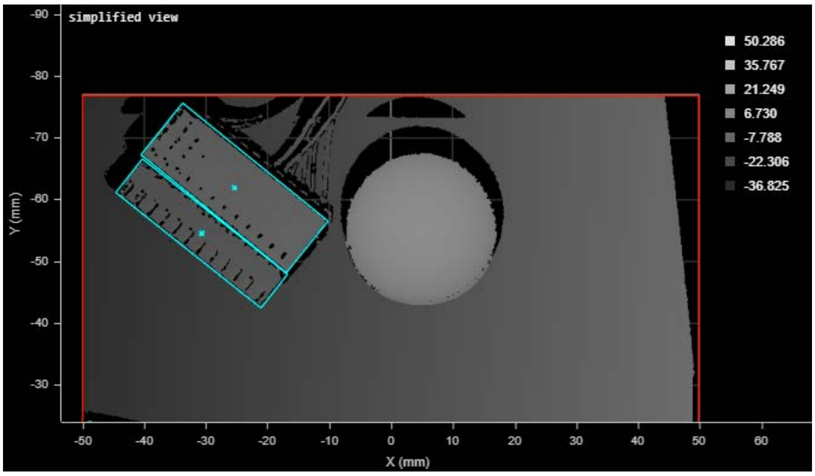
Type	Description
[Center Point {n}]	The point representing the center of a segmented part. The [Number of Part Outputs] setting determines the number of point geometric features listed in the [Features] tab.

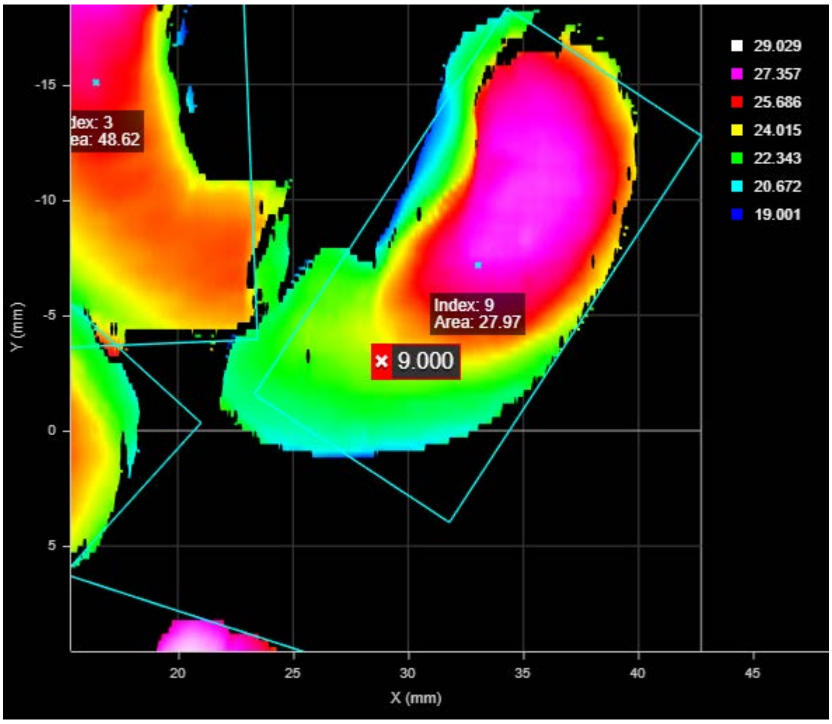
[Data]

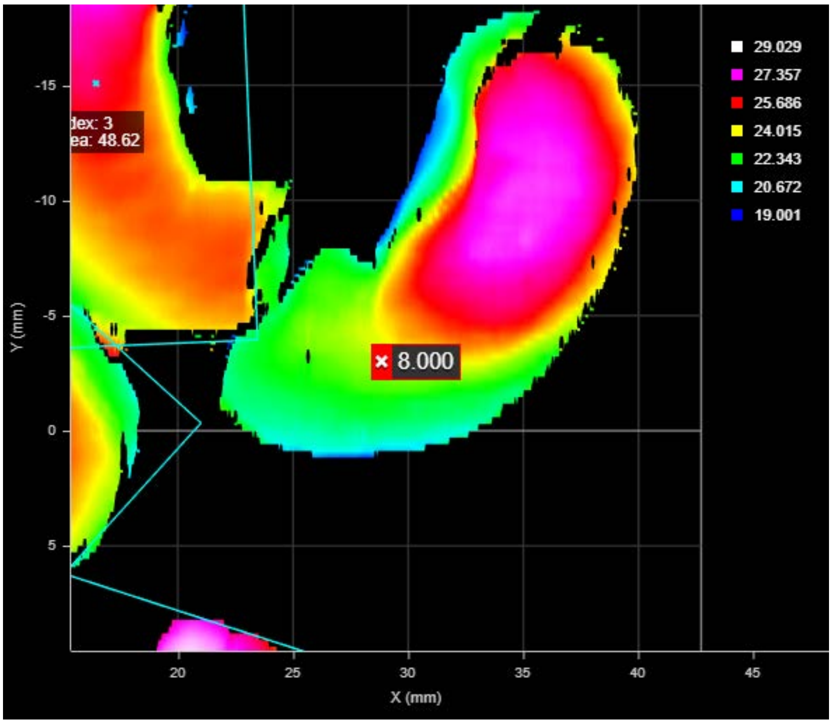
Type	Description
[Segments Array]	An array containing the segments. For an example of how to access this data from an SDK application or a GDK tool, see the appropriate sample in the SDK samples; for more information, see "11.1.1 Setup and Locations" on page 948.
[Diagnostics Surface]	Surface data you can use to evaluate the impact of the tool's kern size and iteration settings, which the tool uses to separate potential segments.
[Surface {n}]	Surface data corresponding to each segmented part.

[Parameters]

Parameter	Description
[Source]	The sensor that provides data for the tool's measurements.
[Use Intensity]	Causes the tool to use intensity. The option is only displayed if intensity data is available.
[Use Region]	Only displayed on older instances of this tool. Newer instances use "flexible regions" (see the parameters below in this table). Indicates whether the tool uses a user-defined region. If this option is not checked, the tool uses data from the entire active area.
[Number of Regions] [Mask Type {n}] / [Region Type {n}] [Inner Circle Diameter] [Inner Ellipse Major Axis] [Inner Ellipse Minor Axis] [Sector Start Angle] [Sector Angle Range] [Mask Source] [Low Threshold] [High Threshold]	Only displayed on newer instances of this tool. When you enable [Use Region], the tool displays additional settings related to the measure region type. For details on flexible regions and their settings, see "• Flexible Regions" on page 240. For general information on regions and the difference between standard and "flexible" regions, see "●Regions" on page 238.
[Part Area Min] [Part Area Max]	The minimum and maximum areas in square millimeters for a part of the scan data to be identified as a segment.
[Part Aspect Min] [Part Aspect Max]	The minimum and maximum aspect ratios (minimum axis length in mm) / (maximum axis length in mm) of the best fit ellipse to the segment contour points for a segment to qualify to be added to the list of found segments.
[Background Filter Kern Size] [Background Filter Iterations]	These settings perform background separation. The greater each of these values is, the more separation will be achieved. You must find a balance that removes noise adequately without degrading the segment find quality.
[Part Edge Filter Kern Size]	Use this value to adjust the “granularity” of the part edge detection.
[Part Edge Filter Threshold]	Controls the separation of the parts, increasing the gap between the parts so that they can be detected more easily.

Parameter	Description
[Hierarchy]	Use this setting to detect segments when they are surrounded by background data. Choose one of the following: [All Parts] or [External Parts]. [All Parts] This option lets you segment parts with surrounding background data. This is the default behavior in firmware 6.0 and later. Jobs created using firmware 5.3 SR1 or earlier default to [External Parts] (see below). For example, in the following image, with [All Parts] selected, the sphere is correctly segmented from the surrounding background.  Note that this option may result in "over-segmentation": the tool may segment a part into two segments. [External Parts] In the following image, with [External Parts], the sphere is not identified as a segment because of the surrounding background. It is treated as part of a large segment that includes all of the background. (This "segment" is indicated by a red border that shows it's currently selected. Note that to exclude this kind of segment, you can set a maximum acceptable part area in the tool.) 

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>[Use Margins]</td><td>
When enabled, discards parts that are too close to the edge of the scanning area or the region, based on the left, right, top, and bottom values.
The tool filters the parts using the center point.
In the following, a part's center point is close to the edge of the XY scan area; the right margin is set to 0, so the part is not discarded. (Total part count is 9.)


In the following, the right margin has been set to 10 mm. Because the center point of the part is now within the margin, the tool discards the part. (Total part count is reduced to 8.)


</td></tr>
</table>

Parameter	Description
[Ordering]	Orders the measurements, features, and surface data of the individual parts output by the tool. Choose one of the following: • [Area - Large to small] • [Area - Small to large] • [Position - X increasing] • [Position - X decreasing] • [Position - Y increasing] • [Position - Y decreasing] • [Position - Z increasing] • [Position - Z decreasing]
[Show Details]	Toggles whether the tool displays the index and area of each individual part.
[Number of Part Outputs]	Determines the number of parts the tool outputs as measurements, features (center points of parts), and surface data. Currently limited to 200 parts.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X] or [Z]	Lets you choose the X or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

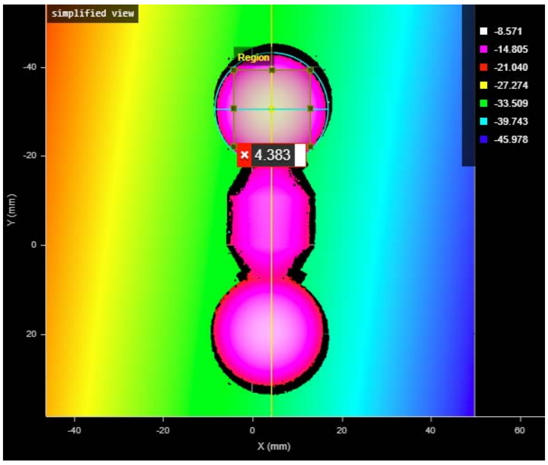
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

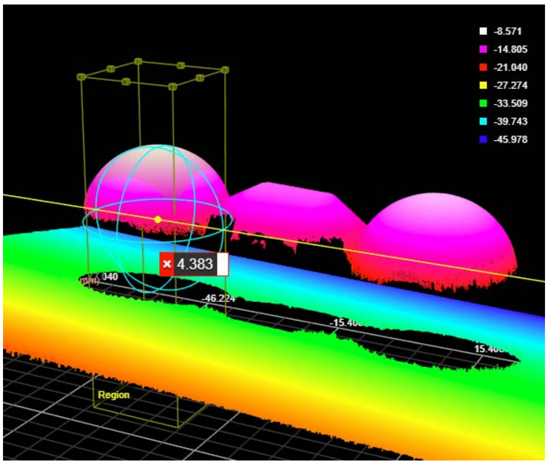
6.30 Sphere

The Sphere tool lets you compute characteristics of a scanned sphere by specifying a region to inspect. For example, you can use the tool to align a robot-mounted sensor to a ball-bar as shown in the images below.

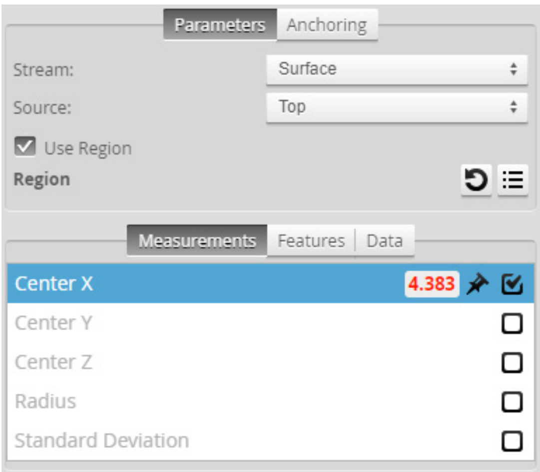
> **Tips**
> For the tool to work properly, the tool's region typically must be enabled and set, and properly placed. For more information, see the table of parameters below.



2D View



3D View

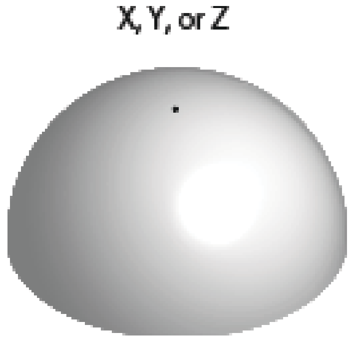
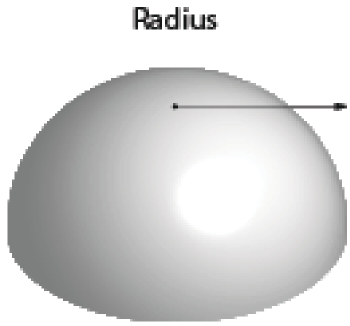


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.30.1 Measurements, Features, Data, and Settings

[Measurements]

Measurement	Illustration
[Center X] Determines the X position of the center of the sphere.	
[Center Y] Determines the Y position of the center of the sphere.	
[Center Z] Determines the Z position of the center of the sphere.	
[Radius] Determines the radius of the sphere.	
[Standard Deviation] Determines the error of the points compared to the computed sphere. It is defined as the square root of the variance of the distance of every point to the computed sphere.	

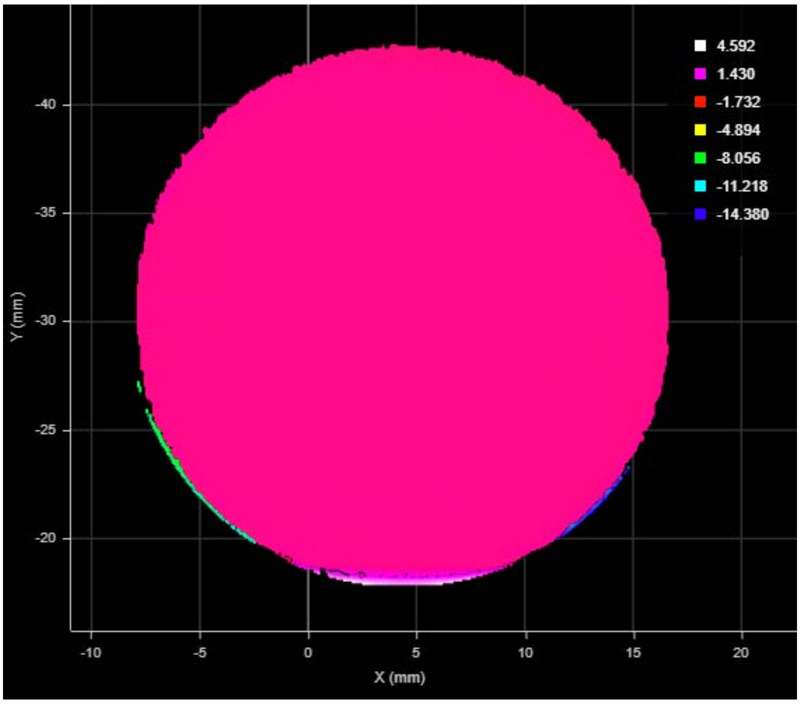
[Features]

Type	Description
[Center]	The center of the circle encompassing the widest part of the fitted sphere.
[Circle]	The circle encompassing the widest part of the fitted sphere.

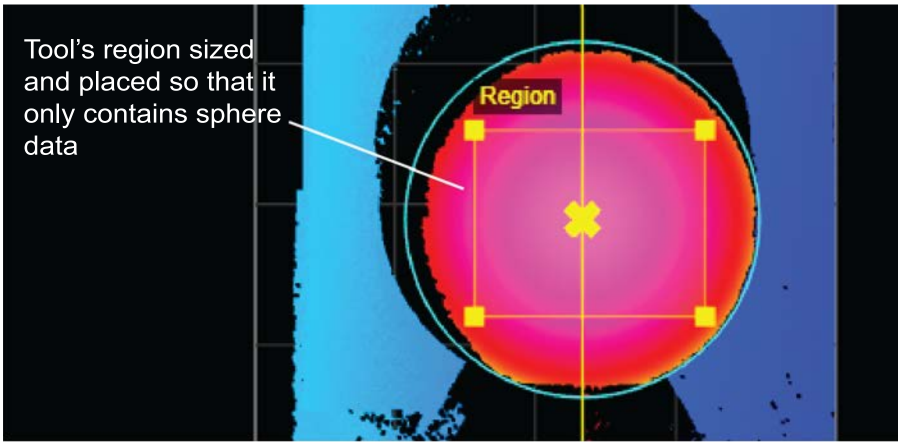
Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Data]

Type	Description
[Difference Surface]	Shows the fit error at each point in the height map. 

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Region]	The region to which the tool's measurements will apply. For more information, see 📖 "●Regions" on page 238. In order for the tool to correctly fit a sphere to the scan data, you must set the region so that it only contains data from the sphere on the target. 
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

6.31 Stitch

> **Tips**
> The tool is supported in emulator scenarios.

The Stitch tool lets you combine up to 24 frames of scans into a single Surface scan. This lets you get a much larger scan volume with fewer sensors (either in a single sensor system or a multi-sensor system). For each scan, you can specify not only X, Y, and Z offsets (translations), but also X, Y, and Z angles (rotations), defining its relationship with the others. This means that when the sensor system is mounted to a robot, or if you are using, for example, an X-Y table, you can get a complete scan with fewer sensors. The resulting combined scan can then be used as input by any other Surface or Feature tool from its [Stream] drop-down.

The tool performs rotation first, and then translation.

You cannot define sections on the combined scan; for more information on sections, see "4.6.3 Sections" on page 224.

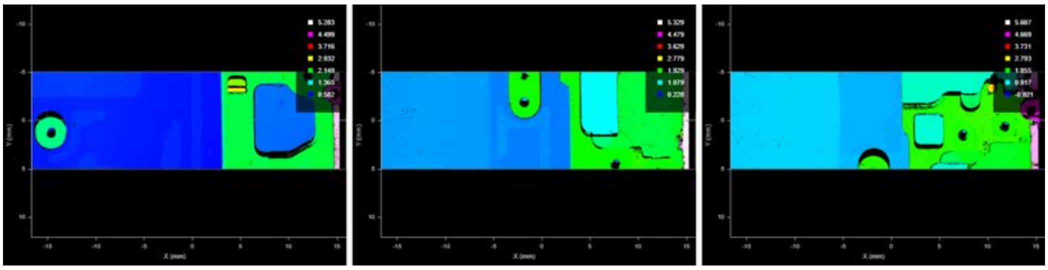
> **Tips**
> The tool combines data simply by overwriting in sequence: it performs no averaging or blending. The tool also performs no fitting.

> **Tips**
> Results are only as accurate as the motion system.

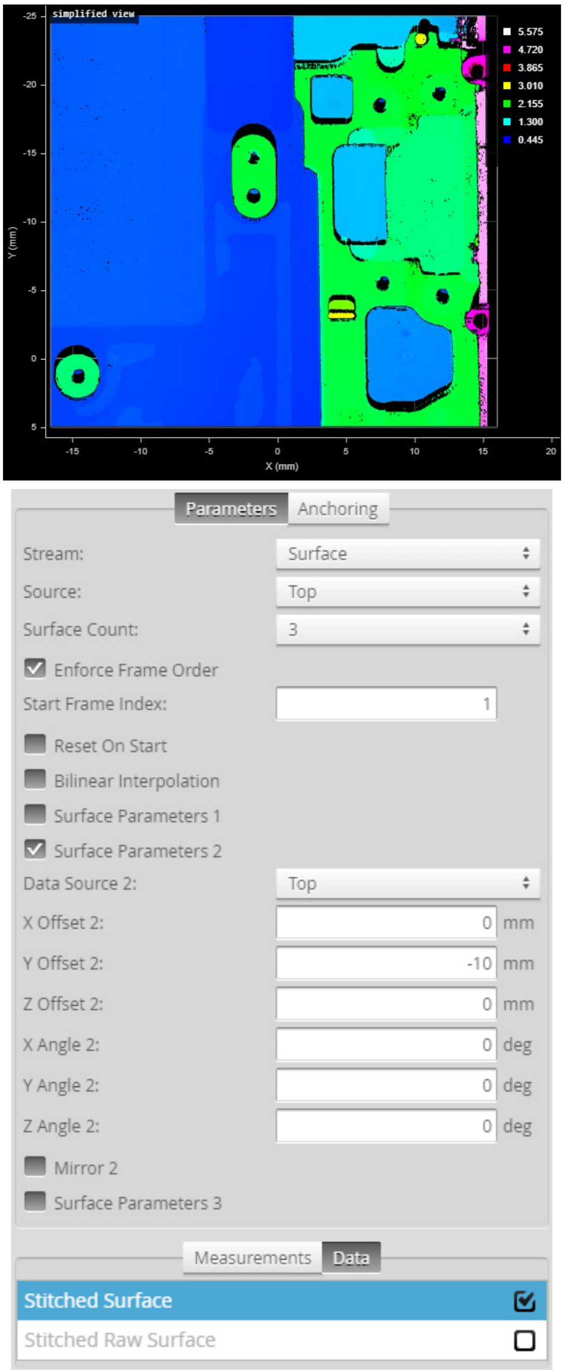
> **Tips**
> Seams are often seen in combined data in stitching performed in anything other than along the Y axis.

The tool returns one measurement, which simply indicates the number of scans successfully added to the combined scan data.

The following shows three individual frames:



In the following, the tool has combined the frames into a single surface.



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.31.1 Measurements, Data, and Settings

[Measurements]

Measurement	Description
[Captured]	Indicates the number of scans successfully added to the combined surface scan.

Tips

Only one of the following data types will contain data, depending on whether [Uniform Spacing] is enabled. For more information, see "4.4.2 Scan Modes" on page 116.

[Data]

Type	Description
[Stitched Surface]	The stitched surface scan, available for use as input in the [Stream] drop-down in other tools. Contains uniform data only and is empty if [Uniform Spacing] is disabled.
[Stitched Raw Surface]	The stitched surface scan, available for use as input in the [Stream] drop-down in other tools. Contains point cloud data only and is empty if [Uniform Spacing] is enabled.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Surface Count]	The number of scans to combine into a single surface. For each, a "Surface Parameters" section is added. The tool accepts setting the number of scans to one: in this case it, behaves like a transform tool.
[Enforce Frame Order]	Restricts the stitching for specific frame indexes, starting at the frame indicated in [Start Frame Index]. If unchecked, an [Operation] drop-down is displayed (see below). This setting is disabled if you attempt to stitch data from individual scans acquired using the Snapshot button (that is, all frame indexes are at 1).
[Operation]	If [Enforce Frame Order] is disabled, the [Operation] drop-down is displayed. One of the following: • [Normal]: The tool automatically chooses this operation after you have chosen another operation. • [Reset buffers]: Resets the buffers used to stitch frames. • [Lock]: Lets you lock the current processing and outputs of the tool. Useful when you need to add another tool that will use this tool's output (for example, a Surface Section tool). If you do not lock the tool, as soon as you add the other tool, the output is cleared, which means you must re-execute the combined output again to configure the additional tool. Be sure to unlock the tool after you have configured any other tools.
[Reset On Start]	Clears buffers for the stitched surface when the sensor is started. Useful for situations where the sensor is started and stopped frequently (to capture a small number of frames), rather than starting the sensor and letting it run for a long period. Enable this parameter to prevent data from a previous capture session being stitched with data from the current capture session.

Parameter	Description
[Bilinear Interpolation]	Evaluates the height of each transformed point (through translation or rotation) based on its neighbors. More precise, but has an impact on performance.
[Surface Parameters {n}]	For each scan to be added to the combined surface scan, a [Surface Parameters] checkbox is added. To configure the parameters of the individual surfaces, check the box and configure the settings. Unchecking the checkbox does not disable the scan or its settings. The following settings are available: • [Data Source] • [X, Y, and Z Offset] • [X, Y, and Z Angle]
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

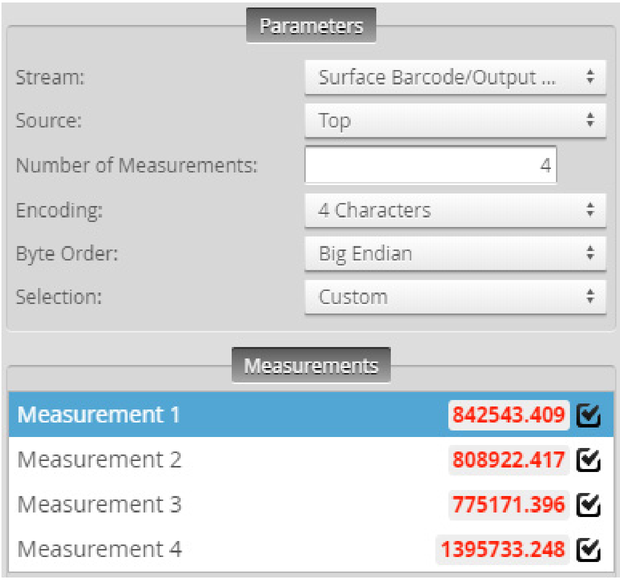
6.32 String Encoding

The tool is supported in emulator scenarios.

Tips

The String Encoding tool is only available from the drop-down in the [Tools] panel after a tool capable of providing compatible input, such as Surface Barcode or Surface OCR, has been added.

The String Encoding tool takes the string output from a Surface Barcode or Surface OCR tool and converts the characters to measurements that can be sent to PLCs. Measurements contain either a single value for each character, or a four-character string. You can set the endianness of the four-character string, letting you use the tool with any PLC.



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.32.1 Measurements and Settings

[Measurements]

Measurement	Description
[Measurement {n}]	A decimal representation of either a single character or a four-character string, depending on the value of the [Encoding] parameter. In both cases, values are displayed with a decimal point, and three places after the decimal point. The number of measurements is set by the [Number of Measurements] parameter. The last character is always a null terminator (\0). If the string passed to the tool is longer than the number of measurements will accommodate, the last character is truncated and replaced with \0.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stream]	The data that the tool will apply measurements to. This setting is only displayed when data from another tool is available as input for this tool. If you switch from one type of data to another (for example, from section profile data to surface data), currently set input features will become invalid, and you will need to choose features of the correct data type.
[Number of Measurements]	The number of measurements the tool adds.
[Encoding]	One of the following: [4 characters]: Each measurement contains a four-character string, encoded using the byte order chosen in the [Byte Order] parameter. [1 character]: Each measurement contains a single character.
[Byte Order]	Selects the byte order the tool uses to encode strings in the measurements. One of the following: Big Endian or Little Endian.
[Selection]	Measurement selection functions. One of the following: [Enable All]: Enables all of the measurements. [Disable All]: Disables all of the measurements. (This parameter defaults to “Custom” before and after performing a selection.)
[Filters]	The filters that are applied to measurement values before they are output. For more information, see 📖 "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

6.33 Stud

The Stud tool measures the location and radius of a stud.

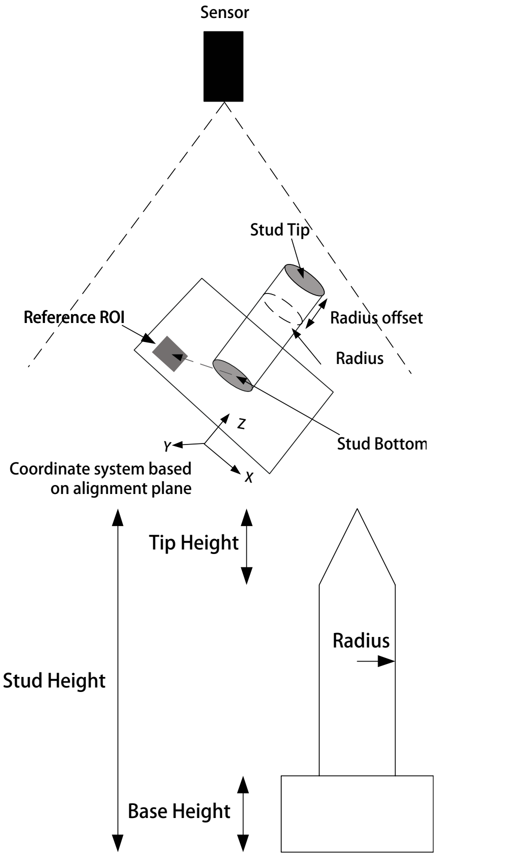
Tips

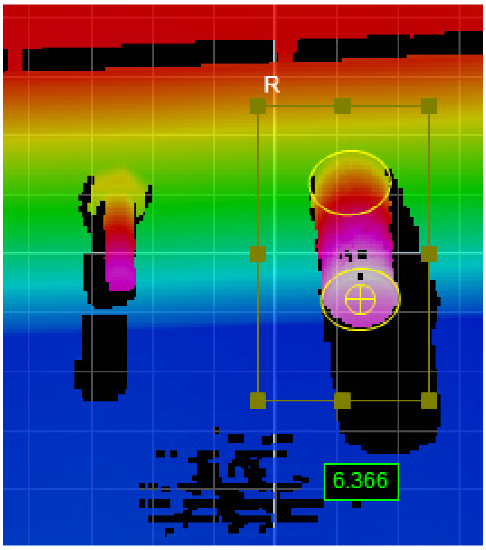
The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

The tool uses a complex feature-locating algorithm to find a hold and then return measurements. See "Stud Algorithm" in the SurfaceMeasure1008S Measurement Tool Technical Manual for a detailed explanation of the algorithm. The behavior of the algorithm can be adjusted by changing the parameters in the measurement panel.

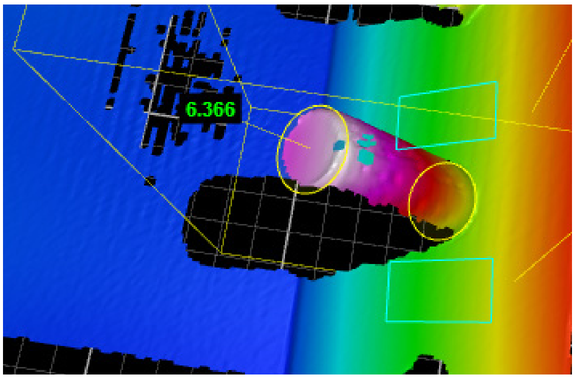
The location of the stud is defined at either the stud tip or the stud base. The tip is the intersection of the stud axis and the top of the stud; the base is the intersection of the stud axis and the surrounding plane.

The stud shape is defined by the tip height and base height. The base and tip heights specify where the shaft with the nominal radius begins and ends.

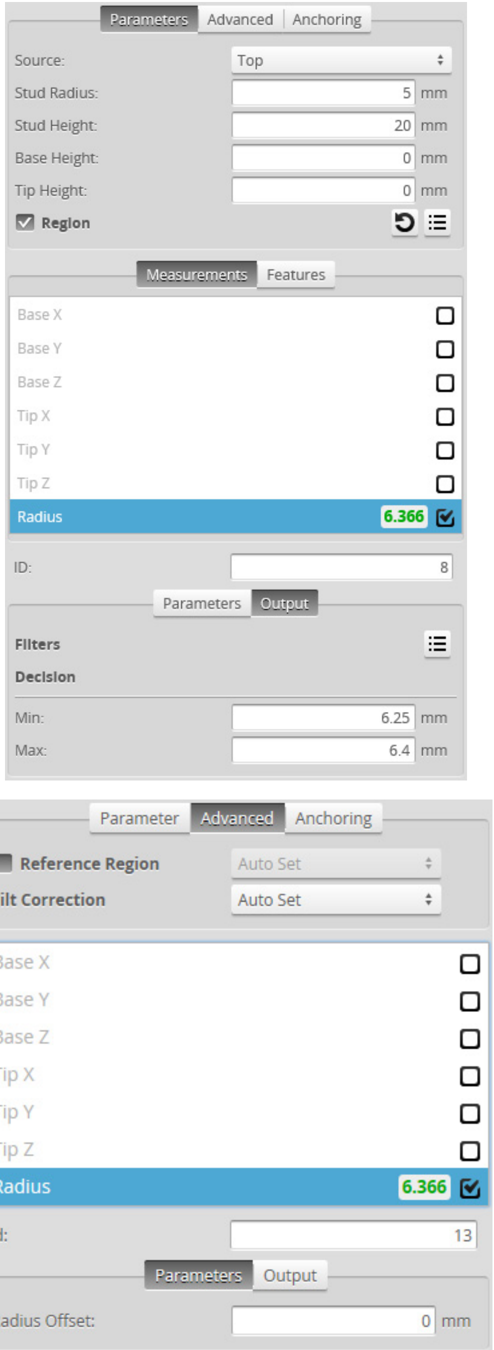




2D View



3D View

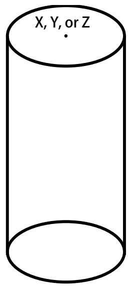
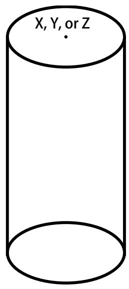
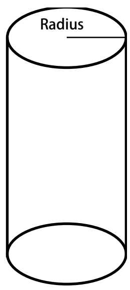


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.33.1 Measurements, Features, and Settings

[Measurements]

Measurement	Illustration
[Tip X] Determines the X position of the stud tip.	
[Tip Y] Determines the Y position of the stud tip.	
[Tip Z] Determines the Z position of the stud tip.	
[Base X] Determines the X position of the stud base.	
[Base Y] Determines the Y position of the stud base.	
[Base Z] Determines the Z position of the stud base.	
[Radius] Determines the radius of the stud.	

[Features]

Type	Description
[Tip Point]	The center point of the tip of the stud.
[Base Point]	The center point of the base of the stud.

Tips

For more information on geometric features, see 📖 "●Geometric Features" on page 250.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Stud Radius]	Expected radius of the stud.
[Stud Height]	Expected height/length of the stud.
[Base Height]	The height above the base surface that will be ignored when the (truncated) cone is fit to the stud data.

Parameter	Description
[Tip Height]	The height from the top of the surface that will be ignored when the (truncated) cone is fit to the stud data.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.
[Reference Regions]	The tool uses the reference regions to calculate the base plane of the stud. Reference regions are relative to the base of the stud.
[Tilt Correction]	Tilt of the target with respect to the alignment plane. [Autoset]: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes. [Custom]: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below).
[X Angle] [Y Angle]	The X and Y angles you must specify when [Tilt Correction] is set to [Custom]. You can use the Surface Plane tool's X Angle and Y Angle measurements to get the angle of the surrounding surface, and then copy those measurement's values to the [X Angle] and [Y Angle] parameters of this tool. For more information, see Plane.
[Radius Offset] (Radius measurement only)	The distance from the tip of the stud from which the radius is measured.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see "●Measurement Anchoring" on page 254.

6.33.2 Measurement Region

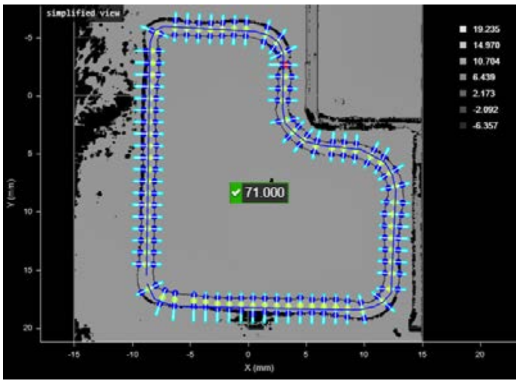
The tip and the side of the stud must be within the measurement region.

6.34 Track

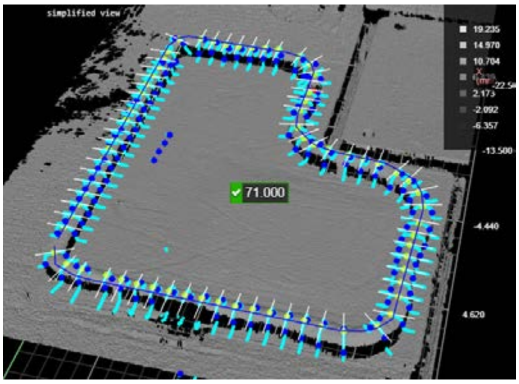
The Track tool lets you perform quality control and inspection along a path you define on representative scan data. The Track tool is especially useful for inspecting materials such as glue / sealant beads. The tool returns width and height measurements of the material, as well as OK and NG ("no good") counts, which let you monitor material overflow and breaks. A major advantage of the tool is that it removes the need to configure individual tools for each location along the path. You can use point and line geometric features to anchor the tool (for more information on geometric features, see 📖 "●Geometric Features" on page 250).

Tips

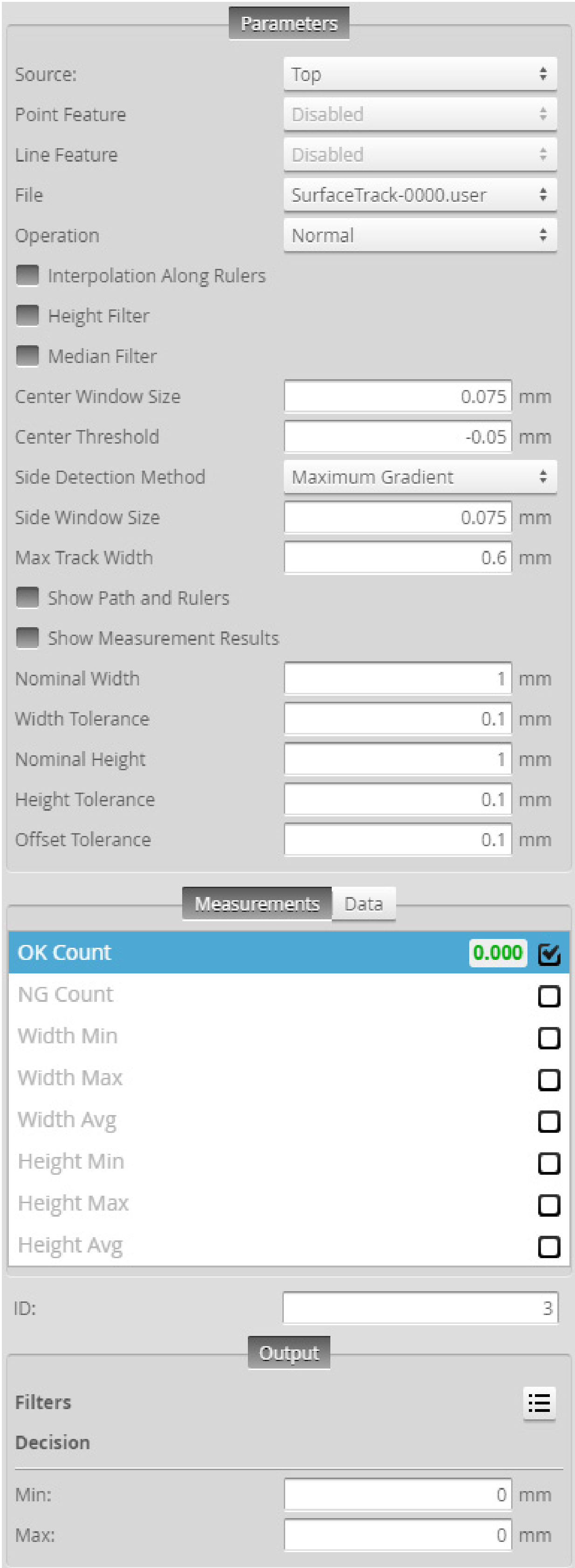
SurfaceMeasure1008S sensors have a limited amount of space for storing path files. For this reason, when working with large datasets, we recommend that you run the Track tool on a PC through the SurfaceMeasure1008S accelerator. For more information on the accelerator, see 📖 "7 SurfaceMeasure1008S Acceleration" on page 627.



2D View

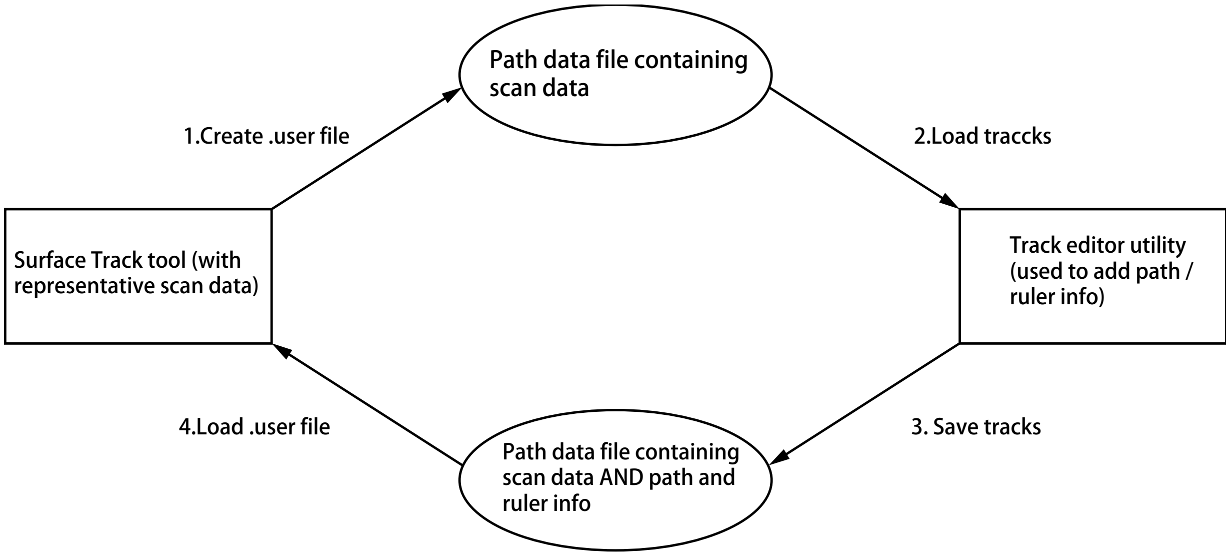


3D View



Measurement Panel

You define the path along which the tool performs its internal measurements using a separate, PC-based utility (the "track editor"). The following shows the relationship between the Track tool and the track editor.



For more information on the track editor, see "6.34.7 Using the Track Editor" on page 605

Tips

All instances of the Track tool share the same path file set in [File] (ending in .user). For this reason, you must be careful when editing or removing path files shared by another instance of the tool.

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

6.34.1 Key Concepts

The following are important concepts for using both the track editor (see "Using the Track Editor" on page 605) and the Track tool itself:

[Track]: The material being measured, for example glue or sealant. The material can sit on a flat area on the target, or sit in a groove where the material touches one or both sides.

[Path]: The ideal centerline of the track. You define the path in the track editor. You can define more than one path for use on scanned targets, but the Track tool returns the combined results for all paths.

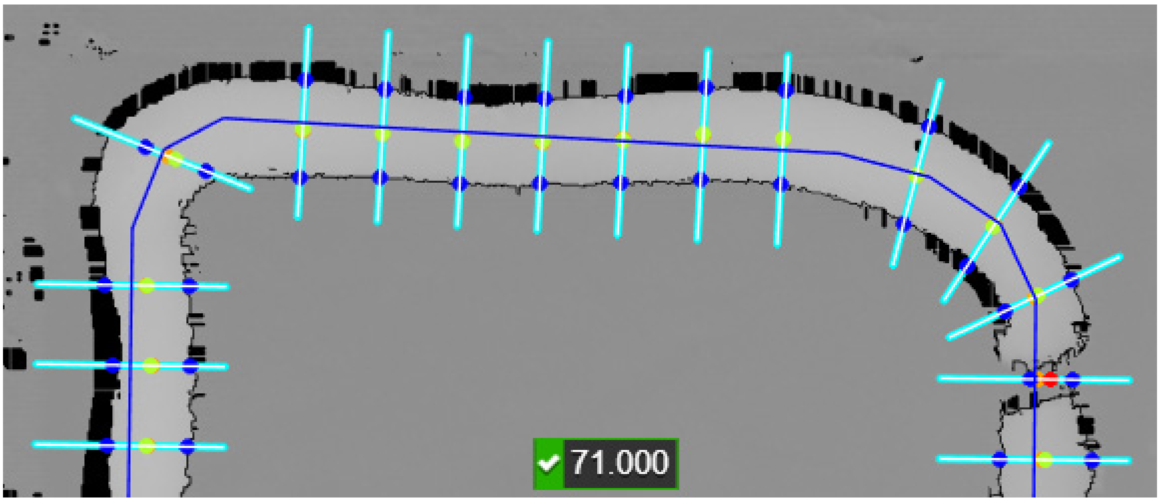
For more information on the track editor, see "6.34.7 Using the Track Editor" on page 605.

[Ruler]: A ruler is one of the areas perpendicular to the path you define. You define the size and spacing of the rulers in the track editor. The Track tool extracts a profile from the surface data beneath a ruler and performs internal measurements based on the values you choose in the Track tool's parameters.

[Ruler profiles]: The profiles extracted from the surface data under a ruler. The tool's internal measurements, which are configured using the tool's settings, are applied to these profiles.

[Segment]: One portion of the path, between points created by clicking on an image of scan data in the track editor. You can choose to configure rulers in segments independently, or choose to configure them in a batch mode.

The following shows a track with rulers and measurement results:

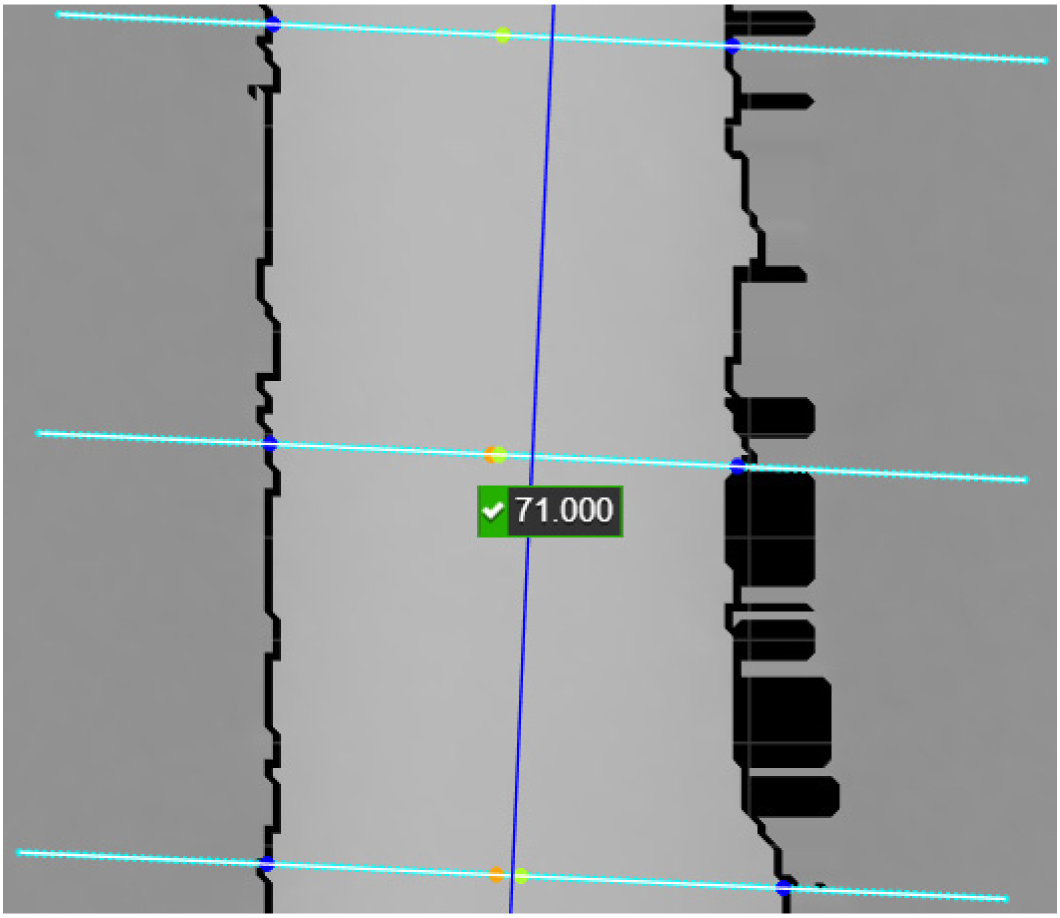


Track tool in data viewer, showing a track (lighter grey), path (dark blue line), rulers running perpendicular to the track (white lines centered on light blue dots).
Dots of other colors provide additional information (see below).

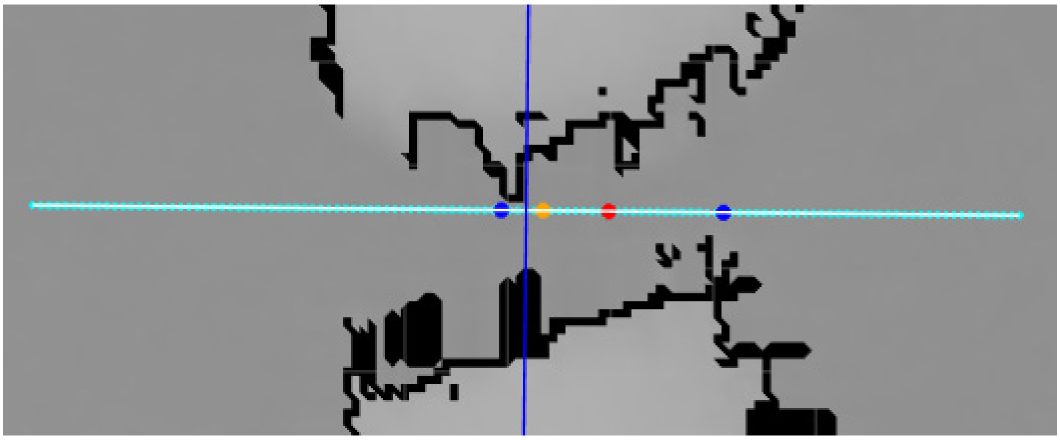
When you enable [Show Measurement Results], the Track tool displays dots on the rulers to provide the following information (see also the images below):

- Light blue dots: The data points in the ruler profile. When you enable [Show Path and Rulers], the tool displays a white line centered on these dots to indicate the location of the ruler.
- Dark blue dotes: The detected sides of the track. These represent the width of the track under that ruler.
- Green dots: Center points on rulers that pass the criteria set in the tool. These count toward the "OK Count" measurement.
- Red dots: Center points on rulers that fail at least one of the criteria set in the tool. These count toward the "NG Count" measurement.
- Orange dots: The peak (highest) point on the ruler. If the center point (green or red) is the same as

the peak point, the tool only shows the center point.



Three "OK" rulers, indicated by green center points. In the bottom two, the peak point (orange) is slightly to the left of the center point (green).



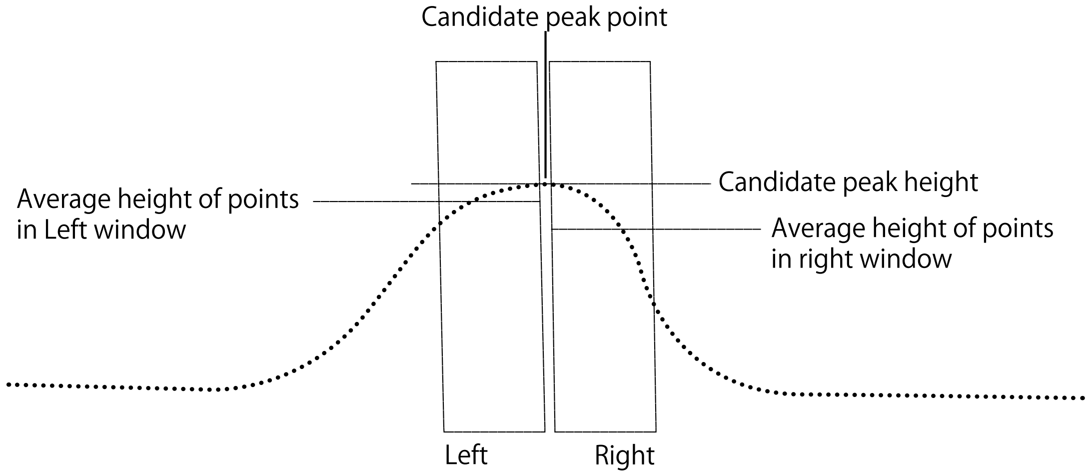
A "NG" ruler, indicated by the red center point.

6.34.2 Track Location

The tool attempts to locate the track using the profile data it extracts under each ruler, and does this by first locating the "peak" (the highest point on the ruler profile, based on certain criteria) and then locating the side points representing the "sides" of the track.

6.34.3 Peak Detection

The tool determines the peak point on a ruler profile by moving two windows—one to each side of the point being examined—and comparing the average height in those windows with the height of the point being examined. (The size of these windows is specified in [Center Window Size].) If the height of the point being examined is greater than both the left and right average height by the value specified in [Center Threshold], that point is considered a candidate peak point. The tool uses the candidate point with the highest average height over both windows as the peak point.



6.34.4 Side Detection

After the tool has located the peak point, it locates the sides of the track starting from the peak point. You can choose between two methods for side detection: Maximum Gradient and Height Threshold.

Maximum Gradient:
Use this side detection method when the slope of the two sides show a clear drop-off. The following settings define the area in which the tool searches for a maximum gradient, which will determine the edge of the track.

Maximum Gradient Side Detection Parameters

[Side Window Size]	The size of the two adjacent windows the tool uses to determine the maximum slope on the left and right side of the track. Set this to roughly 3 to 5 times the smaller of the X and Y resolution of the sensor.
[Max Track Width]	The maximum width of the track over the ruler profile the tool searches for edge points. The tool uses this value to limit where the edge of the track might be detected. Set this to slightly larger than [Side Window Size].

Height Threshold:
Use this side detection method when the slope of two sides is very gradual. The tool finds the left and right edges by averaging the height of small fixed-size windows moving away from the peak point. Edge points are the left-most and right-most window locations where the average height is below a minimum height threshold.

Height Threshold Side Detection Parameters

[Side Height Threshold]	The minimum height that the average calculated in the fixed-width height threshold windows must be below.

Center Point Detection

The Track tool calculates the center point as the mid point between the left and right side points. This means that the center point may be different from the peak point.

6.34.5 Configuring the Track Tool

To configure the tool, you must first acquire scan data of a representative target; preferably, the material on the target will fall within the expected tolerances. Next, you save the scan data from within the Track tool, and then load the scan data into the track editor. Then, after adding a path or paths, and configuring rulers to the data, you load the track data back into the Track tool. Finally, you configure the tool. For more information on key concepts you need to understand to configure the Track tool, see "6.34.1 Key Concepts" on page 596.

To configure the Track tool:

1 **Scan a representative target, or load previously scanned data.**

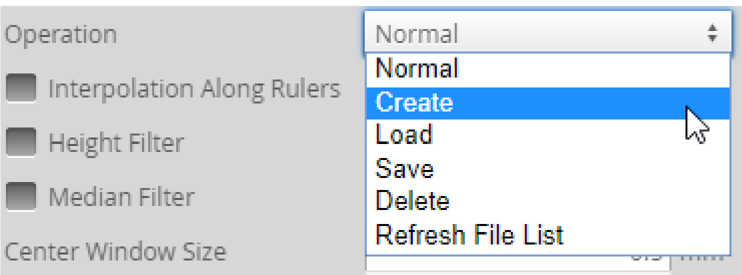
For more information on loading previously scanned data, see "■Recording, Playback, and Measurement Simulation" on page 81.

2 **Add a Surface Track tool.**

SurfaceMeasure1008S adds a Surface Track tool and creates a "C:\GoTools\SurfaceTrack" folder if it doesn't exist.
For more information on adding a tool, see "■Adding and Configuring a Measurement Tool" on page 235.

3 **In the Surface Track tool, choose [Create] from the [Operation] drop-down.**

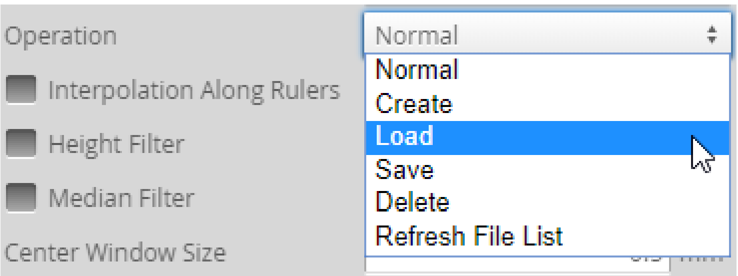
The tool creates a file (for example, SurfaceTrack-0000.user) containing scan data in "C:/LMI/Surface Track". You will use the track editor to add path data to this file.



4 **Launch the track editor and configure the path or paths.**

For information on using the track editor, see "6.34.7 Using the Track Editor" on page 605.

5 **After you have finished editing the track data in the track editor, in the Surface Track tool, choose [Load] in the [Operation] drop-down to load the path data you just created.**

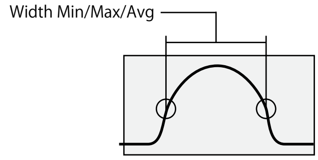
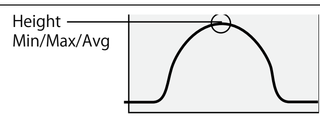
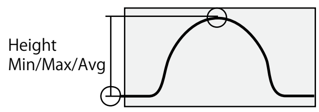
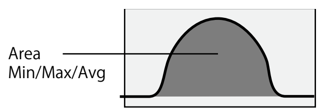


6 **Configure the Track tool as required.**

For information on the tool's measurements and settings, see the below.

6.34.6 Measurements, Data, and Settings

[Measurements]

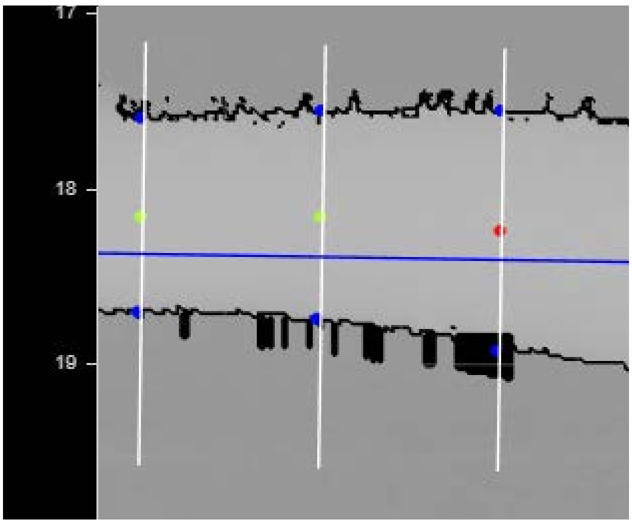
Measurement	Illustration
[OK Count] Returns the number of rulers along the path that pass all of the criteria set in the tool's parameters.	
[NG Count] Returns the number of rulers along the track path that fail the criteria set in the tool's parameters. (They are "no good.")	
[Width Min] [Width Max] [Width Avg] These measurements return the minimum, maximum, and average width of the track.	 Width measurements on a ruler profile. The Track tool's settings determine the locations of the "sides" of the track.
[Height Min] [Height Max] [Height Avg] These measurements return the minimum, maximum, and average height of the track at the center point. When [Height Mode] is set to [Absolute Height], the height returned is the absolute value. When it is set to [Step Height], the height is relative to the surface next to the track.	 Height measurements on a ruler profile with Height Mode set to Absolute Height.  Height measurements on a ruler profile with Height Mode set to Step Height.
[Area Min] [Area Max] [Area Avg] These measurements return the minimum, maximum, and average area under the rulers.	 Area measurements under a ruler profile.

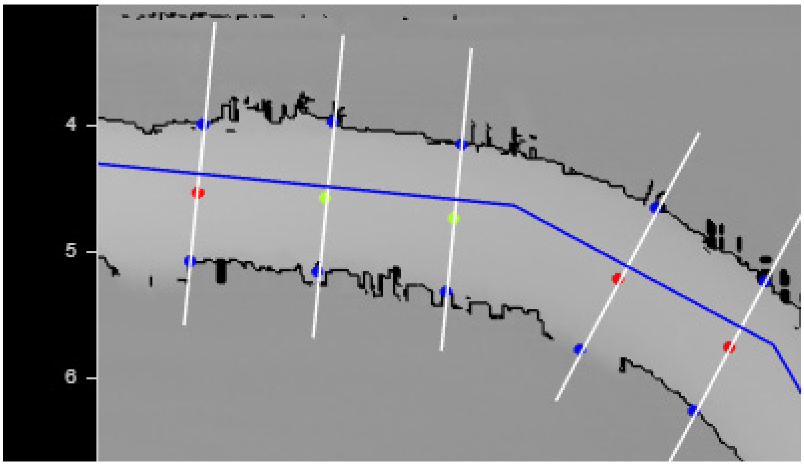
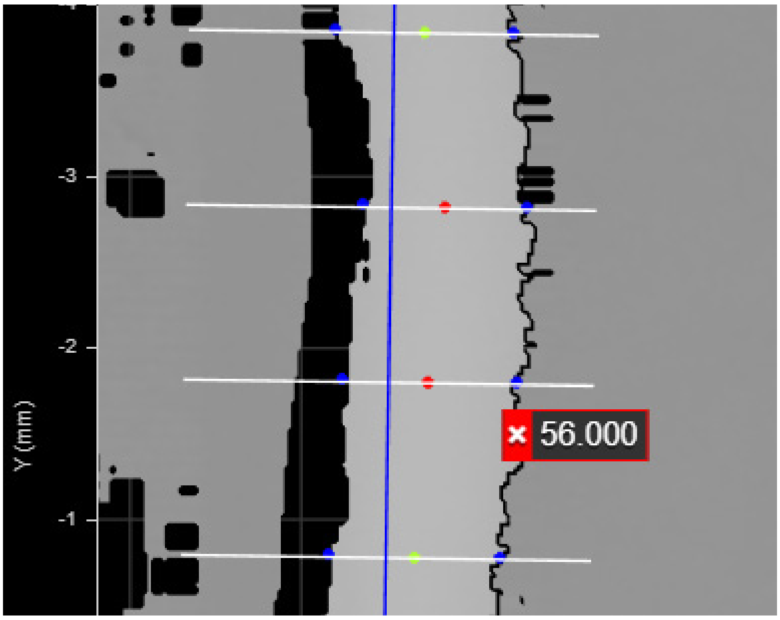
[Data]

Type	Description
[Output Measurement]	Data containing the results from each ruler, namely: • track ID • segment ID • track width • track height • track offset • X position of the center point • Y position of the center point A sample included in the SDK package shows how you can use this output data in an application.
[Profiles List]	A list of the profiles extracted from the tracks.
[Profiles List Diagnostics Surface]	Surface data created by combining the extracted profiles. Use for diagnostics.

[Main Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Point Feature] [Line Feature]	Point and line geometric features (produced by another tool) that you can select as anchors for translation and rotation transformations, respectively. Currently, you must select both in order for anchoring to work. For more information on geometric features, see "●Geometric Features" on page 250.
[File]	The CSV file that contains scan and path data. You add path data to the file using the track editor. For more information on the track editor, see "6.34.7 Using the Track Editor" on page 605.
[Operation]	Provides operations related to the CSV scan / path data file. One of the following: • [Normal]: Selected by the tool after you perform another file operation. • [Create]: Creates a new CSV file for use with the track editor. • [Load]: Loads the path file selected in [File]. • [Save]: Saves changes made in the scan data, as well as the geometric features used as anchors in the [Point Feature] and [Line Feature] settings, to the file selected in [File]. • [Delete]: Deletes the path file selected in [File]. • [Refresh File List]: Refreshes the list of files.
[Interpolation]	Enables linear interpolation on the profile extracted from the rulers to achieve sub-pixel accuracy in the width and height measurements.
[Height Filter] [Threshold High] [Threshold Low]	When [Height Filter] is enabled, use the [Threshold Low] and [Threshold High] settings to set a range to filter out noise or exclude other undesired data along the ruler profiles.
[Median Filter] [Window Size]	When [Median Filter] is enabled, specify the window the tool will use to smooth the height values of the points in the ruler profiles in the [Window Size] setting.
[Center Window Size]	The size of the left and right windows the tool moves along the ruler profile to detect whether the point centered between the two is the highest point along a ruler (the center point). Set this to roughly 50% of the typical width of the track as a starting point.

Parameter	Description
[Center Threshold]	The center point is determined by moving two side-by-side windows (left and right, [Center Window Size] setting) over each ruler profile. At each point, the height value between the two windows is compared to the average height of the left and right windows. If the center point height is greater, by the amount set in [Center Threshold], than the average height in both the left and right windows, that point is considered a candidate center point. The candidate center point with the highest average height over both windows is used as the center point. It may be necessary to use a negative number in some cases. It may be necessary to use a negative value under some circumstances. For example, when the top point slightly dips below its surroundings.
[Side Detection Method]	The method the tool uses to detect the two sides of the track. One of the following: [Maximum Gradient] or [Height Threshold]. For more information on side detection method settings, see "6.34.4 Side Detection" on page 598.
[Height Mode]	Determines how height values are interpreted in the tool's [Nominal Height] setting and what the returned height measurements represent. One of the following: [Absolute Height] - Height values are interpreted globally (the entire scan data). [Step Height] - Height values are relative to the surrounding area of the track.
[Show Path and Rulers]	Displays the path and rulers (as defined in the track editor) on the scan data.
[Show Measurement Result]	Shows dots on each ruler representing the results of the internal measurements on the profile extracted from the surface data under the ruler. For more information, see "6.34.1 Key Concepts" on page 596.
[Nominal Width]	The expected width of the track.
[Width Tolerance]	The tolerance applied to the nominal width. 
[Nominal Height]	The expected height of the track. The expected height is the absolute height in the scan data, not relative to the surrounding area. This setting applies to the peak point, not the center point.

Parameter	Description
[Height Tolerance]	The tolerance applied to the nominal height. This setting applies to the peak point, not the center point. In the following, the distance between the blue dots indicating the width of the track under the ruler to the right (white vertical line) is greater than the width tolerance; this is indicated by the red center point dot, and counts as a NG measurement. The widths of the track under the two rulers to the left are within tolerance; this is indicated by green center points, and count as OK measurements. The track is lighter grey than the surrounding surface. 
[Nominal Area]	The expected cross-sectional area under the rulers on the track.
[Area Tolerance]	The tolerance applied to the nominal area.
[Offset Tolerance]	The maximum allowed distance between the center (highest) point on a ruler and the path. This setting applies to the center point. In the following, the top and bottom center points (green) are at an acceptable distance from the blue path. The red center points fail because they are too far from the path. The track is lighter grey than the surrounding surface. 
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.

Parameter	Description
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see 📖 "●Decisions" on page 251.

● Anchoring

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

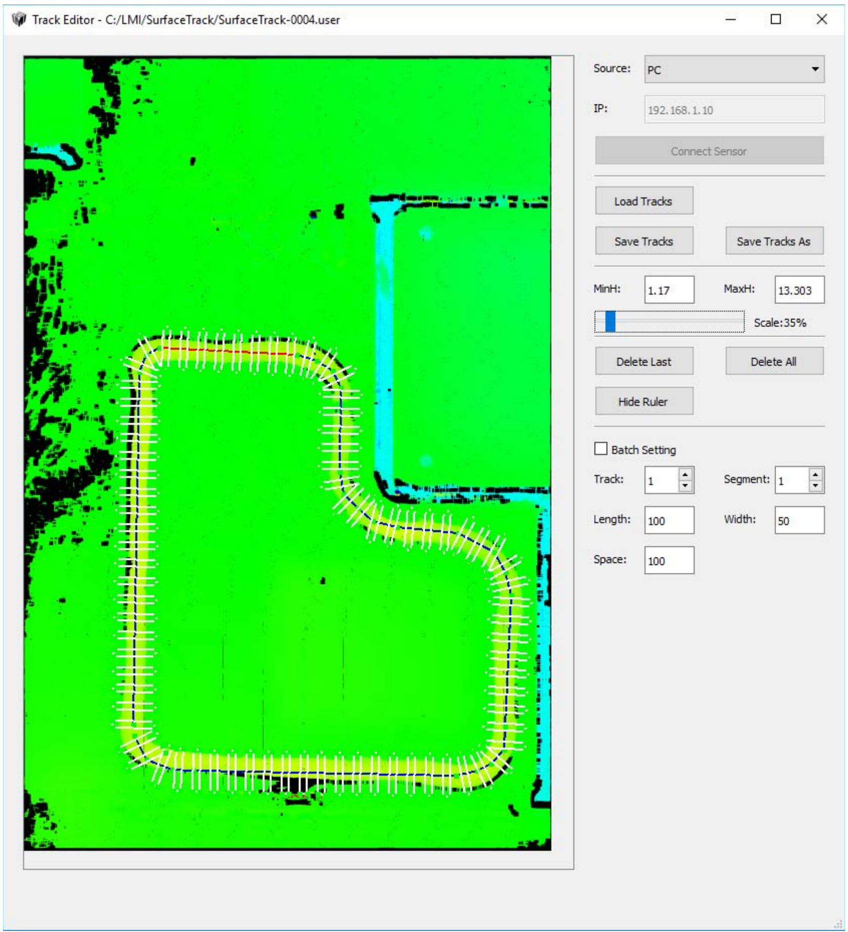
Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

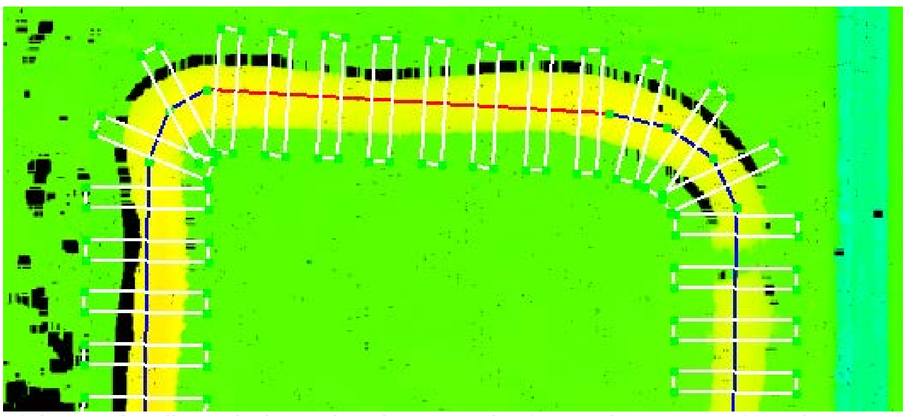
6.34.7 Using the Track Editor

You use the track editor to configure "path" and "ruler" information on a frame of scan data from a sensor. The Track tool uses this information to inspect targets along the defined path.



The track editor

In the track editor, you can define one or more paths, and configure rulers along these paths.


Closeup of the track editor window, showing a track of material on a surface (yellow on green), a path (blue segments; red segment for the currently selected segment), path points (green dots), and rulers (white rectangles).

Tips

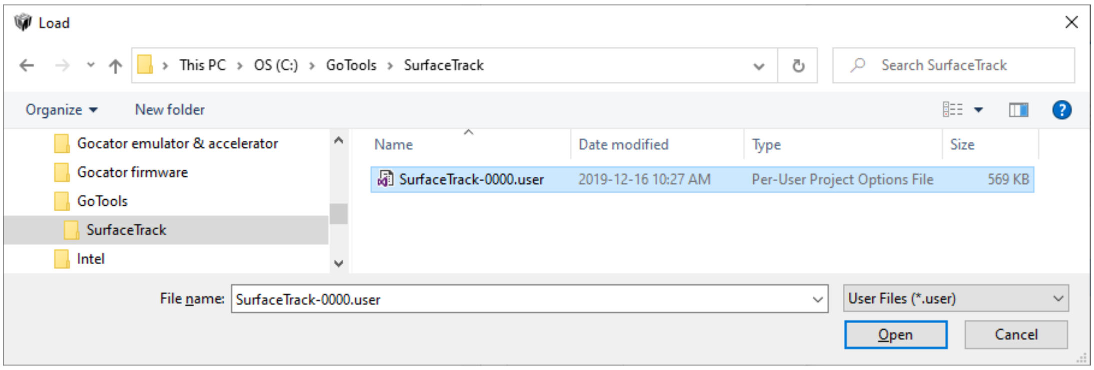
The following assumes that you have already scanned a representative target and created a CSV file from within the Track tool. For more information, see the first steps of "To configure the Track tool:" on page 599.

Loading and working with scan/track data:

1 In the track editor, in the Source drop-down, choose one of the following:

- [PC]: Choose this option if you are using the Track tool through the accelerator. The track editor will retrieve the path data file from local (PC) storage and save changes there. (Choose the same if you are using the emulator).
- [Sensor]: Choose this option if you are not using the accelerator. The track editor will retrieve the path data file from the sensor at the IP address specified in the [IP] field. Because sensors have a limited amount of space to store path data, only use this option for simple paths.

2 Click [Load Tracks], navigate to "C:\GoTools\SurfaceTrack" (if you have chosen PC as the source), and choose the .user file you created using the Surface Track tool.



The track editor loads the data. If paths have been previously defined, they are also loaded.

Note that previous versions of this tool created and placed files in a "C:\LMI" folder. Files are still read from both locations but only written to C:\GoTools. Rename the existing C:\LMI folder to C:\GoTools for seamless transition.

3 Do one or more of the following:

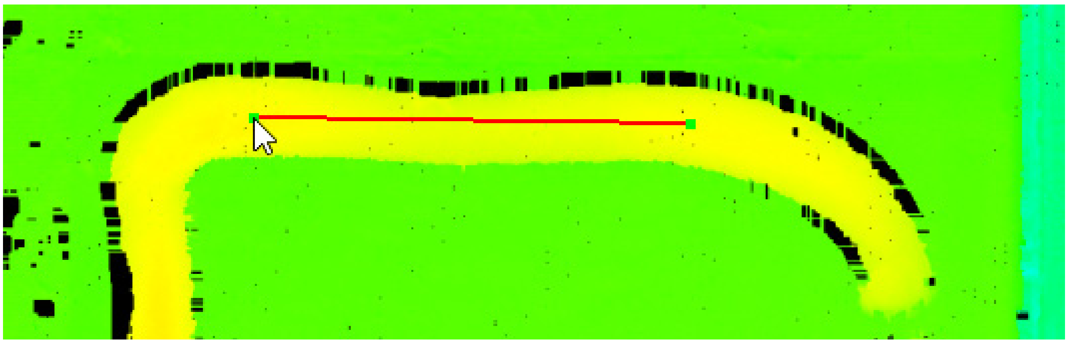
- Move the slider to the left or right to zoom in or out in the editor's viewer.
- Move the data in the track editor's window using the scrollbars or the mouse wheel.
- Set MinH and MaxH and then reload the track data to assign a narrower height range to the height map colors. This may help make the track clearer in the editor.

After you have loaded the data, you must add a path and configure its rulers.

To add a path:

1 In the track editor, click on the middle of the track somewhere in the scan data, move the mouse pointer to another location and click again.

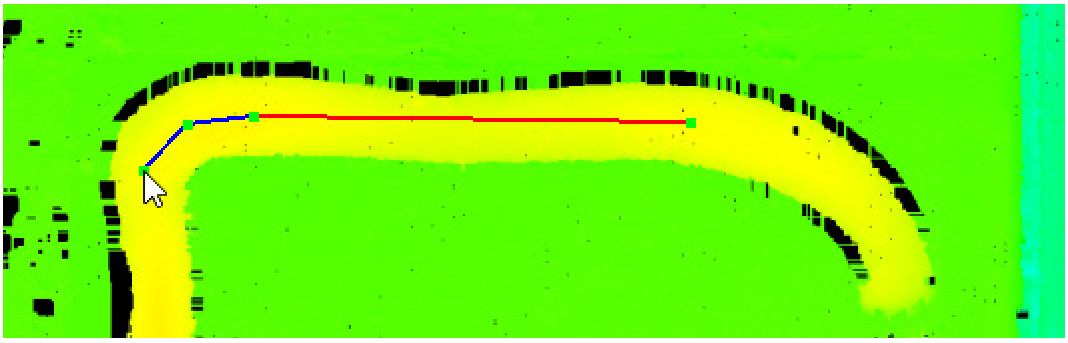
A red segment between the first two green path points appears in the editor window.



You can move path points using the mouse at any time to adjust the path. You can also delete the last point by clicking [Delete Last]. To delete all path points, click [Delete All].

2 **Continue clicking along the track to add more path points, building up the path.**

When adding points on corners, add more points to follow the track more precisely.



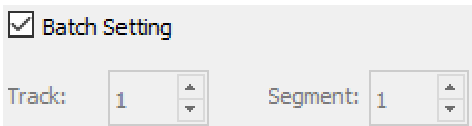
3 **Continue clicking until you complete the path along the track.**

You cannot close the path: simply click close to the starting path point when you have finished.

4 **Click [Save Tracks] to save the path information to the data.**

5 **(Optional) You can add other paths if necessary by clicking somewhere in the scan data after you have saved the track data.**

After you have finished adding a path, you must configure the rulers on the path (the dimensions and the spacing of the rulers). You can choose to apply dimensions/spacing to all rulers in all segments at the same time by checking [Batch Setting]. The settings also apply to all paths if you have defined more than one path.



Otherwise, you must move through the individual path segments by clicking the spinner control in the [Segment] field and set the ruler dimensions for each segment. If you have defined multiple paths, you will have to click through the paths too, using the [Track] spinner.

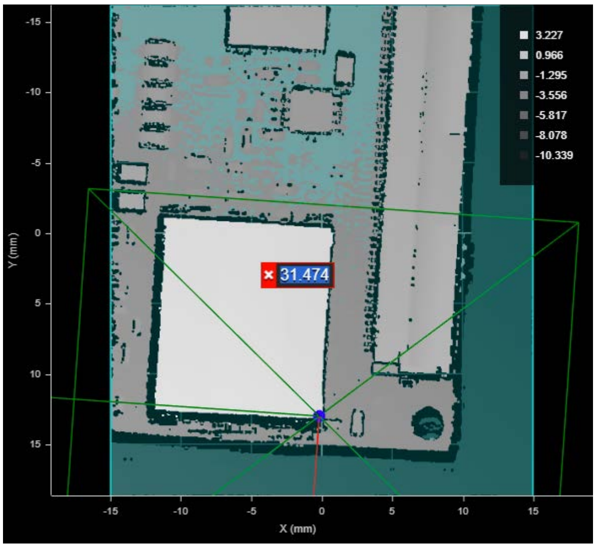
The following table lists the ruler settings available in the track editor:

Track editor: ruler settings

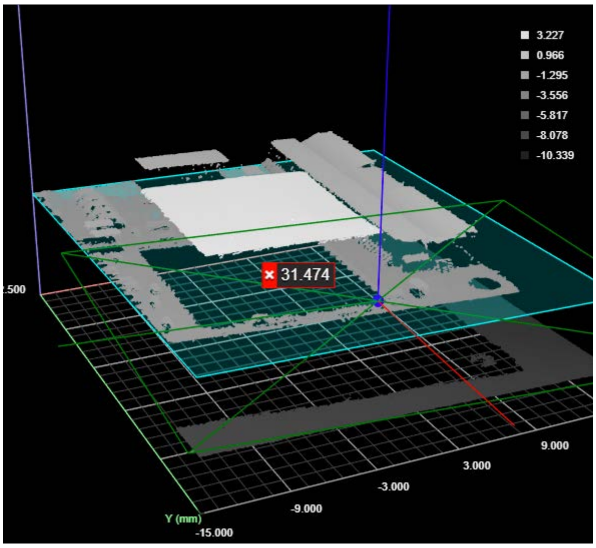
Setting	Description
[Length]	The dimension of the ruler perpendicular to the path. Be sure to use a value large enough to cover the track from one side to another and to include enough surface on each side of the track (the surface to which the material is applied) for the Track tool to properly detect the track.
[Width]	The dimension of the ruler along the path.
[Space]	The space between rulers on the path. Because you will typically place path points closer together around corners, you may need to use smaller spacing around corners.

6.35 Transform

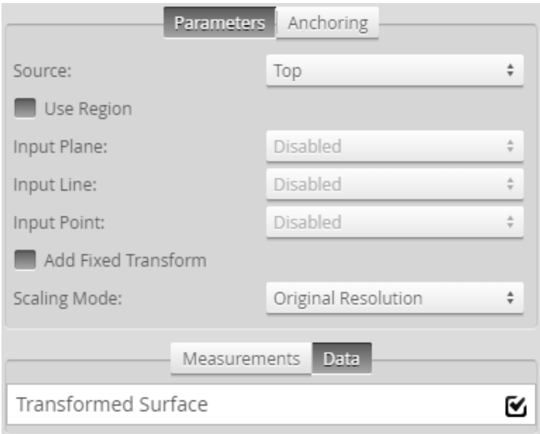
The Surface Transform tool generates a new surface based on the coordinate system of geometric features the tool uses as input. The tool can take a zero-plane, line, and origin point to define this new coordinate system. You can then apply the built-in measurement tools or GDK tools to this new surface data. This could let you, for example, get the height of a feature relative to a slightly tilted or warped adjacent or surrounding reference surface, rather than the absolute height in the original scan volume relative to the sensor. The result is increased repeatability of your measurements.



2D View

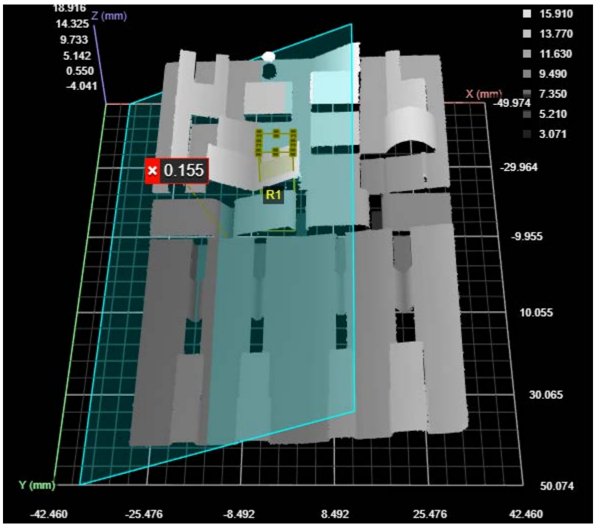


3D View

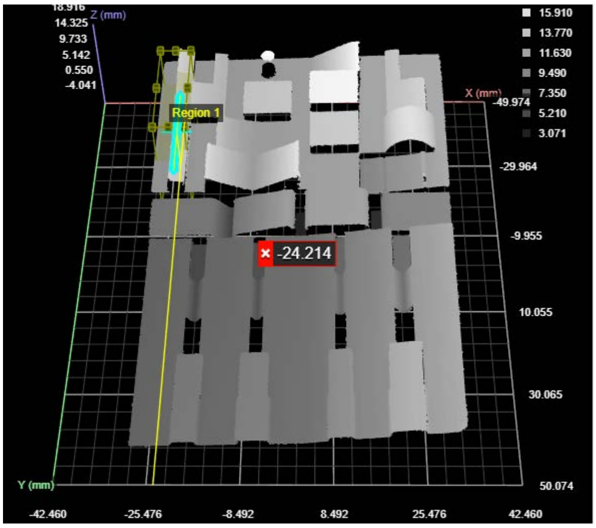


Measurement Panel

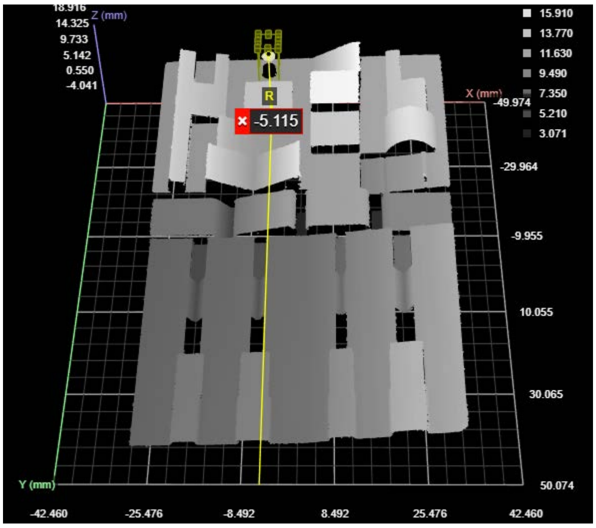
In 📖 "6.35.1 Combinations of geometric feature inputs and results" on page 612, the following geometric features are used by a Surface Transform tool in various combinations (a plane, a line, and a point).



A Surface Plane tool, with the region set to a small left-facing angled surface

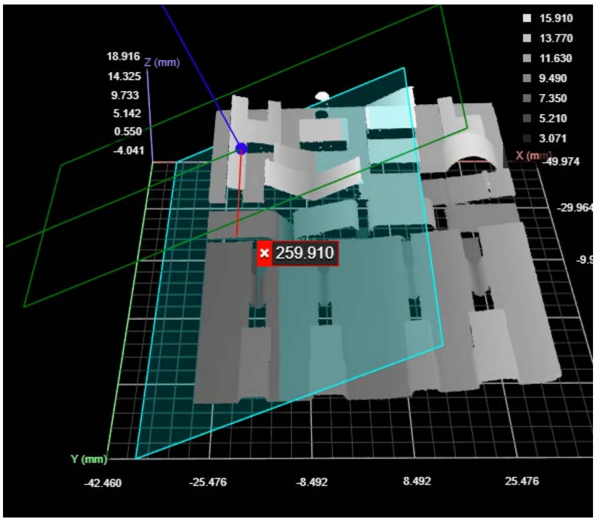


A Surface Edge tool, with the region set to the left edge of a raised surface (upper left of data viewer).



A Surface Position tool (maximum Z), with the region set to the raised point near the top of the data viewer.

Furthermore, in the sections below, two types of data are shown: the original (input) scan data and the transformed data. When the tool displays the original data, it overlays indicators of the new, transformed coordinate system on the data.



A Surface Transform tool using all three types of geometric feature inputs.

The data viewer is set to display the input surface data with an overlay of the transformed coordinate system.

In the data viewer, the following is displayed:

X, Y, and Z axes

The transformed axes are represented above by the red, green, and blue lines intersecting on the surface data above. Note how these are rotated with respect to the original coordinate system (the background grid, axes, and values along the axes).

Origin

The new origin is represented by the dark blue dot at the intersection of the transformed axes.

Plane

The new plane is represented by the cyan rectangle.

Bounding box containing the transformed surface

The bounding box that indicates where the transformed data is in relation to the original coordinate system.

Tips

To switch between the original and transformed data, choose Surface or Tool in the first drop-down above the data viewer, respectively.

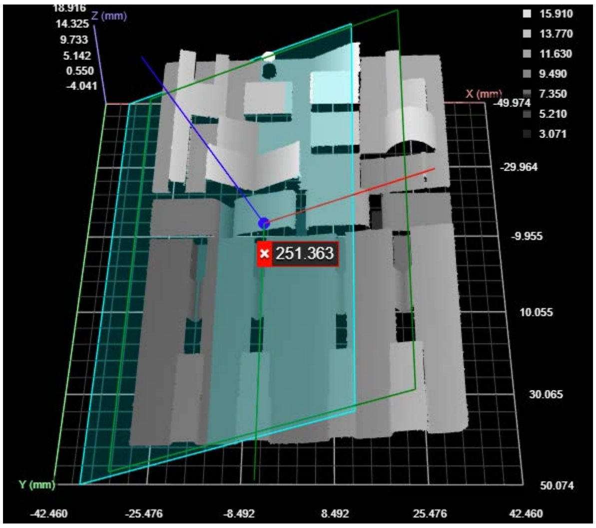
6.35.1 Combinations of geometric feature inputs and results

The Surface Transform tool accepts all combinations of input geometric features (plane, line, and point). For details and examples of each, see the following sections.

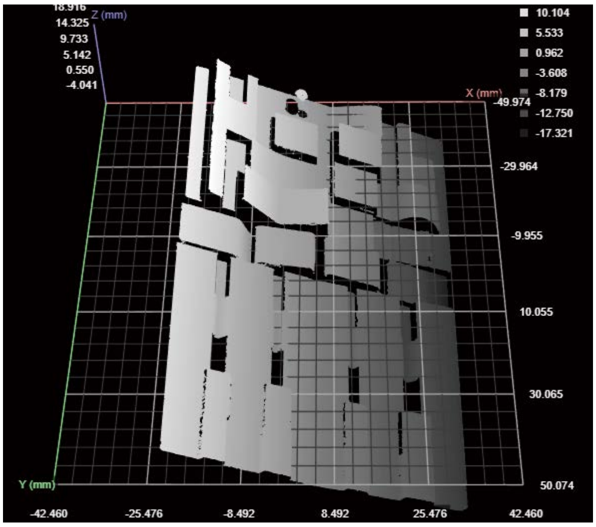
[Plane]

New Z=0 XY Plan	New X Axis	New Origin
Matches the input plane.	Parallel to the old X axis.	Old origin projected to plane.

Original data with overlay



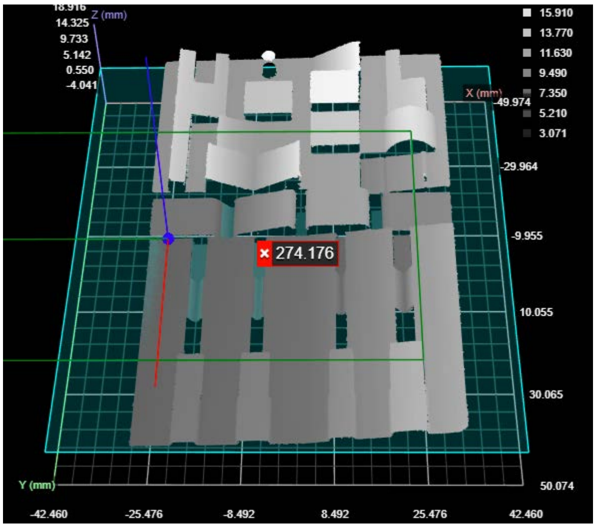
Transformed data



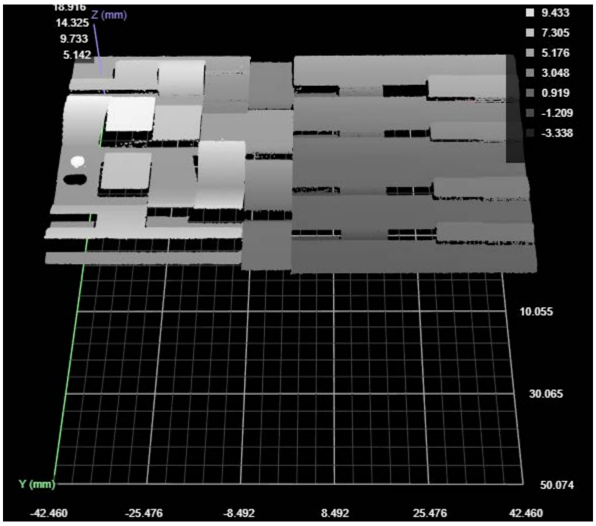
[Line]

New Z=0 XY Plane	New X Axis	New Origin
The new plane contains the line. The intersection of the new plane and the old plane is perpendicular to the input line.	Matches the line.	Old origin projected onto the line.

Original data with overlay



Transformed data

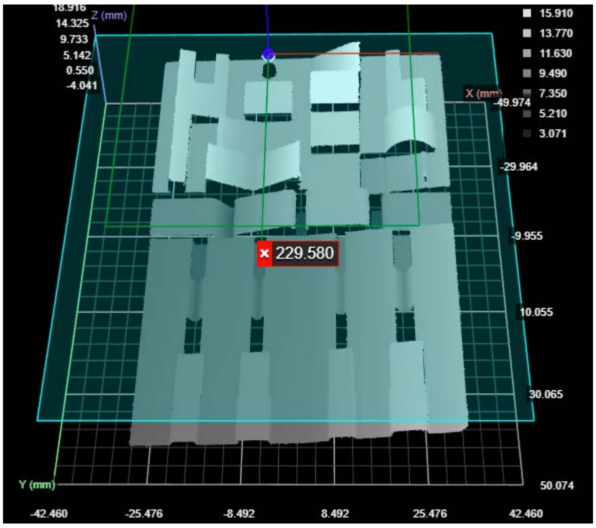


The direction of the X axis depends on the tool generating the line that Surface Transform takes as input. You may need to adjust the direction using the Add Fixed Transform settings.

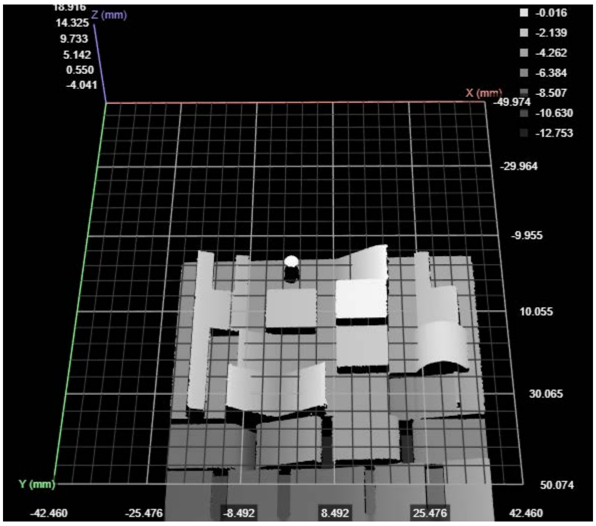
[Point]

New Z=0 XY Plane	New X Axis	New Origin
Through the input point, parallel to old Z=0 plane.	Parallel to the old axis.	The input point.

Original data with overlay



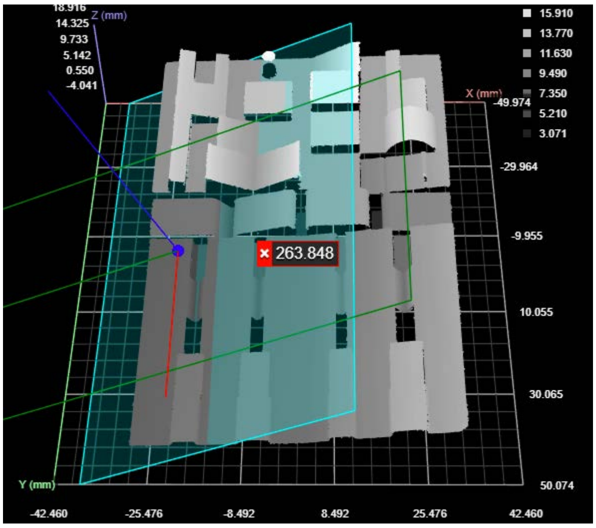
Transformed data



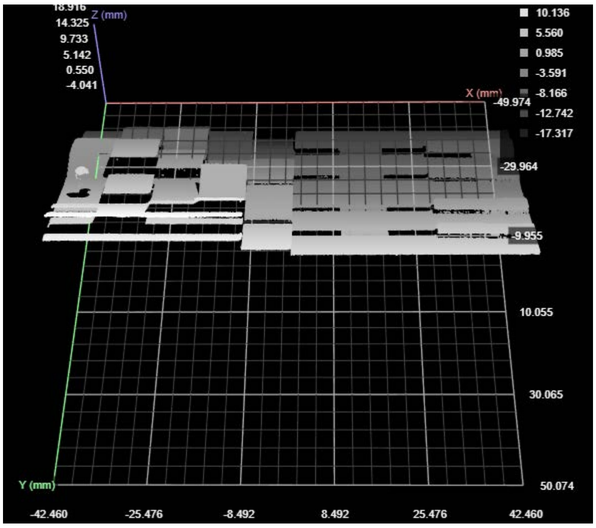
[Plane] + [Line]

New Z=0 XY Plane	New X Axis	New Origin
Matches the input plane.	Line projected onto the plane.	Old origin projected onto the projected line.

Original data with overlay



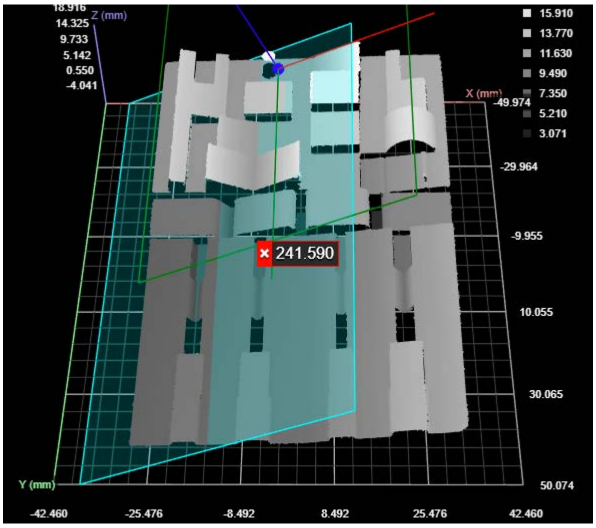
Transformed data



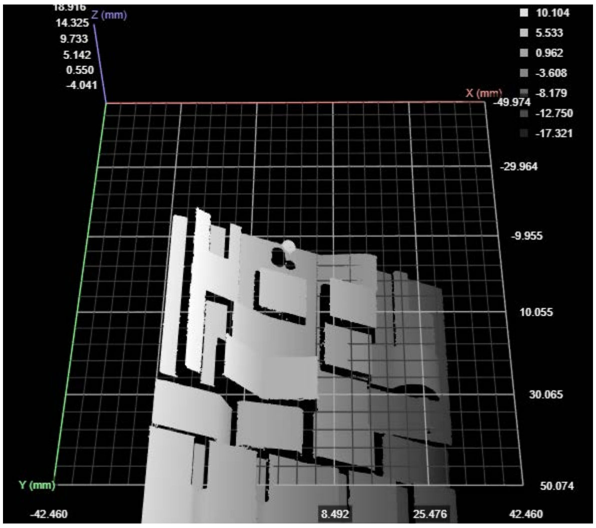
[Plane] + [Point]

New Z=0 XY Plane	New X Axis	New Origin
Matches the input plane.	Parallel to the old X axis.	At the input point, projected onto the plane.

Original data with overlay



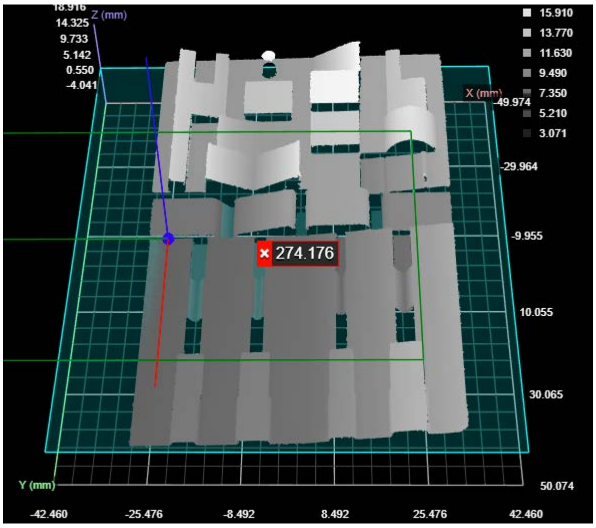
Transformed data



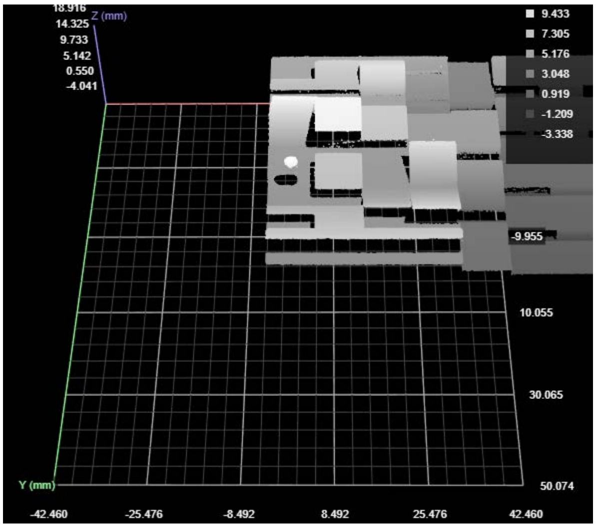
[Line] + [Point]

New Z=0 XY Plane	New X Axis	New Origin
The new plane contains the line. The intersection of the new plane and the old plane is perpendicular to the input line.	Matches the line.	The input point projected onto the line.

Original data with overlay



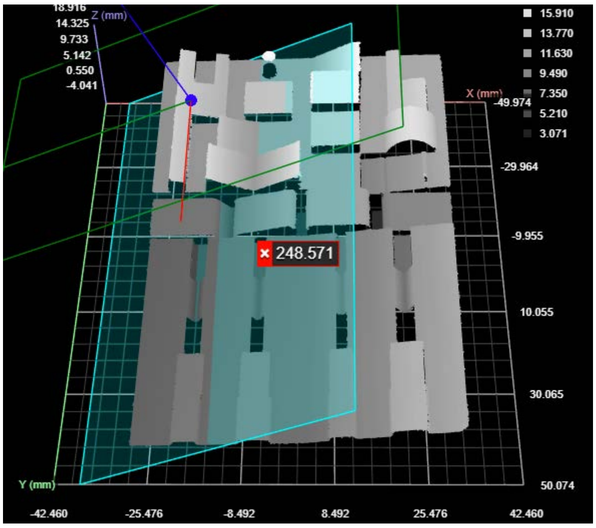
Transformed data



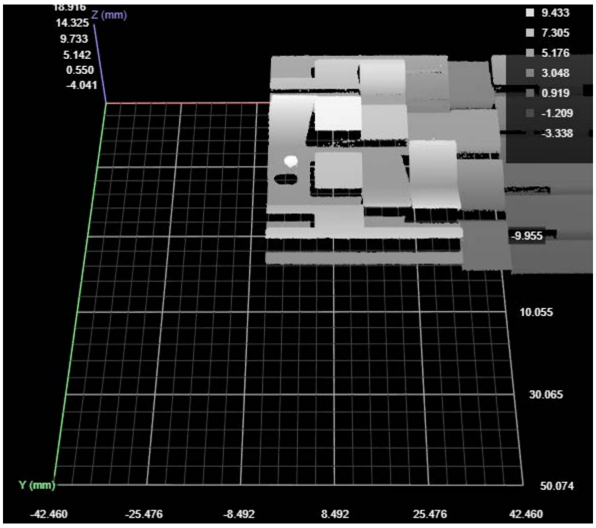
[Plane] + [Line] + [Point]

New Z=0 XY Plane	New X Axis	New Origin
Matches the input plane.	The input line projected onto the plane.	The input point projected onto the input line.

Original data with overlay



Transformed data



For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.35.2 Scaling Modes

Line profile sensors have independent X and Y resolution settings: the former is set using the [Spacing] setting (for more information, see 📖 "■Spacing" on page 135), whereas the Y resolution is set using the [Spacing Interval] setting in the [Trigger] panel (for more information, see 📖 "■Trigger Settings" on page 120). In many applications, the X resolution can be as much as 3-5 times higher than the Y resolution. Rotating scan data around Z greater than 45 degrees (for example, with the Transform tool) when there is a large difference between X and Y resolutions can result in significant data quality reduction. To avoid data quality reduction, choose one of the scaling modes that the tool offers (see below).

6.35.3 Measurements, Data, and Settings

[Measurements]

Measurement	Description
[Running Time (ms)]	The amount of time required for tool execution. Used for diagnostic purposes.

[Data]

Type	Description
[Transformed Surface]	The transformed surface. Available via the Stream drop-down in other tools.

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Input Plane]	The plane the tool uses to transform the surface scan data.
[Input Line]	The line the tool uses to transform the surface scan data.
[Input Point]	The point the tool uses to transform the surface scan data.

Parameter	Description
[Scaling Mode]	Determines whether the tool scales the X or Y resolution so that they are the same (a 1:1 ratio), or leaves the X and Y resolutions as the original. One of the following. • [Optimal (uniform)] Brings the X/Y resolution ratio to 1:1 while preserving the pixel area. Best for random rotation around Z. Provides a balance between the highest and lowest possible resolutions, requiring an average amount of memory and processing time compared to the [High Oriented (uniform)] or [Low Oriented (uniform)] options. • [High Oriented (uniform)] Interpolates the lower resolution to match the higher resolution (between X and Y) in the input. Choose this option when increased resolution is preferred over speed and low memory usage. (This can result in a very high resolution output, creating a lot of data for subsequent tools to process. This can in turn result in slower processing.) • [Low Oriented (uniform)] Decimates the higher resolution to match the lower resolution (between X and Y) in the input. Choose this option when speed and low memory usage is preferred over resolution. (It can result in significant data quality reduction with large Z rotations if the X and Y resolutions of the input are very different.) • [Original Resolution] Keeps the original X and Y resolution of the scan. Use this option only when you expect little or no Z rotation. Otherwise, with X/Y resolution ratios that are not 1:1, large rotation around Z results in severe data quality reduction For more information, see "6.35.2 Scaling Modes" on page 619.
[Add Fixed Transform]	When enabled, displays X, Y, and Z offset and angle fields you can use to set additional transformations, which are applied after any transformations supplied by the input geometric features. Setting a fixed transformation can be useful if the geometric features the tool uses results in data rotated to an unusual orientation; you could, for example, rotate the data 90 or 180 degrees so that it is in the "expected" orientation, or shift it so that it's easier to work with.
[Use Region]	When this setting is enabled, the tool only outputs the surface contained in the defined region.
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The [Max] and [Min] settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.

Tips

A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

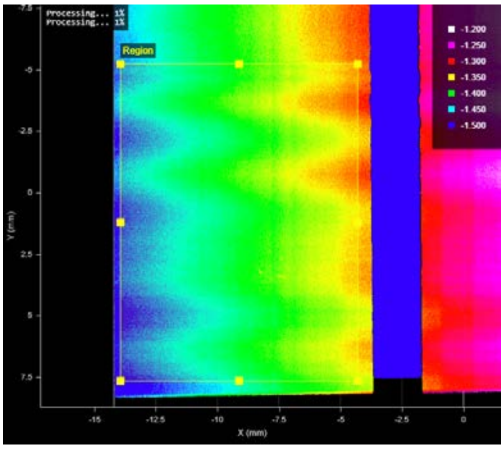
6.36 Vibration Correction

The tool is supported in emulator scenarios.

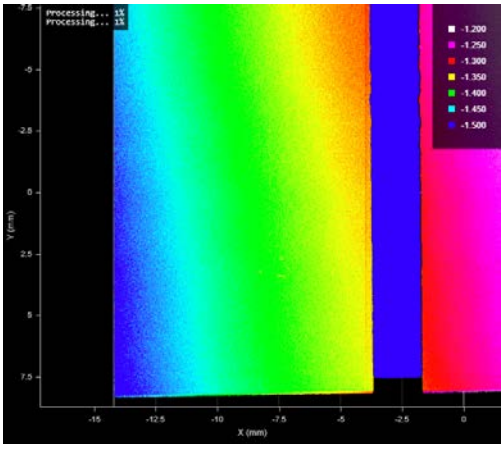
The Vibration Correction tool analyzes variation in surface data to remove high frequency noise in the data. The tool is useful for improving repeatability and accuracy of measurements when subtle vibrations in your transport system introduce height variations. The tool's intended use is to send corrected surface data to other tools.

Tips

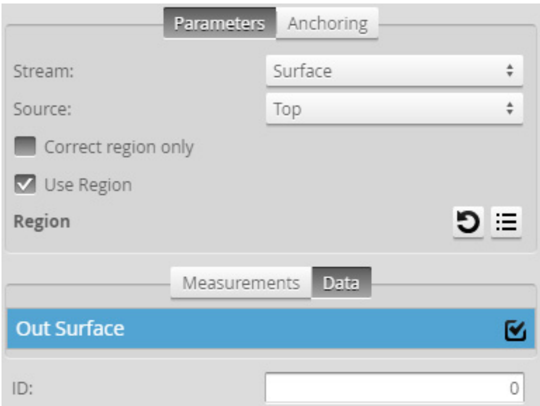
The Vibration Correction tool requires at least 64 lines of data in the surface data it receives as input to be able to output corrected surface data.



Uncorrected surface data



Corrected surface data: a better representation of the actual target



Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see 📖 "4.7.3 Tools Panel" on page 234.

6.36.1 Data and Settings

[Data]

Type	Description
[Corrected Surface]	Surface data corrected for vibration, available for use as input in the [Stream] drop-down in other tools.
[Difference Surface]	Diagnostic Surface data showing the difference between the corrected surface and the original. Available for use as input in the [Stream] drop-down in other tools

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see 📖 "●Source" on page 238.
[Correct region only]	If enabled, only the area under the region is corrected for vibration in the output surface data. This setting can be useful if vibration regularly occurs in a specific area of the scan data. This option is only displayed if [Use Region] is enabled.
[Use Region]	When enabled, lets you set a region and optionally choose to apply vibration correction only to that region (using [Correct region only]).
[Region]	The region whose data the tool will use to calculate the vibration correction.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

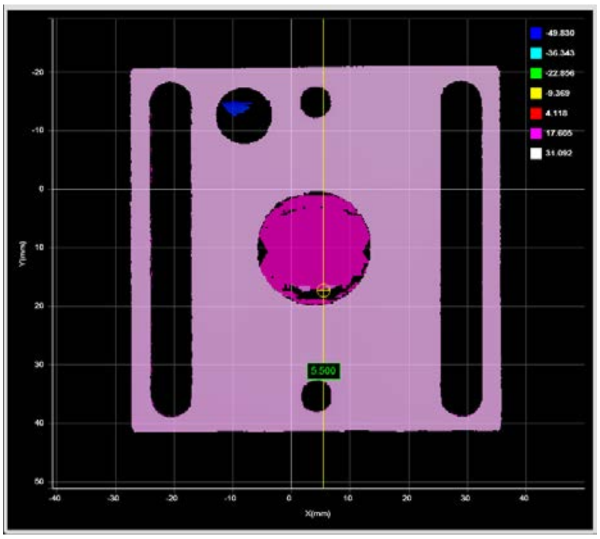
Tips

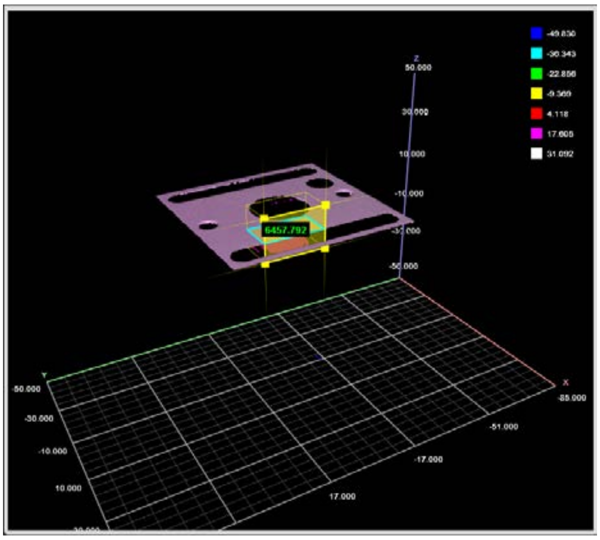
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

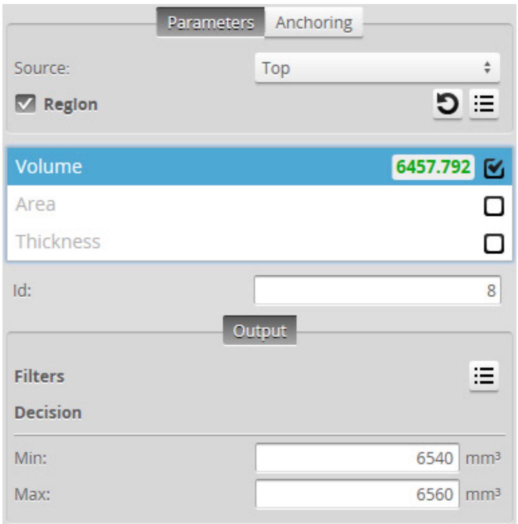
For more information on anchoring, see 📖 "●Measurement Anchoring" on page 254.

6.37 Volume

The Volume tool determines the volume, area, and thickness of a part.


2D View

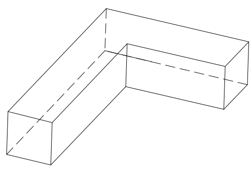

3D View

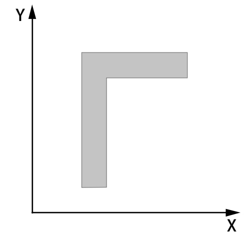
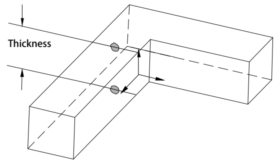


Measurement Panel

For information on adding, managing, and removing tools and measurements, as well as detailed descriptions of settings common to most tools, see "4.7.3 Tools Panel" on page 234.

[Measurements]

Measurement	Illustration
[Volume] Measures volume in XYZ space.	

Measurement	Illustration
[Area] Measures area in the XY plane. The area is the number of valid points multiplied by the X and Y resolution. Note that this is different compared to the area calculations produced by Surface Segmentation and Surface Blob; for more information, see the descriptions of the Area {n} measurements in "6.29 Segmentation" on page 573 and "6.5 Blob" on page 431.	
[Thickness] Measures thickness (height) of a part.	

[Parameters]

Parameter	Description
[Source]	The sensor, or combination of sensors, that provides data for the tool's measurements. For more information, see "●Source" on page 238.
[Region]	The region to which the tool's measurements will apply. For more information, see "●Regions" on page 238.
[Location] (Thickness measurement only)	One of the following: • [Max] • [Min] • [Average] • [Median] • [2D Centroid] (height of the centroid in the XY plane) • [3D Centroid] (height of the centroid in the XYZ space).
[Filters]	The filters that are applied to measurement values before they are output. For more information, see "●Filters" on page 253.
[Decision]	The Max and Min settings define the range that determines whether the measurement tool sends a pass or fail decision to the output. For more information, see "●Decisions" on page 251.

[Anchoring]

Anchor	Description
[X], [Y], or [Z]	Lets you choose the X, Y, or Z measurement of another tool to use as a positional anchor for this tool.
[Z angle]	Lets you choose the Z Angle measurement of another tool to use as an angle anchor for this tool.

Tips

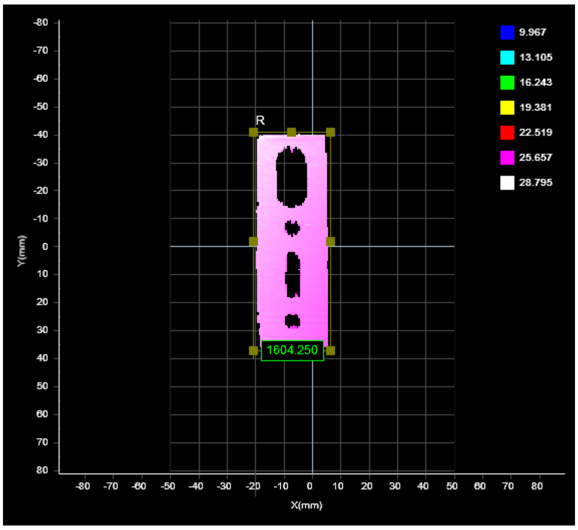
A measurement must be enabled in the other tool for it to be available as an anchor. The anchor measurement should also be properly configured before using it as an anchor.

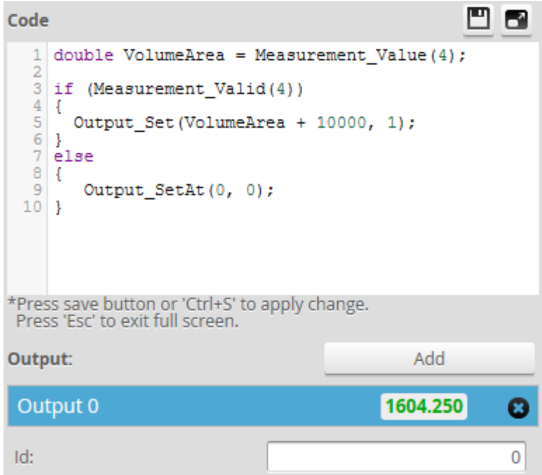
For more information on anchoring, see "●Measurement Anchoring" on page 254.

6.38 Script

A Script measurement can be used to program a custom measurement using a simplified C-based syntax. A script measurement can produce multiple measurement values and decisions for the output.

For more information on script tool syntax, see "4.7.10 Scripts" on page 321.





To create or edit a Script measurement:

1 Add a new Script tool or select an existing Script measurement.

2 Edit the script code.

3 Add script outputs using the [Add] button.

For each script output that is added, an index will be added to the [Output] drop-down and a unique ID will be generated.

To remove a script output, click on the button next to it.

4 Click the [Save] button to save the script code.

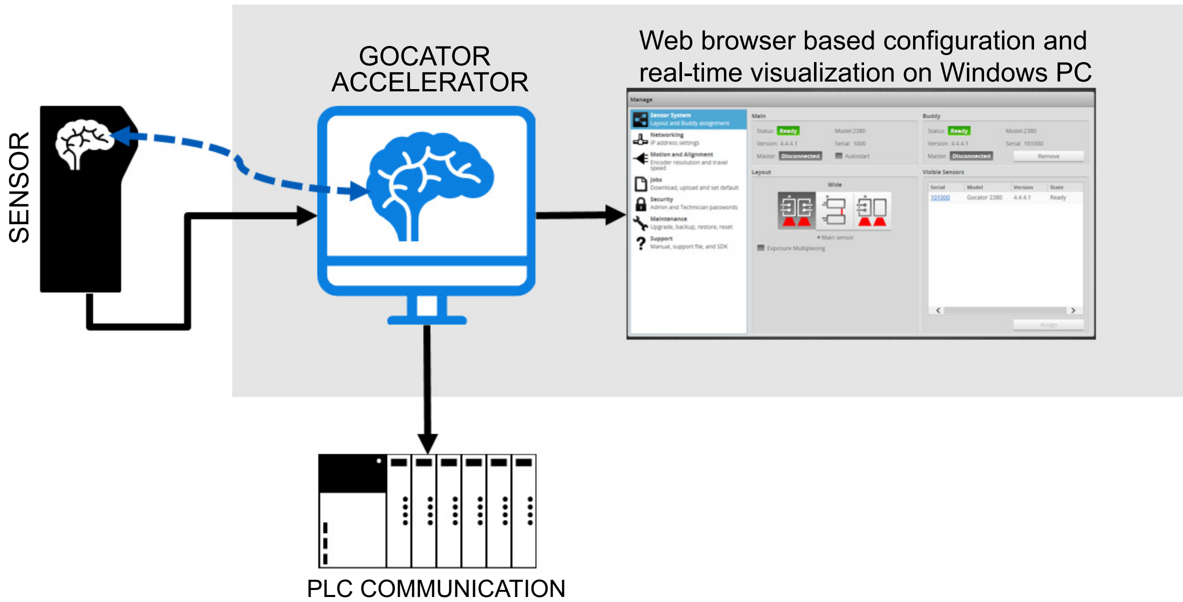
If there is a mistake in the script syntax, the result will be shown as a "Invalid" with a red border in the data viewer when you run the sensor.
Outputs from multiple measurement tools can be used as inputs to the script. A typical script would take results from other measurement tools using the value and decision function, and output the result using the output function. Stamp information, such as time and encoder stamps, are available in the script, whereas the actual 3D point cloud data is not. (The script engine is not powerful enough to process the data itself.) Only one script can be created.

MEMO

7 SurfaceMeasure1008S Acceleration

SurfaceMeasure1008S sensors are all-in-one devices, combining scanning, measurement, and control capabilities in a single housing. However, to achieve higher scan rates and measurement performance in very high density data scenarios, you may wish to use one of two acceleration methods.

For information on the ports acceleration uses (for example, in order to ensure ports are not blocked over your network), see "2.5.3 Required Ports" on page 49.



Acceleration improves a sensor system's processing capability by transferring the processing to a dedicated processing device in the system. The accelerator can accelerate one or more standalone sensors or multi-sensor systems. Mitutoyo provides two acceleration solutions:

- A hardware Smart Vision Accelerator called GoMax
- PC-based acceleration software (available either as a standalone utility or via the SDK)

For estimated performance and scan rates, see "7.5 Estimated Performance" on page 634.

Tips

The SurfaceMeasure1008S emulator and accelerator (software and GoMax) do not support the PROFINET protocol.

The web interface of an accelerated sensor is identical to the interface of an unaccelerated sensor. The Ethernet-based output protocols (SurfaceMeasure1008S, EtherNet/IP, ASCII, and Modbus) are also identical to those found on an unaccelerated sensor, and are fully supported.

Tips
Accelerators support digital, analog, and serial output from sensors. However, because output must be passed to the accelerator and then back to the sensor, network latency will have an impact on performance.

When a sensor is accelerated, it sends data directly to the accelerating device. You access the web interface using the IP address of the accelerating device, rather than the IP of the sensor. SDK applications can interface to the accelerator in the same way as is possible with a physical sensor, although the IP of the accelerating device must be used for the connection.

7.1 Benefits

Accelerated sensors provide several benefits.

Acceleration is completely transparent: because the output protocols of an accelerated sensor are identical to those of an unaccelerated sensor, SDK and PLC applications require no changes whatsoever for controlling accelerated sensors and receiving health information and data.

Measurement latency is reduced on accelerated sensors, which results in shorter cycle times. This means a sensor can scan more targets in a given time period.

The memory of accelerated sensors is limited only by the memory of the accelerating device. Accelerated sensors can therefore handle large 3D point clouds more effectively.

7.2 Dashboard and Health Indicators

After a sensor is accelerated, the values of some health indicators come from the accelerating PC instead of the sensor. Others come from a combination of the accelerated sensor and the accelerating PC.

- For information on which indicators are affected in the Dashboard in the web interface, see 📖 "4.9.3 State and Health Information" on page 339.
- For information on which indicators accessed through the SurfaceMeasure1008S protocol are affected, see 📖 "●Health Results" on page 811.

7.3 Hardware Acceleration: GoMax

The GoMax Smart Vision Accelerator is a dedicated, small form factor device that can accelerate one or more sensors. Using GoMax to accelerate a sensor system rather than a PC greatly simplifies implementation and maintenance, providing a plug-and-play experience. And GoMax better handles continuous 3D data streams over Ethernet. Finally, GoMax automatically recovers from temporary power losses or system disconnects.

For more information on GoMax, see the product's user manual.

7.4 Software-Based Acceleration

You can implement acceleration capabilities in client applications that you create using the SurfaceMeasure1008S SDK. You can also use the provided standalone utility (GoAccelerator.exe) that you can use to instantly accelerate systems.

Tips
The firmware version of the sensor you want to accelerate must match the version of the SDK used to build an accelerator-based application (or the version of the GoAccelerator utility).

7.4.1 System Requirements and Recommendations

■ Minimum System Requirements

The following are the minimum system requirements for accelerating a single sensor with the accelerator PC application:

PC

- Processor: Intel Core i3 or equivalent (32- or 64-bit)
- RAM: 4 GB
- Hard drive: 128 GB
- Operating system: Windows 7 or higher (32- or 64-bit)

Tips
To accelerate more sensors or run the system at higher speeds, use a computer with greater system resources.

Graphics Card
The acceleration of line profile sensors does not currently make use of a computer's graphics card.

■ Recommendations

The following are general recommendations:

- Purchase a PC based on the hardware specifications described in "7.5 Estimated Performance" on page 634.
- Run only the accelerator application on the PC: third-party applications can consume system resources in unpredictable ways and at random times.
- Limit background Windows processes such as drive optimization (defragmentation) or virus scans, or schedule them so that they don't interfere with scanning sessions.
- Ensure that sufficient overhead in the system's resources is available. You can review the PC's resources with the Windows Task Manager and Resource Monitor applications. We recommend that you leave at least 20% network bandwidth, CPU, memory and disk utilization at all times.
- To verify system stability and robustness, perform long-term testing over multiple days.

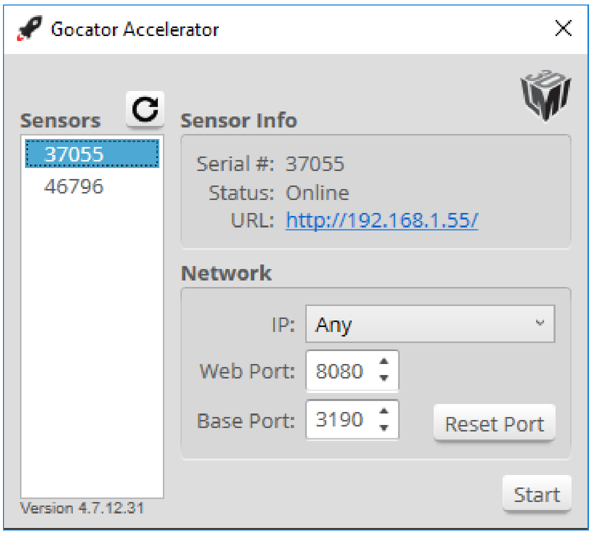
7.4.2 Installation

To get the necessary packages, access the website at https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/ and download the appropriate package.

- For the GoAccelerator utility, download the 14405-x.x.xx.x_SOFTWARE_Utilities_SM1008S.zip package.
- For the SDK libraries and DLL for integrating acceleration into a client application, download the 14400-x.x.xx.x_SOFTWARE_SDK_SM1008S.zip.

7.4.3 SurfaceMeasure1008S Accelerator Utility

The Accelerator utility accelerates the standalone sensors or multi-sensor systems you choose.



To accelerate a sensor using the Accelerator utility:

1. **Power up the sensor system you want to accelerate.**

2. **Launch the Accelerator utility.**

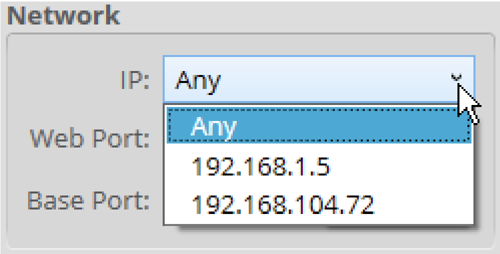
3. **If a Windows Security alert asks whether you want to allow GoAccelerator.exe to communicate on networks, make sure [Public] and [Private] are checked, and then click [Allow Access].**

4. **In the [Sensors] list, click the sensor you want to accelerate.**

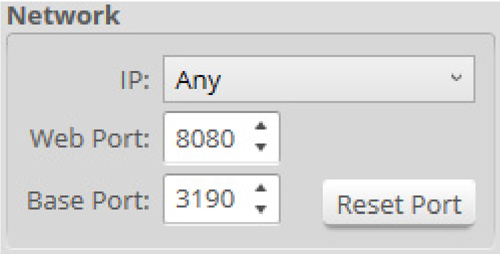
   » If you do not see the sensor, you may need to wait a few seconds and then click the Refresh button ( ).

   » In multi-sensor systems, only the Main sensor is listed.

5 (Optional) In the [IP] drop-down, choose an IP or choose [Any] to let the application choose.



6 (Optional) Set [Web Port] to a port for use with the accelerated sensor's URL.



Tips

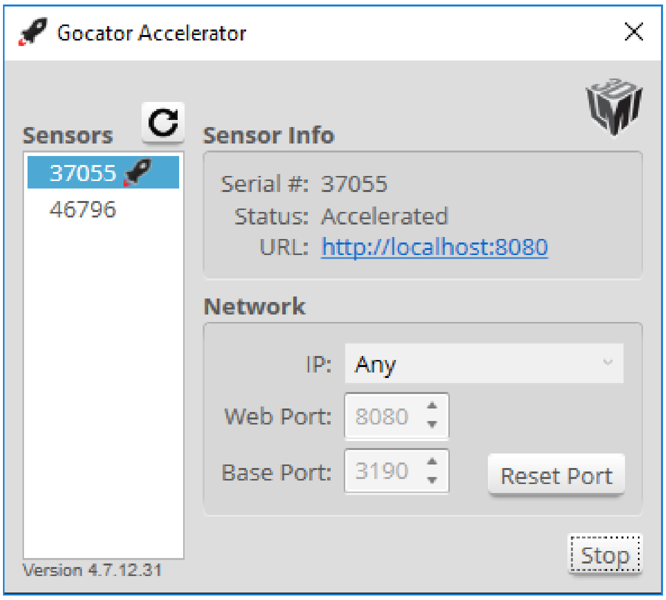
If port 8080 is already in use, set [Web Port] to an unused port.

7 (Optional) If you are accelerating multiple systems, click on another sensor in the [Sensors] list, and repeat the steps above.

- The application uses [Base Port] as an offset for several communication port numbers.
- To avoid port conflicts, you should increment the base port number by at least 10 for each accelerated sensor.
- Port 3190 is the default base port number, allowing connections from SDK-based applications and the web UI without manually specifying ports.

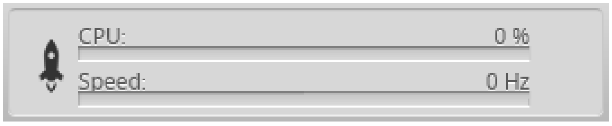
8 **Click [Start].**

The sensor system is now accelerated. An icon appears next to the accelerated sensor in the [Sensors] list to indicate this.



9 **To open the accelerated sensor's web interface, in the Accelerator application, click the link next to [URL].**

» When a sensor is accelerated, a "rocket" icon appears in the metrics area.



Tips

If you restart an accelerated sensor, the sensor will continue to be accelerated when it restarts.

To stop an accelerated sensor in the Accelerator application:

1 **Select the sensor in the [Sensors] list.**

2 **Click [Stop].**

To exit the Accelerator application:

1 **Right-click the icon Accelerator icon ( ) in the notification tray.**

Clicking the X icon in the application only minimizes the application.

2 **Choose [Exit].**

7.4.4 SDK Application Integration

Sensor acceleration can be fully integrated into an SDK application. Users simply need to instantiate the GoAccelerator object and connect it to a sensor object.

```
GoAccelerator accelerator = kNULL;

// obtain GoSensor object by sensor IP address
if ((status = GoSystem_FindSensorByIpAddress(system, &ipAddress, &sensor)) != kOK)
{
printf("Error: GoSystem_FindSensorByIpAddress:%d\n", status);
return;
}

// construct accelerator
if ((status = GoAccelerator_Construct(&accelerator, kNULL)) != kOK)
{
printf("Error: GoAccelerator_Construct:%d\n", status);
return;
}
// start accelerator
if ((status = GoAccelerator_Start(accelerator)) != kOK)
{
printf("Error: GoAccelerator_Start:%d\n", status);
return;
}
printf ("GoAccelerator_Start completed\n");
if ((status = GoAccelerator_Attach(accelerator, sensor)) != kOK)
{
printf("Error: GoAccelerator_Attach:%d\n", status);
return;
}

// create connection to GoSensor object
if ((status = GoSensor_Connect(sensor)) != kOK)
{
printf("Error: GoSensor_Connect:%d\n", status);
return;
}
```

After, the SDK application can control an accelerated sensor in the same way as an unaccelerated sensor.

7.5 Estimated Performance

The following table lists the running time of various measurement tools, with and without GoMax, as well as the performance increase factor when running with GoMax.

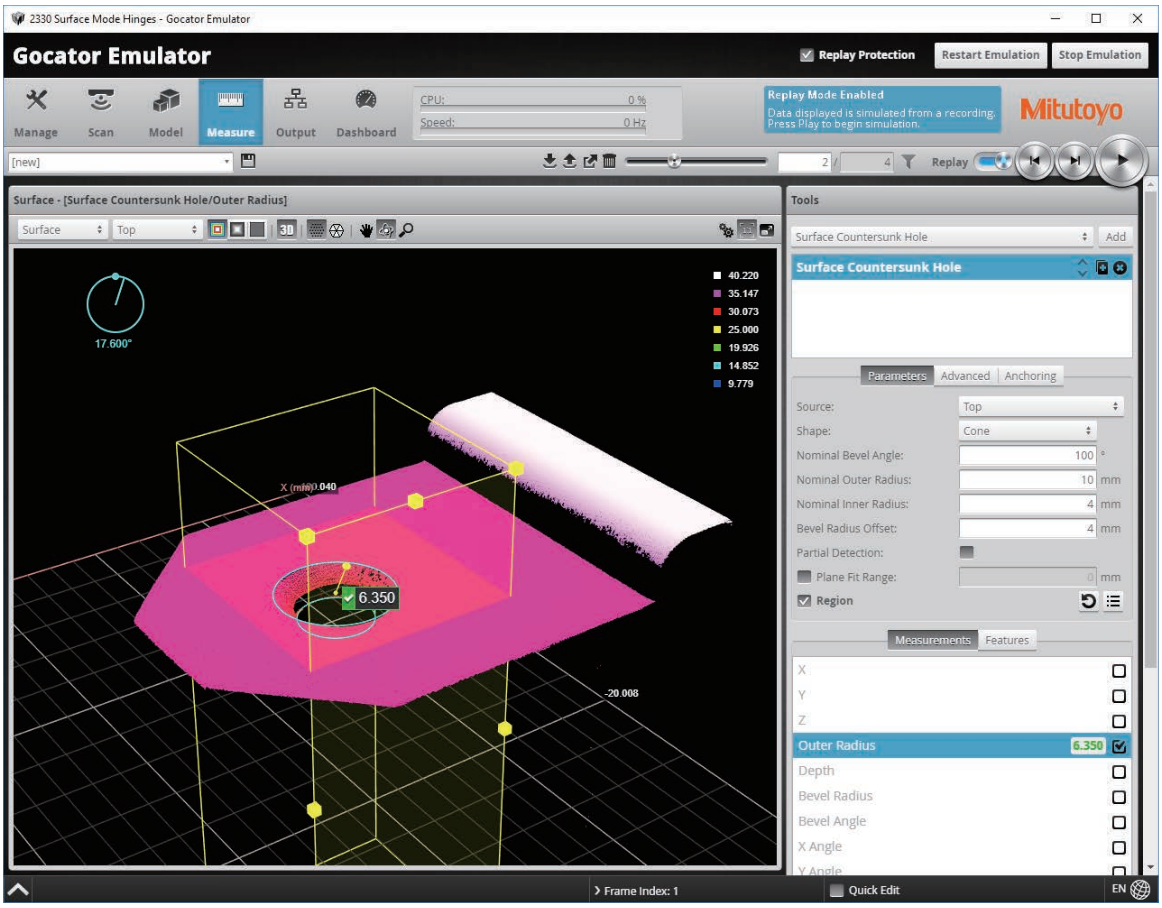
Note that although sensor models and job file configurations will affect running times, the performance increase factor for tools should be consistent across models and configurations.

SurfaceMeasure1008S 2510 Performance Increase Factors

Measurement Tool	Running Time on Sensor (ms)	Running Time with GoMax (ms)	Performance Increase Factor
Surface Hole	40	11	3.5
Surface Bounding Box	30	9	3.3
Surface Plane	2.3	0.4	6.0
Profile Dimension	0.054	0.037	1.5
Profile Intersect	0.075	0.028	2.7

8 SurfaceMeasure1008S Emulator

The emulator is a stand-alone application that lets you run a "virtual" sensor, encapsulated in a "scenario." When running a scenario, you can test jobs, evaluate data, and even learn more about new features, rather than take a physical device off the production line to do this. You can also use a scenario to familiarize yourself with the overall interface if you are new to SurfaceMeasure1008S.



Emulator showing a part in recorded data.
A measurement is applied to the recorded data.

8.1 System Requirements

The following are the system requirements for the software:

PC

- Processor: Intel Core i3 or equivalent (64-bit)
- RAM: 4 GB
- Hard drive: 500 GB
- Operating system: Windows 7 or higher (64-bit)

8.2 Limitations

In most ways, a scenario behaves like a real sensor, especially when visualizing data, setting up models and part matching, and adding and configuring measurement tools. The following are some of the limitations:

- Changes to job files in the emulator are not persistent (they are lost when you close or restart the emulator). However, you can keep a modified job by first saving it and then downloading it from the [Jobs] list on the [Manage] page to a client computer. The job file can then be loaded into the emulator at a later time or even onto a physical sensor for final testing.
- Performing alignment in the emulator has no effect and will never complete.
- The emulator does not support the PROFINET protocol.

For information on saving and loading jobs in the emulator, see "8.5.1 Creating, Saving, and Loading Jobs" on page 642.

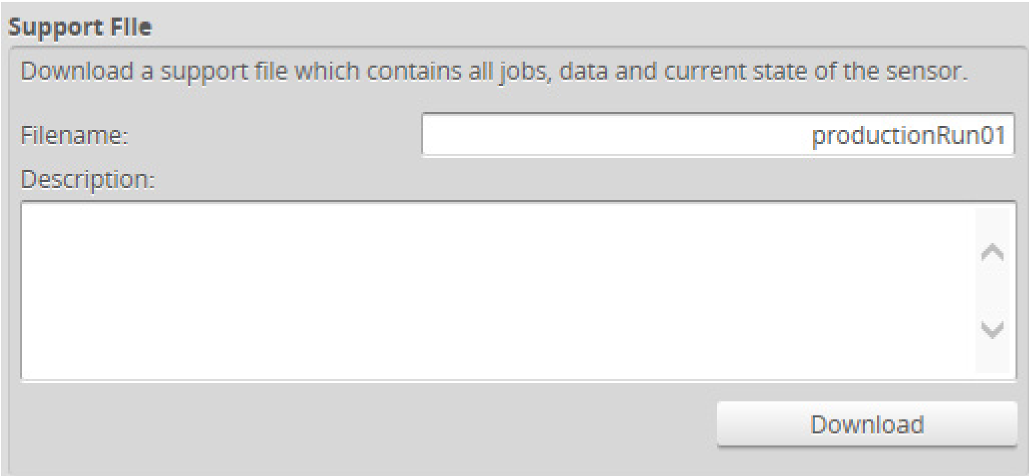
For information on uploading and downloading jobs between the emulator and a computer, and performing other job file management tasks, see "8.5.4 Downloading and Uploading Jobs" on page 647.

8.3 Downloading a Support File

The emulator provides several preinstalled scenarios.

You can also create scenarios yourself by downloading a support file from a physical sensor and then adding it to the emulator.

Support files can contain jobs, letting you configure systems and add measurements in an emulated sensor. Support files can also contain replay data, letting you test measurements and some configurations on real data. Dual-sensor systems are supported.



To download a support file:

1 Go to the [Manage] page and click on the [Support] category.

2 In [Filename], type the name you want to use for the support file.

When you create a scenario from a support file in the emulator, the filename you provide here is displayed in the emulator's scenario list.

Support files end with the .gs extension, but you do not need to type the extension in [Filename].

3 (Optional)In [Description], type a description of the support file.

When you create a scenario from a support file in the emulator, the description is displayed below the emulator's scenario list.

4 Click [Download], and then when prompted, click [Save].

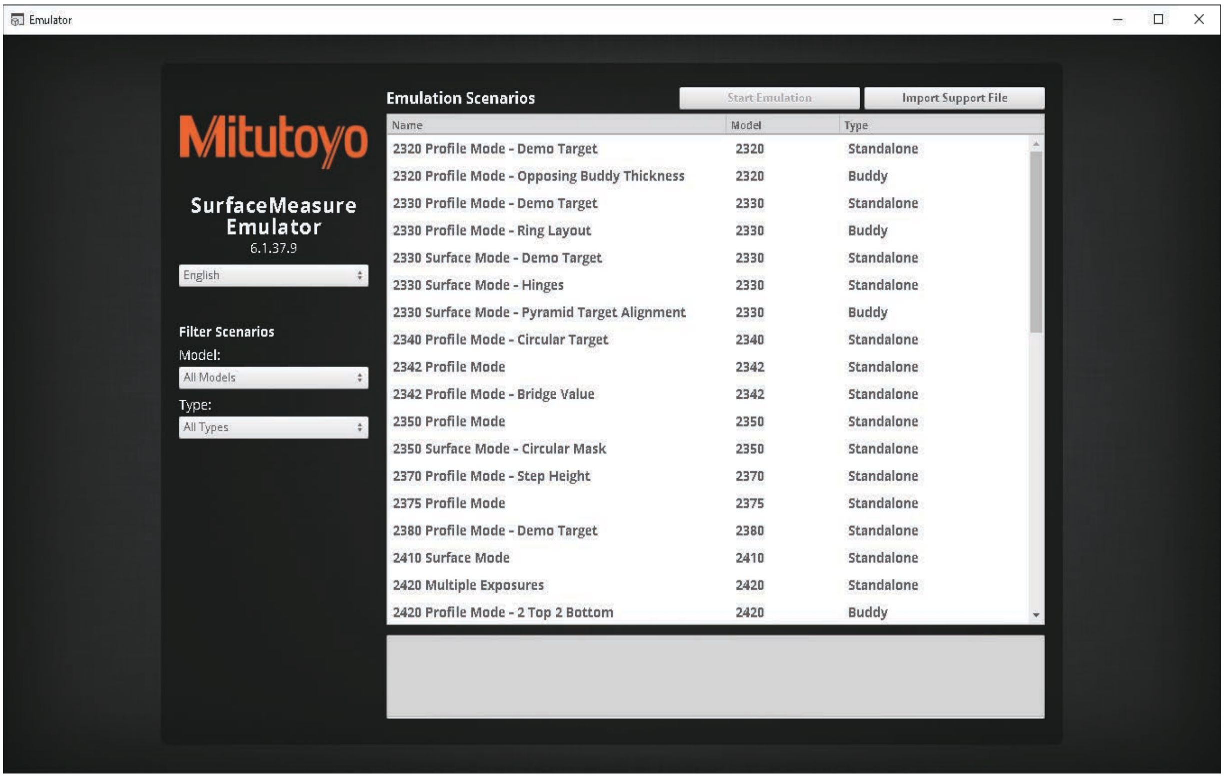
IMPORTANT

Downloading a support file stops the sensor.

8.4 Running the Emulator

The emulator is contained in the utilities package (14405-x.x.xx.x_SOFTWARE_Utilities_SM1008S.zip). Access the website at https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/ and download the appropriate package.

To run the emulator, unzip the package and double-click the GoEmulator link in the unzipped Emulator and Accelerator subfolder.



Emulator launch screen

You can change the language of the emulator's interface from the launch screen. To change the language, choose a language option from the top drop-down:

Selecting the emulator interface language

8.4.1 Adding a Scenario to the Emulator

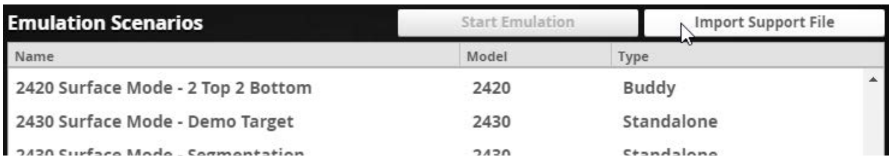
To simulate a physical sensor using a support file downloaded from a sensor, you must add it as a scenario in the emulator.

Tips
You can add support files downloaded from any series of SurfaceMeasure1008S to the emulator.

To add a scenario:

1 Launch the emulator if it isn't running already.

2 Click the [Add] button and choose a previously saved support file (.gs extension) in the [Choose File to Upload] dialog.

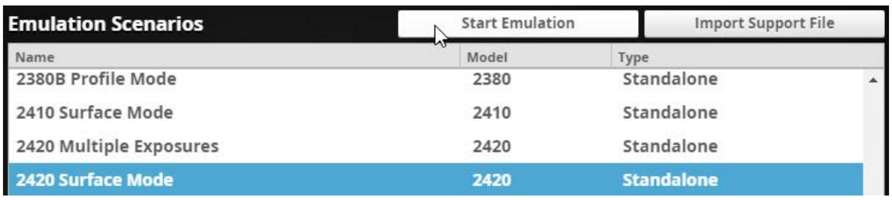


3 (Optional) In the field below the list, type a description.

Tips
You can only add descriptions for user-added scenarios.

8.4.2 Running a Scenario

After you have added a virtual sensor by uploading a support file to the emulator, you can run it from the [Available Scenarios] list on the emulator launch screen. You can also run any of the scenarios included in the installation.



To run a scenario:

1 If you want to filter the scenarios listed in [Available Scenarios], do one or both of the following:

- Choose a model family in the [Model] drop-down.
- Choose [Standalone] or [Buddy] to limit the scenarios to single-sensor or dual-/multi-sensor scenarios, respectively.

2 Select a scenario in the [Available Scenarios] list and double-click it in the list or click [Start].

8.4.3 Removing a Scenario from the Emulator

You can easily remove a scenario from the emulator.

> **Tips**
> You can only remove user-added scenarios.

To remove a scenario:

1. **If the emulator is running a scenario, click Stop Emulation to stop it.**
2. **In the [Available Scenarios] list, scroll to the scenario you want to remove.**
3. **Click the button next to the scenario you want to remove.**
   » The scenario is removed from the emulator.

8.4.4 Using Replay Protection

Making changes to certain settings on the [Scan] page causes the emulator to flush replay data. The [Replay Protection] option protects replay data by preventing changes to settings that affect replay data. Settings that do not affect replay data can be changed.

If you try to uncheck [Replay Protection], you must confirm that you want to disable it.
[Replay Protection] is on by default.

8.4.5 Stopping and Restarting the Emulator

To stop the emulator:

- Click [Stop Emulation].

Stopping the emulator returns you to the launch screen.

To restart the emulator when it is running:

- Click Restart Emulation.
  » Restarting the emulator restarts the currently running simulation.

8.4.6 Running the Emulator in Default Browser

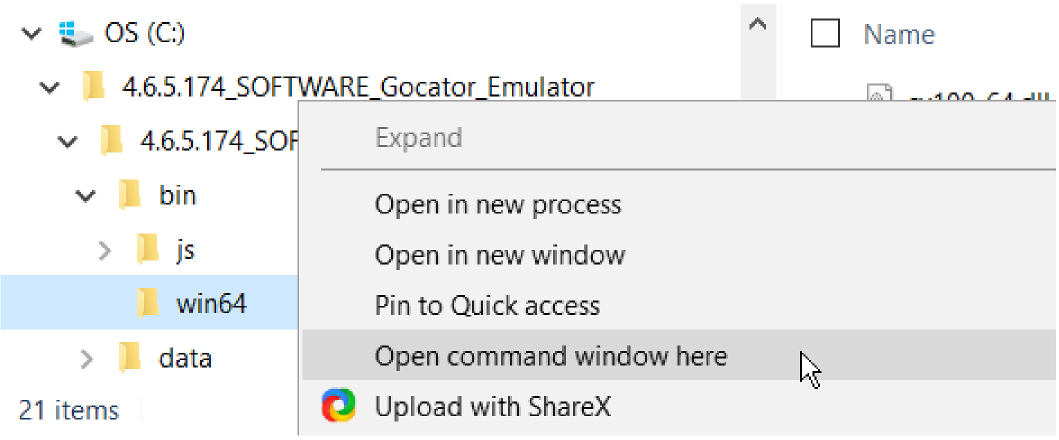
When you use the /browser command line parameter, the emulator application launches normally but also launches in your default browser. This provides additional flexibility when using the emulator. For example, you can resize the emulator running in a browser window.

To run the emulator in your default browser:

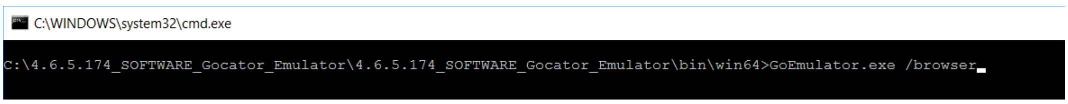
1. **In Windows Explorer (Windows 7) or File Explorer (Windows 8 or 10), browse to the location of the emulator.**

   » The emulator is under bin\win64, in the location in which you installed the emulator.

2. **Press and hold [Shift], right-click the win64 folder containing the emulator, and choose [Open command window here] (or [Open PowerShell window here]).**



3. **In the command prompt, type GoEmulator.exe /browser (or .\GoEmulator.exe /browser for PowerShell).**



After the emulator application starts, the emulator also launches in your default browser.

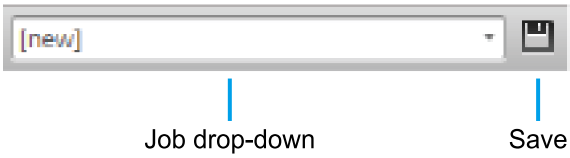
8.5 Working with Jobs and Data

The following topics describe how to work with jobs and replay data (data recorded from a physical sensor) in a scenario running on the emulator.

8.5.1 Creating, Saving, and Loading Jobs

Changes saved to job files in the emulator are not persistent (they are lost when you close or restart the emulator). To keep jobs permanently, you must first save the job in the emulator and then download the job file to a client computer. See below for more information on creating, saving, and switching jobs. For information on downloading and uploading jobs between the emulator and a computer, see "8.5.4 Downloading and Uploading Jobs" on page 647.

The job drop-down list in the toolbar shows the jobs available in the emulator. The job that is currently active is listed at the top. The job name will be marked with "[unsaved]" to indicate any unsaved changes.



To create a job:

1 **Choose [New] in the job drop-down list and type a name for the job.**

2 **Click the [Save] button or press [Enter] to save the job.**

» The job is saved to the emulator using the name you provided.

To save a job:

1 **Click the Save button .**

» The job is saved to the emulator.

To load (switch) jobs:

1 **Select an existing file name in the job drop-down list.**

» The job is activated.

If there are any unsaved changes in the current job, you will be asked whether you want to discard those changes.

8.5.2 Playback and Measurement Simulation

The emulator can replay scan data previously recorded by a physical sensor, and also simulate measurement tools on recorded data. This feature is most often used for troubleshooting and fine-tuning measurements, but can also be helpful during setup.

Playback is controlled using the toolbar controls.

Tips
Recording is not functional in the emulator.

Playback controls when replay is on

To replay data:

1 **Toggle [Replay] mode on by setting the slider to the right in the [Toolbar].**

» The slider's background turns blue.

To change the mode, you must uncheck [Replay Protection].

2 **Use the [Replay] slider or the [Step Forward], [Step Back], or [Play] buttons to review data.**

The [Step Forward] and [Step Back] buttons move the current replay location forward and backward by a single frame, respectively.

The [Play] button advances the replay location continuously, animating the playback until the end of the replay data.

The [Stop] button (replaces the [Play] button while playing) can be used to pause the replay at a particular location.

The [Replay] slider (or [Replay Position] box) can be used to go to a specific replay frame.

To simulate measurements on replay data:

1 **Toggle [Replay] mode on by setting the slider to the right in the [Toolbar].**

» The slider's background turns blue.

To change the mode, [Replay Protection] must be unchecked.

2 **Go to the [Measure] page.**

Modify settings for existing measurements, add new measurement tools, or delete measurement tools as desired. For information on adding and configuring measurements, see "4.7 Measurement and Processing" on page 230.

3 **Use the [Replay Slider], [Step Forward], [Step Back], or [Play] button to simulate measurements.**

» Step or play through recorded data to execute the measurement tools on the recording.

Individual measurement values can be viewed directly in the data viewer. Statistics on the measurements that have been simulated can be viewed in the [Dashboard] page; for more information on the dashboard, see "4.9 Dashboard" on page 337.

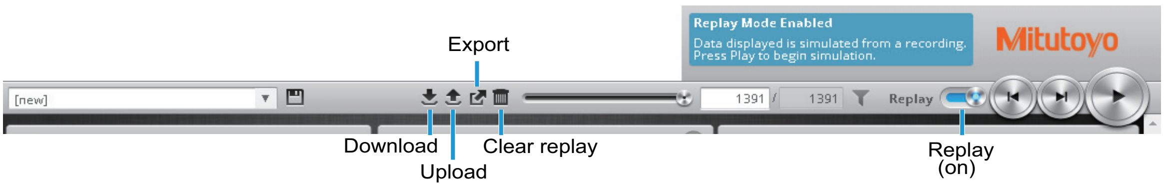
To clear replay data:

- Click the [Clear Replay] Data button.

8.5.3 Downloading, Uploading, and Exporting Replay Data

Replay data (recorded scan data) can be downloaded from the emulator to a client computer, or uploaded from a client computer to the emulator.

> **Tips**
> You can only upload replay data to the same sensor model that was used to create the data.



> **Tips**
> Replay data is not loaded or saved when you load or save jobs.

To download replay data:

1 **Click the Download button.**

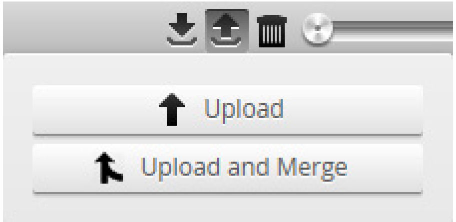
2 **In the [File Download] dialog, click [Save].**

3 **In the [Save As...] dialog, choose a location, optionally change the name, and click [Save].**

To upload replay data:

1 Click the Upload button .

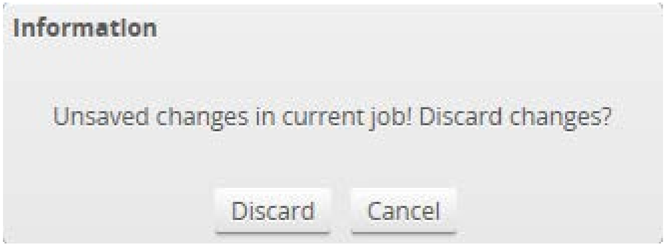
» The Upload menu appears.



2 In the Upload menu, choose one of the following:

- [Upload]: Unloads the current job and creates a new unsaved and untitled job from the content of the replay data file.
- [Upload and merge]: Uploads the replay data and merges the data's associated job with the current job. Specifically, the settings on the [Scan] page are overwritten, but all other settings of the current job are preserved, including any measurements or models.

» If you have unsaved changes in the current job, the firmware asks whether you want to discard the changes.



3 Do one of the following:

- Click [Discard] to discard any unsaved changes.
- Click [Cancel] to return to the main window to save your changes.

4 If you clicked [Discard], navigate to the replay data to upload from the client computer and click [OK].

» The replay data is loaded, and a new unsaved, untitled job is created.

Replay data can be exported using the CSV format. If you have enabled [Acquire Intensity] in the [Scan Mode] panel on the [Scan] page, the exported CSV file includes intensity data.

Tips
Surface intensity data cannot be exported to the CSV format. It can only be exported separately as a bitmap.

To export replay data in the CSV format:

1 **Switch to Replay mode.**

2 **Click the Export button and select [All Data as CSV].**

» In Profile mode, all data in the record buffer is exported.

» In Surface mode, only data at the current replay location is exported.

Use the playback control buttons to move to a different replay location; for information on playback, see To replay data in "8.5.2 Playback and Measurement Simulation" on page 643.

3 **(Optional)Convert exported data to another format using the CSV Converter Tool.**

For information on this tool, see "12.2 CSV Converter Tool" on page 974.

Tips

The decision values in the exported data depend on the current state of the job, not the state during recording. For example, if you record data when a measurement returns a pass decision, change the measurement's settings so that a fail decision is returned, and then export to CSV, you will see a fail decision in the exported data.

Recorded intensity data can be exported to a bitmap (.BMP format). [Acquire Intensity] must be checked in the [Scan Mode] panel while data was being recorded in order to export intensity data.

To export recorded intensity data to the BMP format:

- Switch to Replay mode and click the Export button and select Intensity data as BMP.

  » Only the intensity data in the current replay location is exported.

  Use the playback control buttons to move to a different replay location; for information on playback, see To replay data in "8.5.2 Playback and Measurement Simulation" on page 643.

To export video data to a BMP file:

1 **Move the playback position.**

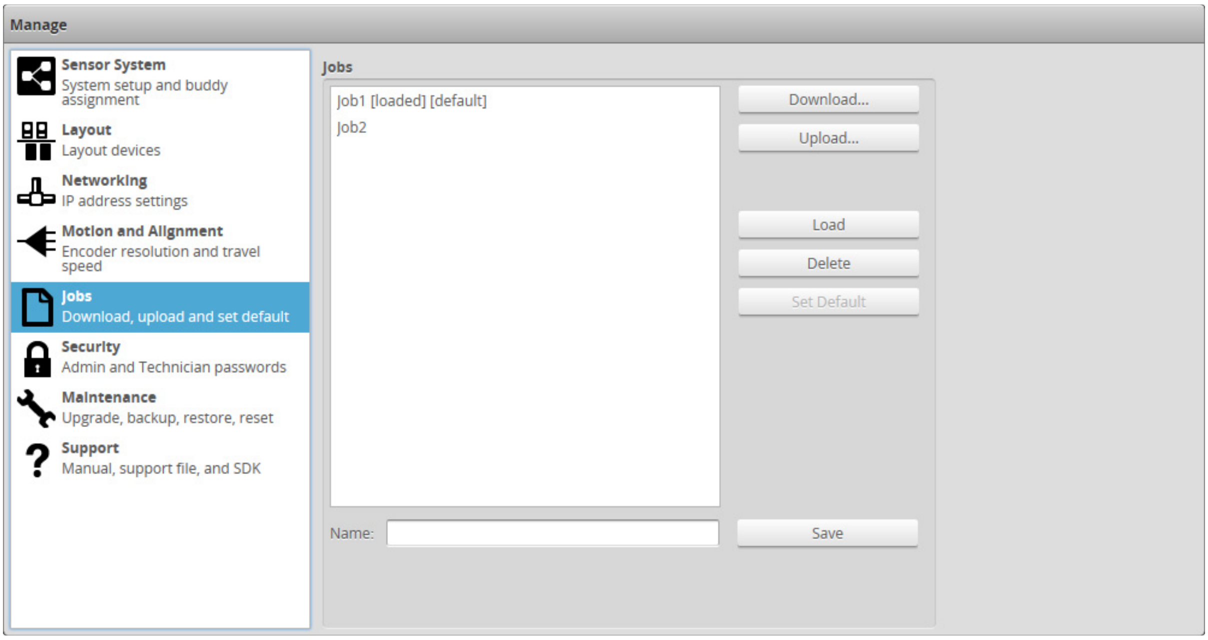
Use the playback control buttons to move to a different replay location; for information on playback, see To replay data in "8.5.2 Playback and Measurement Simulation" on page 643.

2 **Switch to Replay mode.**

3 **Click the Export button and select [Video data as BMP].**

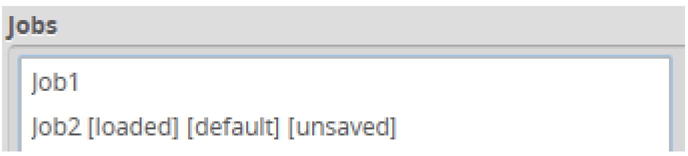
8.5.4 Downloading and Uploading Jobs

The [Jobs] category on the [Manage] page lets you manage the jobs in the emulator.



Element	Description
Name field	Used to provide a job name when saving files.
Jobs list	Displays the jobs that are currently saved in the emulator.
[Save] button	Saves current settings to the job using the name in the Name field. Changes to job files are not persistent in the emulator. To keep changes, first save changes in the job file, and then download the job file to a client computer. See the procedures below for instructions.
[Load] button	Loads the job that is selected in the job list. Reloading the current job discards any unsaved changes.
[Delete] button	Deletes the job that is selected in the job list.
[Set Default] button	Setting a different job as the default is not persistent in the emulator. The job set as default when the support file (used to create a virtual sensor) was downloaded is used as the default whenever the emulator is started.
[Download...] button	Downloads the selected job to the client computer.
[Upload...] button	Uploads a job from the client computer.

Unsaved jobs are indicated by "[unsaved]".



Tips

Changes to job files in the emulator are not persistent (they are lost when you close or restart the emulator). However, you can keep modified jobs by first saving them and then downloading them to a client computer.

To save a job:

1. **Go to the [Manage] page and click on the [Jobs] category.**

2. **Provide a name in the [Name] field.**

   To save an existing job under a different name, click on it in the [Jobs] list and then modify it in the [Name] field.

3. **Click on the [Save] button or press [Enter].**

To download, load, or delete a job, or to set one as a default, or clear a default:

1. **Go to the [Manage] page and click on the [Jobs] category.**

2. **Select a job in the [Jobs] list.**

3. **Click on the appropriate button for the operation.**

8.6 Scan, Model, and Measurement Settings

The settings on the [Scan] page related to actual scanning will clear the buffer of any scan data that is uploaded from a client computer, or is part of a support file used to create a virtual sensor. If [Replay Protection] is checked, the emulator will indicate in the log that the setting can't be changed because the change would clear the buffer. For more information on Replay Protection, see 📖 "8.4.4 Using Replay Protection" on page 640.

Other settings on the [Scan] page related to the post-processing of data can be modified to test their influence on scan data, without modifying or clearing the data, for example edge filtering (page 205), and filters on the X axis (page 192). Note that modifying the Y filters causes the buffer to be cleared.

For information on creating models and setting up part matching, see 📖 "4.6 Models" on page 209.

For information on adding and configuring measurement tools, see 📖 "4.7 Measurement and Processing" on page 230.

8.6.1 Calculating Potential Maximum Frame Rate

You can use the emulator to calculate the potential maximum frame rate you can achieve with different settings.

For example, when you reduce the active area, in the [Active Area] tab on the [Sensor] panel, the maximum frame rate displayed on the [Trigger] panel is updated to reflect the increased speed that would be available in a physical sensor. (See 📖 "■Active Area" on page 124 for more information on active area.)

Similarly, you can adjust exposure on the [Exposure] tab on the [Sensor] panel to see how this affects the maximum frame rate. (See 📖 "■Exposure" on page 130 on page 172 for more information on exposure.)

> **Tips**
> To adjust active area in the emulator, [Replay Protection] must be turned off. See 📖 "8.4.4 Using Replay Protection" on page 640 for more information.

> **Tips**
> Saving changes to active area causes replay data to be flushed.

8.7 Protocol Output

The emulator simulates output for all of SurfaceMeasure1008S's Ethernet-based protocols, with the exception of PROFINET.

- SurfaceMeasure1008S
- ASCII
- Modbus
- EtherNet/IP

Clients (such as PLCs) can connect to the emulator to access the simulated output and use the protocols as they would with a physical sensor.

The emulator allows connections to emulated sensors on localhost (127.0.0.1). You can also allow connections to emulated sensors on your computer's network card; for more information, see "8.7.1 Remote Operation" on page 650.

8.7.1 Remote Operation

You can specify the IP address of one of your computer's network cards to allow clients to connect remotely to an emulated sensor using the /ip command line parameter. When the /ip parameter is not used, emulated sensors are only available on the local machine (that is, 127.0.0.1 or localhost).

Tips

Clients can only connect to emulated sensors.

Tips

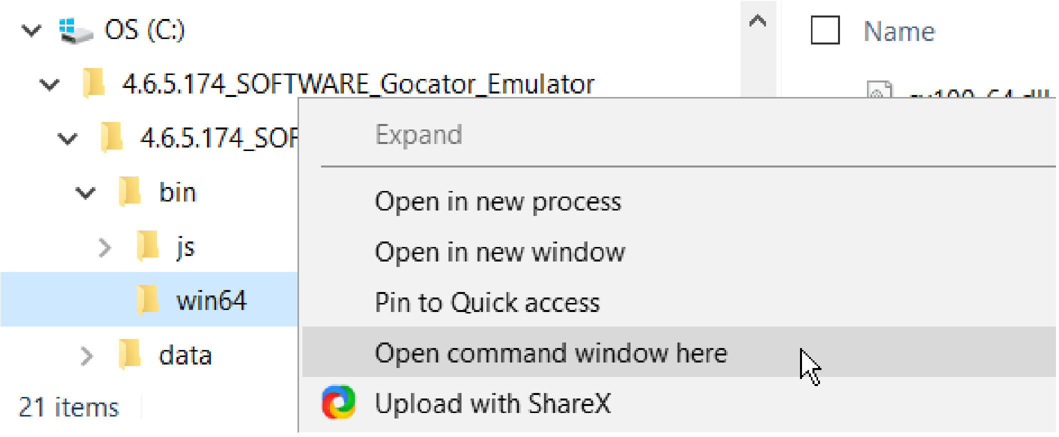
You may need to contact your network administrator to allow connections to the computer running the emulated sensor.

To allow remote connections to an emulated sensor:

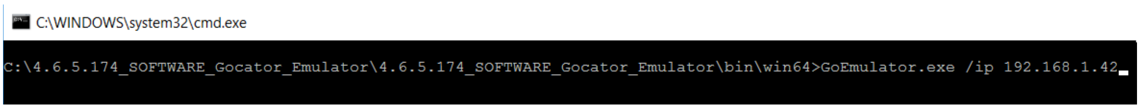
1 **In Windows Explorer (Windows 7) or File Explorer (Windows 8 or 10), browse to the location of the emulator.**

The emulator is under bin\win64, in the location in which you installed the emulator.

2 **Press and hold Shift, right-click the win64 folder containing the emulator, and choose [Open command window here] (or [Open PowerShell window here]).**



3 **In the command prompt, type GoEmulator.exe /ip, followed by a valid IPV4 address on your network.**



» The emulator application starts.

Tips
The emulator does not check that the IP address is valid.

4 **From the emulator launch page, start a scenario.**

For more information, see "8.4.2 Running a Scenario" on page 639.

5 **Provide the IP address you used with the /ip parameter, followed by port number 3191, to users who want to connect to the emulated sensor, for example:**

192.168.1.42:3191

MEMO

9 Sensor Device Files

This section describes the user-accessible device files stored on a sensor.

9.1 Live Files

Various "live" files stored on a sensor represent the sensor's active settings and transformations (represented together as "job" files), the active replay data (if any), and the sensor log.

By changing the live job file, you can change how the sensor behaves. For example, to make settings and transformations active, write to or copy to the _live.job file. You can also save active settings or transformations to a client computer, or to a file on the sensor, by reading from or copying these files, respectively.

Tips

The live files are stored in volatile storage. Only user-created job files are stored in non-volatile storage.

The following table lists the live files:

Live Files

Name	Read/Write	Description
_live.job	Read/Write	The active job. This file contains a Configuration component containing the current settings. If Alignment Reference in the active job is set to Dynamic, it also contains a Transform component containing transformations. For more information on job files (live and user-created), accessing their components, and their structure, see "9.2 Job File Structure" on page 655.
_live.cfg	Read/Write	A standalone representation of the Configuration component contained in _live.job. Used primarily for backwards compatibility.
_live.tfm	Read/Write	[If Alignment Reference of the active job is set to Dynamic:] A copy of the Transform component in _live.job. Used primarily for backwards compatibility. [If Alignment Reference of the active job is set to Fixed:] The transformations that are used for all jobs whose Alignment Reference setting is set to Fixed.
_live.log	Read	A sensor log containing various messages. For more information on the log file, see "9.1.1 Log File" on page 654.
_live.rec	Read/Write	The active replay simulation data.
ExtendedId.xml	Read	Sensor identification.

9.1.1 Log File

The log file contains log messages generated by the sensor. The root element is Log.

To access the log file, use the Read File command, passing "_live.log" to the command. The log file is read-only.

Log Child Elements

Element	Type	Description
@idStart	64s	Identifier of the first log.
@idEnd	64s	Identifier of the final log.
List of (Info | Warning | Error)	List	An ordered list of log entries. This list is empty if idEnd < idStart.

Log/Info | Log/Warning | Log/Error Elements

Element	Type	Description
@time	64u	Log time, in uptime (µs).
@source	32u	The serial number of the sensor the log was produced by.
@id	32u	The Indentifier, or index, of the log
@value	String	Log content; may contain printf-style format specifiers (e.g. %u).
List of (IntArg | FloatArg | Arg)	List	An ordered list of arguments: IntArg – Integer argument FloatArg – Floating-point argument Arg – Generic argument

The arguments are all sent as strings and should be applied in order to the format specifiers found in the content.

9.2 Job File Structure

The following sections describe the structure of job files.

Job files, which are stored in a sensor's internal storage, control system behavior when a sensor is running. Job files contain the settings and potentially the transformations and models associated with the job (if Alignment Reference is set to Dynamic).

There are two kinds of job files:

- A special job file called "_live.job." This job file contains the active settings and potentially the transformations and models associated with the job. It is stored in volatile storage.
- Other job files that are stored in non-volatile storage.

9.2.1 Job File Components

A job file contains components that can be loaded and saved as independent files. The following table lists the components of a job file:

Job File Components

Component	Path	Description
Configuration	config.xml	The job's configurations. This component is always present. For more informa-tion, see "9.2.3 Configuration" on page 656.
Transform	transform.xml	Transformation values. Present only if Alignment Reference is set to Dynamic. For more information, see "9.2.4 Transform" on page 743.
Part model	<name>.mdl	One or more part model files. Part models are created using models and part matching. For more information, see "9.2.5 Part Models" on page 744.

Elements in the components contain three types of values: settings, constraints, and properties. Settings are input values that can be edited. Constraints are read-only limits that define the valid values for settings. Properties are read-only values that provide supplemental information related to sensor setup.

When a job file is received from a sensor, it will contain settings, constraints, and properties. When a job file is sent to a sensor, any constraints or properties in the file will be ignored.

Changing the value of a setting can affect multiple constraints and properties. After you upload a job file, you can download the job file again to access the updated values of the constraints and properties.

9.2.2 Accessing Files and Components

Job file components can be accessed individually as XML files using path notation. For example, the configurations in a user-created job file called productionRun01.job can be read by passing “productionRun01.job/config.xml” to the Read File command. In the same way, the configurations in the active job could be read using "_live.job/config.xml".

Tips

If Alignment Reference is set to Fixed, the active job file (_live.job) will not contain transformations. To access transformations in this case, you must access them via _live.tfm.

Tips

The following sections correspond to the XML structure used in job file components.

9.2.3 Configuration

The Configuration component of a job file contains settings that control how a sensor behaves.

You can access the Configuration component of the active job as an XML file, either using path notation, via "_live.job/config.xml", or directly via "_live.cfg".

You can access the Configuration component in user-created job files in non-volatile storage, for example, "productionRun01.job/config.xml". You can only access configurations in user-created job files using path notation.

See the following sections for the elements contained in this component.

All sensors share a common job file structure and settings for all features are included in job files, regardless of the model.

Tips

If a setting in a job file is not used by a sensor, the setting's used property is set to 0.

Configuration Child Elements

Element	Type	Description
@version	32u	Configuration version (101).
@versionMinor	32u	Configuration minor version (9).
Setup	Section	For a description of the Setup elements, see "■Setup" on page 657.
Replay	Section	Contains settings related to recording filtering (see "■Replay" on page 676).
Streams	Section	Read-only collection of available data streams (see "■Streams/ Stream (Read-only)" on page 677).
ToolOptions	Section	List of available tool types and their information. See "■ToolOptions" on page 679 for details.
Tools	Collection	Collection of sections. Each section is an instance of a tool and is named by the type of the tool it describes. For more information, see the sections for each tool under "■Tools" on page 681.

Tools.options	String (CSV)	Deprecated. Replaced by ToolOptions.
Outputs	Section	For a description of the Output elements, see "■Output" on page 738.

■ Setup

The Setup element contains settings related to system and sensor setup.

Setup Child Elements

Element	Type	Description
TemperatureSafetyEnabled	Bool	Enables laser temperature safety control. Only applies to certain laser-based sensors.
TemperatureSafetyEnabled.used	Bool	Whether or not this property is used.
ScanMode		The default scan mode.
ScanMode options	String (CSV)	List of available scan modes.
OcclusionReductionEnabled	Bool	Enables occlusion reduction.
OcclusionReductionEnabled.used	Bool	Whether or not property is used.
OcclusionReductionEnabled.value	Bool	Actual value used if not configurable.
OcclusionReductionAlg	32s	The Algorithim to use for occlusion reduction: 0 – Standard 1 – High Quality
OcclusionReductionAlg.used	Bool	Whether or not property is used
OcclusionReductionAlg.value	Bool	Actual value used if not configurable
UniformSpacingEnabled	Bool	Enables uniform spacing.
UniformSpacingEnabled.used	Bool	Whether or not property is used.
UniformSpacingEnabled.readonly	Bool	Whether or not property can be modified.
UniformSpacingEnabled.value	Bool	Actual value used if not configurable.
IntensityEnabled	Bool	Enables intensity data collection.
IntensityEnabled.used	Bool	Whether or not property is used.
IntensityEnabled.value	Bool	Actual value used if not configurable.
FlickerFreeModeEnabled	Bool	Enables flicker-free operation.
FlickerFreeModeEnabled.used	Bool	Whether flicker-free operation can be used on this sensor.
ExternalInputZPulseEnabled	Bool	Enables the External Input based encoder Z Pulse feature.
ExternalInputZPulseIndex	32u	Input index to use for the input triggered z pulse feature.

Element	Type	Description
ExternalInputZPulseEn-abled.used	Bool	Whether the index can be set.
BackgroundSuppression	Section	See "●BackgroundSuppression" on page 658.
Filters	Section	See "●Filters" on page 658.
Trigger	Section	See "●Trigger" on page 661.
Layout	Section	See "●Layout" on page 663.
Alignment	Section	See "●Alignment" on page 664.
Devices	Collection	A collection of two Device sections (with roles main and buddy). See "●Devices / Device" on page 666.
SurfaceGeneration	Section	See "●SurfaceGeneration" on page 670.
SurfaceSections	Section	See "●SurfaceSections" on page 671.
ProfileGeneration	Section	See "●ProfileGeneration" on page 672. Used by Surface-Measure1008S displacement sensors.
PartDetection	Section	See "●PartDetection" on page 673.
PartMatching	Section	See "●PartMatching" on page 674.
Custom	Custom	Used by specialized sensors.

● BackgroundSuppression

The BackgroundSuppression element contains settings related to background suppression.

BackgroundSuppression Child Elements

Element	Type	Description
Enabled	Bool	Enables background suppression.
FrameRatio	64f	Ratio of background frames to calibration frames

● Filters

The Filters element contains settings related to post-processing profiles before they are output or used by measurement tools.

- **XSmoothing**

XSmoothing Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **YSmoothing**

  YSmoothing Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **XGapFilling**

  XGapFilling Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **YGapFilling**

  YGapFilling Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **XMedian**

  XMedian Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **YMedian**

  YMedian Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).

Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **XDecimation**

XDecimation Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **YDecimation**

YDecimation Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **XSlope**

Tips

This filter is only available on displacement sensors.

XSlope Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

- **YSlope**

> **Tips**
> This filter is only available on displacement sensors.

YSlope Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
Enabled	Bool	Enables filtering.
Window	64f	Window size (mm).
Window.min	64f	Minimum window size (mm).
Window.max	64f	Maximum window size (mm).

Trigger

The Trigger element contains settings related to trigger source, speed, and encoder resolution.

Trigger Child Elements

Element	Type	Description
Source	32s	Trigger source: 0 – Time 1 – Encoder 2 – Digital Input 3 – Software
Source.options	32s (CSV)	List of available source options.
ExternalInputIndex	32s	Index of external input when Source (above) is set to 2 – Digital Input and connected to a Master. 0 – first digital input 1 – second digital input 2 – third digital input 3 – fourth digital input
ExternalInputIndex.options	32s (CSV)	List of available external input indices.
ExternalInputIndex.used	Bool	Whether the external input index used.
Units	32s	Sensor triggering units when source is not clock or encoder: 0 – Time 1 – Encoder
FrameRate	64f	Frame rate for time trigger (Hz).
FrameRate.min	64f	Minimum frame rate (Hz).
FrameRate.max	64f	Maximum frame rate (Hz).
FrameRate.maxSource	32s	Source of maximum frame rate limit: 0 – Imager 1 – Surface generation
TracheidRate	64f	The frame rate of Tracheid data (Read Only)
TracheidRate.used	Bool	Whether the sensor has a Tracheid data rate.

Element	Type	Description
FrameDataRate	64f	The frame rate of normal (range/profile/surface) data (Read Only)
FrameDataRate.used	Bool	Whether the sensor has a separate FrameDataRate
EncoderSpacing.min	64f	Minimum encoder spacing (mm).
EncoderSpacing.max	64f	Maximum encoder spacing (mm).
EncoderSpacing.min-Source	32s	Source of minimum encoder spacing: 0 – Resolution 1 – Surface generation
EncoderSpacing.used	Bool	Whether or not this parameter is configurable.
EncoderTriggerMode	32s	Encoder triggering mode: 0 – Tracking backward 1 – Bidirectional 2 – Ignore backward
Delay	64f	Trigger delay (µs or mm).
Delay.min	64f	Minimum trigger delay (µs or mm).
Delay.max	64f	Maximum trigger delay (µs or mm).
GateEnabled	Bool	Enables digital input gating.
GateEnabled.used	Bool	True if this parameter can be configured.
GateEnabled.value	Bool	Actual value if the parameter cannot be configured.
BurstEnabled	Bool	Enables burst triggering.
BurstEnabled.Used	Bool	Whether or not this parameter is configurable.
BurstCount	32u	Number of scans to take during burst triggering.
BurstCount.used	Bool	Whether or not this parameter is configurable.
BurstCount.max	32u	Maximum burst count.
ReversalDistanceAutoEn-abled	Bool	Whether or not to use auto-calculated value.
ReversalDistanceAutoEn-abled.used	Bool	Whether or not this parameter can be configured.
ReversalDistance	64f	Encoder reversal threshold (for jitter handling)
ReversalDistance.used	Bool	Whether or not this parameter is used.
ReversalDistance.value	64f	Actual value.
LaserSleepMode.used	Bool	Whether or not this feature can be configured.
LaserSleepMode/Enabled	Bool	Enables or disables the feature.
LaserSleepMode/IdleTime	64u	Idle time before laser is turned off (µs).
LaserSleepMode/Waku-pEncoderTravel	64u	Minimum amount of encoder movement before laser turns on (mm).

- Layout

Layout Child Elements

Element	Type	Description
DataSource	32s	Data source of the layout output (read-only): 0 – Top 1 – Bottom 2 – Top left 3 – Top right 4 – Top Bottom 5 – Left Right
XSpacingCount	32u	Number of points along X when data is resampled.
YSpacingCount	32u	Number of points along Y when data is resampled.
TransformedDataRegion	Region3D	Transformed data region of the layout output.
Orientation	32s	Sensor orientation: 0 – Normal (single-sensor system) / Wide (dual-sensor system) 1 – Opposite 2 – Reverse 3 – Grid
Grid	Grid	Grid representation of the multi-sensor layout.
Orientation.options	32s (CSV)	List of available orientation options.
Orientation.value	32s	Actual value used if not configurable.
MultiplexBuddyEnabled	Bool	Enables multiplexing for buddies.
MultiplexSingleEnabled	Bool	Enables multiplexing for a single sensor configuration.
MultiplexSingleExposureDuration	64f	Exposure duration in µs (currently rounded to integer when read by the sensor)
MultiplexSingleDelay	64f	Delay in µs. (Currently gets rounded up when read by the sensor.)
MultiplexSinglePeriod	64f	Period in µs. (Currently gets rounded up when read by the sensor.)
MultiplexSinglePeriod.min	64f	Minimum period in µs.

Region3D Child Elements

Element	Type	Description
X	64f	X start (mm).
Y	64f	Y start (mm).
Z	64f	Z start (mm).
Width	64f	X extent (mm).
Length	64f	Y extent (mm).
Height	64f	Z extent (mm).
ZAngle	64f	Z Angle start (degrees).
ZAngle.used	Bool	Whether or not this property is used.

Grid Elements

Element	Type	Description
ColumnCount	32u	Column count.
ColumnCount.value	32u	Column count value.

● Alignment

The Alignment element contains settings related to alignment and encoder calibration.

Alignment Child Elements

Element	Type	Description
@used	Bool	Whether or not this field is used
InputTriggerEnabled	Bool	Enables digital input-triggered alignment operation.
InputTriggerEnabled.used	Bool	Whether or not this feature can be enabled. This feature is available only on some sensor models.
InputTriggerEnabled.value	Bool	Actual feature status.
Type	32s	Type of alignment operation: 0 – Stationary 1 – Moving
Type.options	32s (CSV)	List of available alignment types.
StationaryTarget	32s	Stationary alignment target: 0 – None 1 – Disk 2 – Bar 3 – Plate
StationaryTarget.options	32s (CSV)	List of available stationary alignment targets.
MovingTarget	32s	Moving alignment target: 1 – Disk 2 – Bar
MovingTarget.options	32s (CSV)	List of available moving alignment targets.
EncoderCalibrateEnabled	Bool	Enables encoder resolution calibration.
Disk	Section	See 📖 "• Disk" on page 664.
Bar	Section	See 📖 "• Bar" on page 665.
Plate	Section	See 📖 "• Plate" on page 665.
Polygon	Section	See 📖 "• Polygon" on page 665.

• Disk

Disk Child Elements

Element	Type	Description
Diameter	64f	Disk diameter (mm).
Height	64f	Disk height (mm).

- **Bar**

Bar Child Elements

Element	Type	Description
Width	64f	Bar width (mm).
Height	64f	Bar height (mm).
HoleCount	32u	Number of holes.
HoleCount.value	32u	Actual number of holes expected by system.
HoleCount.used	Bool	Whether the hole count with be used in the bar alignment proceudure.
HoleDistance	64f	Distance between holes (mm).
HoleDistance.used	Bool	Whether the hole distance will be used in the bar alignment procedure.
HoleDiameter	64f	Diameter of holes (mm).
HoleDiameter.used	Bool	Whether the hold diameter will be used in the bar alignment procedure.
DegreesOfFreedom	32s	Degrees of freedom (DOF) to align: 42 – 3 DOF: x, z, y angle 58 – 4 DOF: x, y, z, y angle 59 – 5 DOF: x, y, z, y angle, z angle

- **Plate**

Plate Child Elements

Element	Type	Description
Height	64f	Plate height (mm).
HoleCount	32u	Number of holes.
RefHoleDiameter	64f	Diameter of reference hole (mm).
SecHoleDiameter	64f	Diameter of secondary hole(s) (mm).

- **Polygon**

Polygon Child Elements

Element	Type	Description
Corners	List	Contains a list of Corners (described below).
Corners.minCount	32s	Minimum number of corners.

- **Polygon/Corner**

Corner Child Elements

Element	Type	Description
X	64f	X Position
Y	64f	Y Position
Devices	List of 32u	List of devices this corner is assigned to.
Devices.options	List of 32u	List of valid options for this field.

Devices / Device

Devices / Device Child Elements

Element	Type	Description
@index	32u	Ordered index of devices in device list.
@role	32s	Sensor role: 0 – Main 1 – Buddy
Layout	Layout	Multiplexing bank settings.
DataSource	32s	Data source of device output (read-only): 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right
XSpacingCount	32u	Number of resampled points along X (read-only).
YSpacingCount	32u	Number of resampled points along Y (read-only).
ActiveArea	Region3D	Active area. (Contains min and max attributes for each element.)
TransformedDataRegion	Region3D	Active area after transformation (read-only).
FrontCamera	Window	Front camera window (read-only).
BackCamera	Window	Back camera window (read-only).
BackCamera.used	Bool	Whether or not this field is used.
PatternSequenceType	32s	The projector pattern sequence to display when a projector equipped device is running. The following types are possible: -1 – None 0 – Default 100 – Nine Lines 101 – Focus 102 – Standard Sequence
PatternSequenceType.options	32s	List of available pattern sequence types.
PatternSequenceType.used	Bool	Whether or not this field is used.

Element	Type	Description
PatternSequenceIndex	32u	The index of the pattern sequence to display. Choose the pattern that produces the best data. The indices represent Phase Pattern Sequences, followed by Stripe Pattern Sequences in reverse order. The lower indices are the higher frequency phase code patterns, and the higher indices are the lower frequency binary patterns. Index 1 [Phase Pattern Sequence Image 5]: Highest frequency sinusoid. Index 2 [Phase Pattern Sequence Image 4] [...] Index 5 [Phase Pattern Sequence Image 1]: Lowest frequency sinusoid. Index 6 [Stripe Pattern Sequence Image 7]: Highest bar count. Index 7 [Stripe Pattern Sequence Image 6] [...] Index 12 [Stripe Pattern Sequence Image 1]: Lowest bar count) Index 13 [Reference Image 1]
PatternSequenceIndex.min	32u	The minimum index (inclusive)
PatternSequenceIndex.max	32u	The maximum index (inclusive)
PatternSequenceIndex.used	Bool	Whether or not the pattern sequence index should be displayed
PatternSequenceIndex	32u	The index of the pattern sequence to display.
PatternSequenceIndex.min	32u	The minimum index (inclusive).
PatternSequenceIndex.max	32u	The maximum index (inclusive).
PatternSequenceIndex.used	Bool	Whether or not the pattern sequence index should be displayed.
PatternSequenceCount	32u	Number of frames in the active sequence (read-only).
ExposureMode	32s	Exposure mode: 0 – Single exposure 1 – Multiple exposures 2 – Dynamic exposure
ExposureMode.options	32s (CSV)	List of available exposure modes.
Exposure	64f	Single exposure (μs).
Exposure.min	64f	Minimum exposure (μs).
Exposure.max	64f	Maximum exposure (μs).
Exposure.used	Bool	Whether or not this field is used.
DynamicExposureMin	64f	Dynamic exposure range minimum (μs).
DynamicExposureMax	64f	Dynamic exposure range maximum (μs).
ExposureSteps	64f (CSV)	Mutiple exposure list (μs).
ExposureSteps.countMin	32u	Minimum number of exposure steps.
ExposureSteps.countMax	32u	Maximum number of exposure steps.

Element	Type	Description
IntensitySource	32s	Intensity source: 0 – Both cameras 1 – Front camera 2 – Back camera
IntensitySource.options	32s (CSV)	List of available intensity sources.
IntensityMode	32s	Intensity Mode: 0 – Auto 1 - Preserve
IntensityMode.used	Bool	Whether intensity mode is used
ZSubsampling	32u	Subsampling factor in Z.
ZSubsampling.options	32u (CSV)	List of available subsampling factors in Z.
SpacingInterval	64f	Uniform spacing interval (mm).
SpacingInterval.min	64f	Minimum spacing interval (mm).
SpacingInterval.max	64f	Maximum spacing interval (mm).
SpacingInterval.used	Bool	Whether or not field is used.
SpacingInterval value	64f	Actual value used.
SpacingIntervalType	32s	Spacing interval type: 0 – Maximum resolution 1 – Balanced 2 – Maximum speed 3 – Custom
SpacingIntervalType.used	Bool	Whether or not this field is used.
Tracking	Section	See 📖 Tracking Child Elements on page 720.
Material	Section	See 📖 Material Child Elements on page 720.
Tracheid	Section	See 📖 "• Tracheid Child Elements (These elements are not usable with the product’s current specifications.)" on page 669.
IndependentExposures	Section	See 📖 IndependentExposures Child Elements on page 724
Custom	Custom	Used by specialized sensors.

Region3D Child Elements

Element	Type	Description
X	64f	X start (mm).
Y	64f	Y start (mm).
Z	64f	Z start (mm).
Width	64f	X extent (mm).
Length	64f	Y extent (mm).
Height	64f	Z extent (mm).
ZAngle	64f	Z Angle start (degrees).
ZAngle.used	Bool	Whether or not this property is used.

Window Child Elements

Element	Type	Description
X	32u	X start (pixels).
Y	32u	Y start (pixels).
Width	32u	X extent (pixels).
Height	32u	Y extent (pixels).

Layout Child Elements

Element	Type	Description
Grid	Grid	Layout grid information.
MultiplexingBank	32u	Multiplexing bank ID
MultiplexingBank.used	32u	Whether or not this field can be specified
MultiplexingBank.value	32u	Actual value used by system

Grid Child Elements

Element	Type	Description
@used	Bool	Whether or not this section is used.
Row	32s	Device row position in grid layout.
Row.value	32s	Value in use by the sensor, useful for determining value when used is false.
Column	32s	Device column position in grid layout.
Column.value	32s	Value in use by the sensor, useful for determining value when used is false.
Direction	32s	Sensor orientation direction.
Direction.value	32s	Value in use by the sensor, useful for determining value when used is false.

Tracheid Child Elements (These elements are not usable with the product's current specifications.)

Element	Type	Description
@used	Bool	Whether this field is used. This is not usable with the product's current specifications.
TracheidExposureEnabled	Bool	Whether to use a unique exposure for tracheid capture
TracheidExposure	64f	The exposure value to use for tracheid measurements
TracheidExposure.min	64f	The minimum exposure value possible tracheid measurements
TracheidExposure.max	64f	The maximum exposure value possible for tracheid measurements
Camera0Threshold	32u	The tracheid threshold for camera 0
Camera1Threshold	32u	The tracheid threshold for camera 1

SurfaceGeneration

The SurfaceGeneration element contains settings related to surface generation.

SurfaceGeneration Child Elements

Element	Type	Description
Type	32s	Surface generation type: 0 – Continuous 1 – Fixed length 2 – Variable length 3 – Rotational
Type.options	32s (CSV)	List of available generation types
Type.value	32s	Value in use by the sensor
FixedLength	Section	See "• FixedLength" on page 670.
VariableLength	Section	See "• VariableLength" on page 670.
Rotational	Section	See "• Rotational" on page 671.

• FixedLength

FixedLength Child Elements

Element	Type	Description
StartTrigger	32s	Start trigger condition: 0 – Sequential 1 – Digital input 2 – Software triggered
ExternalInputIndex	32s	Index of external input when Source (above) is set to 1 – Digital Input and connected to a Master. 0 – first digital input 1 – second digital input 2 – third digital input 3 – fourth digital input
ExternalInputIndex.options	32s (CSV)	List of available external input indices.
ExternalInputIndex.used	Bool	Is the external input index in use.
Length	64f	Surface length (mm).
Length.min	64f	Minimum surface length (mm).
Length.max	64f	Maximum surface length (mm).

• VariableLength

VariableLength Child Elements

Element	Type	Description
MaxLength	64f	Maximum surface length (mm).
MaxLength.min	64f	Minimum value for maximum surface length (mm).
MaxLength.max	64f	Maximum value for maximum surface length (mm).

- **Rotational**

Rotational Child Elements

Element	Type	Description
Circumference	64f	Circumference (mm).
Circumference.min	64f	Minimum circumference (mm).
Circumference.max	64f	Maximum circumference (mm).

SurfaceSections

SurfaceSections Child Elements

Element	Type	Description
@used	Bool	Whether surface sectioning is enabled.
@xMin	64f	The minimum valid X value to be used for section definition.
@xMax	64f	The maximum valid X value to be used for section definition.
@yMin	64f	The minimum valid Y value to be used for section definition.
@yMax	64f	The maximum valid Y value to be used for section definition.
Section	Collection	A series of Section elements.

Section Child Elements

Element	Type	Description
@id	32s	The ID assigned to the surface section.
@name	String	The name associated with the surface section.
StartPoint	Point64f	The beginning point of the surface section.
EndPoint	Point64f	The end point of the surface section.
CustomSpacingIntervalEnabled	Bool	Indicates whether a user specified custom spacing interval is to be used for the resulting section.
SpacingInterval	64f	The user specified spacing interval.
SpacingInterval.min	64f	The spacing interval limit minimum.
SpacingInterval.max	64f	The spacing interval limit maximum.
SpacingInterval.value	64f	The current spacing interval used by the system.

● ProfileGeneration

The ProfileGeneration element contains settings related to profile generation.

This element is used by laser displacement sensors.

ProfileGeneration Child Elements

Element	Type	Description
Type	32s	Profile generation type: 0 – Continuous 1 – Fixed length 2 – Variable length 3 – Rotational
Type.options	32s (CSV)	List of available generation types
Type.value	32s	Value in use by the sensor
FixedLength	Section	See 📖 "• FixedLength" on page 672.
VariableLength	Section	See 📖 "• VariableLength" on page 670.
Rotational	Section	See 📖 "• Rotational" on page 673.

• FixedLength

FixedLength Child Elements

Element	Type	Description
StartTrigger	32s	Start trigger condition: 0 – Sequential 1 – Digital input 2 – Software triggered
ExternalInputIndex	32s	Index of external input when Source (above) is set to 1 – Digital Input and connected to a Master. 0 – first digital input 1 – second digital input 2 – third digital input 3 – fourth digital input
ExternalInputIndex.options	32s (CSV)	List of available external input indices.
ExternalInputIndex.used	Bool	Is the external input index in use.
Length	64f	Profile length (mm).
Length.min	64f	Minimum profile length (mm).
Length.max	64f	Maximum profile length (mm).

• VariableLength

VariableLength Child Elements

Element	Type	Description
MaxLength	64f	Maximum surface length (mm).
MaxLength.min	64f	Minimum value for maximum profile length (mm).
MaxLength.max	64f	Maximum value for maximum profile length (mm).

- **Rotational**

Rotational Child Elements

Element	Type	Description
Circumference	64f	Circumference (mm).
Circumference.min	64f	Minimum circumference (mm).
Circumference.max	64f	Maximum circumference (mm).

- PartDetection

PartDetection Child Elements

Element	Type	Description
Enabled	Bool	Enables part detection.
Enabled.used	Bool	Whether or not this field is used.
Enabled value	Bool	Actual value used if not configurable.
MinArea	64f	Minimum area (mm^2).
MinArea.min	64f	Minimum value of minimum area.
MinArea.max	64f	Maximum value of minimum area.
MinArea.used	Bool	Whether or not this field is used.
GapWidth	64f	Gap width (mm).
GapWidth.min	64f	Minimum gap width (mm).
GapWidth.max	64f	Maximum gap width (mm).
GapWidth.used	Bool	Whether or not this field is used.
GapLength	64f	Gap length (mm).
GapLength.min	64f	Minimum gap length (mm).
GapLength.max	64f	Maximum gap length (mm).
GapLength.used	Bool	Whether or not this field is used.
PaddingWidth	64f	Padding width (mm).
PaddingWidth.min	64f	Minimum padding width (mm).
PaddingWidth.max	64f	Maximum padding width (mm).
PaddingWidth.used	Bool	Whether or not this field is used.
PaddingLength	64f	Padding length (mm).
PaddingLength.min	64f	Minimum padding length (mm).
PaddingLength.max	64f	Maximum padding length (mm).
PaddingLength.used	Bool	Whether or not this field is used.
MinLength	64f	Minimum length (mm).
MinLength.min	64f	Minimum value of minimum length (mm).
MinLength.max	64f	Maximum value of minimum length (mm).
MinLength.used	Bool	Whether or not this field is used.
MaxLength	64f	Maximum length (mm).
MaxLength.min	64f	Minimum value of maximum length (mm).
MaxLength.max	64f	Maximum value of maximum length (mm).
MaxLength.used	Bool	Whether or not this field is used.
Threshold	64f	Height threshold (mm).
Threshold.min	64f	Minimum height threshold (mm).

Element	Type	Description
Threshold.max	64f	Maximum height threshold (mm).
ThresholdDirection	32u	Threshold direction: 0 – Above 1 – Below
FrameOfReference	32s	Part frame of reference: 0 – Sensor 1 – Scan 2 – Part
FrameOfReference.used	Bool	Whether or not this field is used.
FrameOfReference.value	32s	Actual value.
IncludeSinglePointsEn-abled	Bool	Enables preservation of single data points in Top+Bottom layout
IncludeSinglePointsEn-abled.used	Bool	Whether or nto this field is available to be modified
EdgeFiltering	Section	See "• EdgeFiltering" on page 674.

- **EdgeFiltering**

EdgeFiltering Child Elements

Element	Type	Description
@used	Bool	Whether or not this section is used.
Enabled	Bool	Enables edge filtering.
PreserveInteriorEnabled	Bool	Enables preservation of interior.
ElementWidth	64f	Element width (mm).
ElementWidth.min	64f	Minimum element width (mm).
ElementWidth.max	64f	Maximum element width (mm).
ElementLength	64f	Element length (mm).
ElementLength.min	64f	Minimum element length (mm).
ElementLength.max	64f	Maximum element length (mm).

● PartMatching

The PartMatching element contains settings related to part matching.

PartMatching Child Elements

Element	Type	Description
Enabled	Bool	Enables part matching.
Enabled.used	Bool	Whether or not this field is used.
MatchAlgo	32s	Match algorithm. 0 – Edge points 1 – Bounding Box 2 – Ellipse
Edge	Section	See "• Edge" on page 675.

Element	Type	Description
BoundingBox	Section	See "• BoundingBox" on page 675.
Ellipse	Section	See "• Ellipse" on page 676.

- **Edge**

Edge Child Elements

Element	Type	Description
ModelName	String	Name of the part model to use. Does not include the .mdl extension.
Acceptance/Quality/Min	64f	Minimum quality value for a match.

- **BoundingBox**

BoundingBox Child Elements

Element	Type	Description
ZAngle	64f	Z rotation to apply to bounding box (degrees).
AsymmetryDetectionType	32s	Determine whether to use asymmetry detection and, if enabled, which dimension is the basis of detection. The possible values are: 0 – None 1 – Length 2 - Width
Acceptance/Width/Min	64f	Minimum width (mm).
Acceptance/Width/Max	64f	Maximum width (mm).
Acceptance/Width/Toler-ance	64f	Width acceptance tolerance value
Acceptance/Width/Toler-ance.deprecated	Bool	Whether this tolerance field is deprecated
Acceptance/Length/Min	64f	Minimum length (mm).
Acceptance/Length/Max	64f	Maximum length (mm).
Acceptance/Length/Toler-ance	64f	Length acceptance tolerance value
Acceptance/Length/Toler-ance.deprecated	Bool	Whether this tolerance field is deprecated
X	64f	X value
X.deprecated	Bool	Whether this X field is deprecated
Y	64f	Y value
Y.deprecated	Bool	Whether this Y field is deprecated
Width	64f	Width value
Width.deprecated	Bool	Whether this width field is deprecated
Length	64f	Length value
Length.deprecated	Bool	Whether this length field is deprecated

- **Ellipse**

Ellipse Child Elements

Element	Type	Description
ZAngle	64f	Z rotation to apply to ellipse (degrees).
AsymmetryDetectionType	32s	Determine whether to use asymmetry detection and, if enabled, which dimension is the basis of detection. The possible values are: 0 – None 1 – Major 2 - Minor
Acceptance/Major/Min	64f	Minimum major length (mm).
Acceptance/Major/Max	64f	Maximum major length (mm).
Acceptance/Major/Tolerance	64f	Major acceptance tolerance value
Acceptance/Major/Tolerance.deprecated	Bool	Whether this tolerance field is deprecated
Acceptance/Minor/Min	64f	Minimum minor length (mm).
Acceptance/Minor/Max	64f	Maximum minor length (mm).
Acceptance/Minor/Tolerance	64f	Minor acceptance tolerance value
Acceptance/Minor/Tolerance.deprecated	Bool	Whether this tolerance field is deprecated
X	64f	X value
X.deprecated	Bool	Whether this X field is deprecated
Y	64f	Y value
Y.deprecated	Bool	Whether this Y field is deprecated
Width	64f	Width value
Width.deprecated	Bool	Whether this width field is deprecated
Length	64f	Length value
Length.deprecated	Bool	Whether this length field is deprecated

■ Replay

Contains settings related to recording filtering.

● RecordingFiltering

RecordingFiltering Child Elements

Element	Type	Description
ConditionCombineType	32s	0 – Any: If any enabled condition is satisfied, the current frame is recorded. 1 – All: All enabled conditions must be satisfied for the current frame to be recorded.
Conditions	Collection	A collection of AnyMeasurement, AnyData, or Measurement conditions.

- **Conditions/AnyMeasurement**

Conditions/AnyMeasurement Elements

Element	Type	Description
Enabled	Bool	Indicates whether the condition is enabled.
Result	32s	The measurement decision criteria to be included in the filter. Possible values are: 0 – Pass 1 – Fail 2 – Valid 3 – Invalid

- **Conditions/AnyData**

Conditions/AnyData Elements

Element	Type	Description
Enabled	Bool	Indicates whether the condition is enabled.
RangeCountCase	32s	The case under which to record data: 0 – Range count at or above threshold of valid data points. 1 – Range count below threshold.
RangeCountThreshold	32u	The threshold for the number of range points that are valid.

- **Conditions/Measurement**

Conditions/Measurement Elements

Element	Type	Description
Enabled	Bool	Indicates whether the condition is enabled.
Result	32s	The measurement decision criteria for the selected ID to be included in the filter. Possible values are: 0 – Pass 1 – Fail 2 – Valid 3 – Invalid
Ids	32s	The ID of the measurement to filter.

■ Streams/Stream (Read-only)

Streams/Stream Child Elements

Element	Type	Description
Step	32s	The data step of the stream being described. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section

Element	Type	Description
Id	32u	The stream ID.
CadenceId	32u	Represents a stage in the data processing pipeline. The greater the number, the farther removed from the initial acquisition stage. One of the following: 0 – Primary 1 – Auxiliary 10 - Diagnostic
DataType	32s	The stream data type 0 – None 4 – Uniform Profile 16 – Uniform Surface
ColorEncoding	32s	The color encoding type. Only appears for Video stream steps (1). 0 – None 1 – Bayer BGGR 2 – Bayer GBRG 3 – Bayer RGGB 4 – Bayer GRBG
IntensityEnabled	Bool	Whether the stream includes intensity data
Sources	Collection	A collection of Source elements as described below.

Source Child Elements

Element	Type	Description
Id	32s	The ID of the data source. Possible values are: 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right 4 – Top Bottom 5 – Left Right 100 to 131 – G2 buddy sensor device indices for configurations with 2 to 31 buddy G2 sensors to identify a particular sensor's scan data. Main sensor is 100. First buddied sensor is 101. Second buddied sensor is 102 and so on.
Capability	32s	The capability of the data stream source. Possible values are: 0 – Full 1 – Diagnostic only 2 - Virtual
Region	Region3d	The region of the given stream source.
AdditionalRegions	Collection	Collection of additional regions (for example, for the second camera).
AdditionalRegions/Region	Region3d	Additional regions.

■ ToolOptions

The ToolOptions element contains a list of available tool types, their measurements, features, and data output types, and settings for related information.

ToolOptions Child Elements

Element	Type	Description
<Tool Names>	Collection	A collection of tool name elements. An element for each tool type is present.

Tool Name Child Elements

Element	Type	Description
@displayName	String	Display name of the tool.
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
MeasurementOptions	Collection	See 📖 "●MeasurementOptions" on page 679.
FeatureOptions	Collection	See 📖 "●FeatureOptions" on page 680.
StreamOptions	Collection	See 📖 "●StreamOptions" on page 680.
ToolDataOutputOptions	Collection	See 📖 "●ToolDataOutputOptions" on page 681.
DefinedSourcesOptions	Collection	See 📖 "●DefinedSouresOptions" on page 681.

● MeasurementOptions

MeasurementOptions Child Elements

Element	Type	Description
<Measurement Names>	Collection	A collection of measurement name elements. An element for each measurement is present.

<Measurement Name> Child Elements

Element	Type	Description
@displayName	String	Display name of the tool.
@minCount	32u	Minimum number of instances in a tool.
@maxCount	32u	Maximum number of instances in a tool.

- FeatureOptions

FeatureOptions Child Elements

Element	Type	Description
<Feature Names>	Collection	A collection of feature name elements. An element for each measurement is present.

<Feature Name> Child Elements

Element	Type	Description
@displayName	String	Display name of the feature.
@minCount	32u	Minimum number of instances in a tool.
@maxCount	32u	Maximum number of instances in a tool.
@dataType	String	The data type of the feature. One of: – PointFeature – LineFeature – CircleFeature – PlaneFeature

- StreamOptions

StreamOptions Child Elements

Element	Type	Description
@step	32s	The data step of the stream being described. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
@ids	CSV	A list representing the available IDs associated with the given step.

- ToolDataOutputOptions

ToolDataOutputOptions Child Elements

Element	Type	Description
@displayName	String	Display name of the tool.
@dataType	32s	The data type of this data output from the tool. Possible values are: 1 – None 2 – Range 3 – Uniform (Resampled) Profile 4 – Profile Point Cloud (Unresampled Profile) 5 – Uniform (Resampled) Surface 6 – Surface Point Cloud (Unresampled Surface) 7 – Reserved 8 – Video 9 – Tracheid 10 – Measurement 0x201 – Feature Point 0x202 – Feature Line 0x203 – Feature Circle 0x204 – Feature Plane 0x80000000 – 0xFFFFFFFF – Generic Data
@minCount	32u	Minimum number of instances in a tool.
@maxCount	32u	Maximum number of instances in a tool.

- DefinedSouresOptions

DefinedSourcesOptions Child Elements

Element	Type	Description
@options	32s	Defines all the sensor positions that can be an input data source to this tool. The allowable sources are specified during tool definition time.

■ Tools

The Tools element contains measurement tools. The following sections describe each tool and its available measurements.

Tools Child Elements

Element	Type	Description
@options	String (CSV)	A list of the tools available in the currently selected scan mode.
<ToolType>	Section	An element for each added tool.

● Profile Types

The following types are used by various measurement tools.

• ProfileFeature

An element of type ProfileFeature defines the settings for detecting a feature within an area of interest.

ProfileFeature Child Elements

Element	Type	Description
Type	32s	Determine how the feature is detected within the area: 0 – Max Z 1 – Min Z 2 – Max X 3 – Min X 4 – Corner 5 – Average 6 – Rising Edge 7 – Falling Edge 8 – Any Edge 9 – Top Corner 10 – Bottom Corner 11 – Left Corner 12 – Right Corner 13 – Median
RegionEnabled	Bool	Indicates whether feature detection applies to the defined Region or to the entire active area.
Region	ProfileRegion 2D	Element for feature detection area.

• ProfileLine

An element of type ProfileLine defines measurement areas used to calculate a line.

ProfileLine Child Elements

Element	Type	Description
RegionCount	32s	Count of the regions.
Regions	(Collection)	The regions used to calculate a line. Contains one or two Region elements of type ProfileRegion2D, with RegionEnabled fields for each.

- **ProfileRegion2d**

An element of type ProfileRegion2d defines a rectangular area of interest.

ProfileRegion2d Child Elements

Element	Type	Description
X	64f	Setting for profile region X position (mm).
Z	64f	Setting for profile region Z position (mm).
Width	64f	Setting for profile region width (mm).
Height	64f	Setting for profile region height (mm).

Surface Types

The following types are used by the various measurement tools.

- **Region3D**

An element of type Region3D defines a rectangular area of interest in 3D.

Region3D Child Elements

Element	Type	Description
X	64f	Volume X position (mm).
Y	64f	Volume Y position (mm).
Z	64f	Volume Z position (mm).
Width	64f	Volume width (mm).
Length	64f	Volume length (mm).
Height	64f	Volume height (mm).

- **SurfaceFeature**

An element of type SurfaceFeature defines the settings for detecting a feature within an area of interest.

SurfaceFeature Child Elements

Element	Type	Description
Type	32s	Setting to determine how the feature is detected within the area: 0 – Average (formerly Centroid 2d) 1 – Centroid (formerly Centroid 3d) 2 – X Max 3 – X Min 4 – Y Max 5 – Y Min 6 – Z Max 7 – Z Min 8 – Median

Element	Type	Description
RegionEnabled	Boolean	Setting to enable/disable region: 0 – Disable 1 – Enable
Region	Region3D	Element for feature detection volume.

- **SurfaceRegion2d**

An element of type SurfaceRegion2d defines a rectangular area of interest on the X-Y plane.

SurfaceRegion2d Child Elements

Element	Type	Description
X	64f	Setting for surface region X position (mm).
Y	64f	Setting for surface region Y position (mm).
Width	64f	Setting for region width (mm).
Length	64f	Setting for region length (mm).

Geometric Feature Types

The Geometric Feature type is used by various measurement tools.

Feature Child Elements

Element	Type	Description
@id	32s	The identifier of the geometric feature. -1 if unassigned.
@dataType	String	The data type of the feature. One of: – PointFeature – LineFeature
@type	String	Type name of feature.
Name	String	The display name of the feature.
Enabled	Bool	Whether the given feature output is enabled.
Pinned	Boolean	Whether the feature is pinned to main renderer.
Parameters	Collection	Collection of GdkParam elements.

Parameter Types

The following types are used by internal and custom (user-created) GDK-based tools.

For the list of attributes of these types, see " GDK Parameter Child Elements" on page 686.

GDK Parameter Bool Type

Element	Type	Description
	Bool	Boolean value of parameter.

GDK Parameter Int Type

Element	Type	Description
	32s	Integer value of parameter of integer type.

GDK Parameter Float Type

Element	Type	Description
	64f	Floating point value of parameter.

GDK Parameter String Type

Element	Type	Description
	String	String value of parameter.

GDK Parameter Profile Region Type

Element	Type	Description
X	64f	X value of region.
Z	64f	Z value of region.
Width	64f	Width value of region.
Height	64f	Height value of region.

GDK Parameter Surface Region 2D Type

Element	Type	Description
X	64f	X value of region.
X	64f	X value of region.
Y	64f	Y value of region.
Width	64f	Width value of region.
Length	64f	Length value of region.

GDK Parameter Surface Region 3D Type

Element	Type	Description
X	64f	X value of region.
Y	64f	Y value of region.
Z	64f	Z value of region.
Width	64f	Width value of region.
Length	64f	Length value of region.
Height	64f	Height value of region.
ZAngle	64f	ZAngle value of region.

GDK Parameter Geometric Feature Type

Element	Type	Description
	32s	Geometric feature Id for parameter.

GDK Parameter Child Elements

Element	Type	Description
@label	String	Parameter label.
@type	String	Type of parameter. It is one of the following (see tables below for elements found in each type): - Bool - Int - Float - ProfileRegion - SurfaceRegion2d - SurfaceRegion3d - GeometricFeature - DataInput
@units	String	Parameter units name.
@options	Variant (CSV)	Options available for this parameter.
@optionNames	String (CSV)	Names
@used	String (CSV)	Parameter currently in use if true. Optional (defaults to true if not explicitly set)
@dataTypes	k32s	For DataInput parameters, it lists all the data types accepted by this parameter.

● ProfileArea

A ProfileArea element defines settings for a profile area tool and one or more of its measurements.

ProfileArea Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.

Element	Type	Description
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
Type	Boolean	Area to measure: 0 – Object (convex shape above the baseline) 1 – Clearance (concave shape below the baseline)
Type.used	Boolean	Whether or not field is used.
Baseline	Boolean	Baseline type: 0 – X-axis 1 – Line
Baseline.used	Boolean	Whether or not field is used.
RegionEnabled	Boolean	If enabled, the defined region is used for measurements. Otherwise, the full active area is used.
Region	ProfileRegion 2d	Measurement region.
Line	ProfileLine	Line definition when Baseline is set to Line.
Measurements\Area	Area tool measurement	Area measurement.
Measurements\CentroidX	Area tool measurement	CentroidX measurement.
Measurements\CentroidZ	Area tool measurement	CentroidZ measurement.
Features\CenterPoint	GeometricFeature	CenterPoint PointFeature.

Area Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable

Element	Type	Description
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

- ProfileBoundingBox

A ProfileBoundingBox element defines settings for a profile bounding box tool and one or more of its measurements.

ProfileBoundingBox Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RegionEnabled	Bool	Whether or not to use the region. If the region is disabled, all available data is used.
Region	ProfileRegion 2d	Measurement region.

Element	Type	Description
Measurements\X	Bounding Box tool measurement	X measurement.
Measurements\Z	Bounding Box tool measurement	Z measurement.
Measurements\Width	Bounding Box tool measurement	Width measurement.
Measurements\Height	Bounding Box tool measurement	Height measurement.
Measurements\GlobalX	Bounding Box tool measurement	GlobalX measurement
Measurements\GlobalY	Bounding Box tool measurement	GlobalY measurement
Measurements\GlobalAngle	Bounding Box tool measurement	GlobalAngle measurement
Features\CenterPoint	GeometricFeature	CenterPoint PointFeature.
Features\CornerPoint	GeometricFeature	CornerPoint PointFeature.

Bounding Box Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.

Element	Type	Description
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

- ## ProfileBridgeValue

A ProfileBridgeValue element defines settings for a profile bridge value tool and one or more of its measurements.

ProfileBridgeValue Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – 4 – Section Surface
Stream\Id	32u	The stream source ID.
RegionEnabled	Boolean	Whether or not to use region. If region is disabled, all available data is used.
Region	ProfileRegion 2d	Measurement region.
WindowSize	64f	A percentage of the profile point heights when ordered from lowest to highest in a histogram, starting from the highest points, to include in the bridge value calculation.

Element	Type	Description
WindowSkip	64f	A percentage of the profile point heights when ordered from lowest to highest in a histogram, starting from the highest points, to exclude from the bridge value calculation. Combines with WindowSize to determine what portion of the profile points are used in the bridge value calculation.
MaxInvalid	64f	The maximum percentage of invalid points.
NormalizeEnabled	Boolean	Whether tilt normalization is enabled.
MaxDifferential	64f	Maximum differential between the lowest and highest profile points (mm).
MaxDifferential.min	64f	Maximum differential limit min (mm).
MaxDifferential.max	64f	Maximum differential limit max (mm).
Measurements\BridgeValue	Bridge Value tool measurement	Bridge Value measurement.
Measurements\Angle	Bridge Value tool measurement	Angle measurement.

BridgeValue Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

● ProfileCircle

A ProfileCircle element defines settings for a profile circle tool and one or more of its measurements.

ProfileCircle Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RegionEnabled	Bool	Whether or not to use the region. If the region is disabled, all available data is used.
Region	ProfileRegion 2d	Measurement region.
Measurements\X	Circle tool measurement	X measurement.
Measurements\Z	Circle tool measurement	Z measurement.
Measurements\Radius	Circle tool measurement	Radius measurement.
Measurements\StdDev	CircleMea-surement	Standard deviation measurement
Measurements\MinError	CircleMea-surement	Minimum error measurement
Measurements\MinErrorX	CircleMea-surement	Minimum error X measurement
Measurements\MinErrorZ	CircleMea-surement	Minimum error Z measurement
Measurements\MaxError	CircleMea-surement	Maximum error measurement

Element	Type	Description
Measurements\MaxErrorX	CircleMea-surement	Maximum error X measurement
Measurements\MaxErrorZ	CircleMea-surement	Maximum error Z measurement
Features\CenterPoint	GeometricFeature	CenterPoint PointFeature.

Circle Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

● ProfileDimension

A ProfileDimension element defines settings for a profile dimension tool and one or more of its measurements.

ProfileDimension Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool

Element	Type	Description
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RefFeature	ProfileFeature	Reference measurement region.
Feature	ProfileFeature	Measurement region.
Measurements\Width	Dimension tool measurement	Width measurement.
Measurements\Height	Dimension tool measurement	Height measurement.
Measurements\Distance	Dimension tool measurement	Distance measurement.
Measurements\CenterX	Dimension tool measurement	CenterX measurement.
Measurements\CenterZ	Dimension tool measurement	CenterZ measurement.

Dimension Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable

Element	Type	Description
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
Absolute (Width and Height measurements only)	Boolean	Setting for selecting absolute or signed result: 0 – Signed 1 – Absolute

- ## ProfileGroove

A ProfileGroove element defines settings for a profile groove tool and one or more of its measurements. The profile groove tool is dynamic, meaning that it can contain multiple measurements of the same type in the Measurements element.

ProfileGroove Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section

Element	Type	Description
Stream\Id	32u	The stream source ID.
Shape	32s	Shape: 0 – U-shape 1 – V-shape 2 – Open
MinDepth	64f	Minimum depth.
MinWidth	64f	Minimum width.
MaxWidth	64f	Maximum width.
RegionEnabled	Bool	Whether or not to use the region. If the region is disabled, all available data is used.
Region	ProfileRegion 2d	Measurement region.
Measurements\X	Groove tool measurement	X measurement.
Measurements\Z	Groove tool measurement	Z measurement.
Measurements\Width	Groove tool measurement	Width measurement.
Measurements\Depth	Groove tool measurement	Depth measurement.

Groove Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

Element	Type	Description
SelectType	32s	Method of selecting a groove when multiple grooves are found: 0 – Max depth 1 – Ordinal, from left 2 – Ordinal, from right
SelectIndex	32s	Index when SelectType is set to 1 or 2.
Location (X and Z measurements only)	32s	Setting for groove location to return from: 0 – Bottom 1 – Left corner 2 – Right corner

- ## ProfileIntersect

A ProfileIntersect element defines settings for a profile intersect tool and one or more of its measurements.

ProfileIntersect Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
RefType	32s	Reference line type: 0 – Fit 1 – X Axis
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RefLine	ProfileLine	Definition of reference line. Ignored if RefType is not 0.

Element	Type	Description
Line	ProfileLine	Definition of line.
Measurements\X	Intersect tool measurement	X measurement.
Measurements\Z	Intersect tool measurement	Z measurement.
Measurements\Angle	Intersect tool measurement	Angle measurement.
Features\IntersectPoint	GeometricFeature	IntersectPoint PointFeature.
Features\Line	Geometric-Feature	Line LineFeature.
Features\BaseLine	Geometric-Feature	BaseLine LineFeature.

Intersect Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
Absolute (Angle measurement only)	Boolean	Setting for selecting the angle range: 0 – A range of -90 to 90 degrees is used. 1 – A range of 0 to 180 degrees is used.

● ProfileLine

A ProfileLine element defines settings for a profile line tool and one or more of its measurements.

ProfileLine Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RegionEnabled	Bool	Whether or not to use the region. If the region is disabled, all available data is used.
Region	ProfileRegion 2d	Measurement region.
FittingRegions	ProfileLine	ProfileLine describing up to 2 regions to fit to.
FittingRegionsEnabled	Bool	Whether the fitting regions are enabled.
Measurements\StdDev	Line tool measurement	StdDev measurement.
Measurements\MaxError	Line tool measurement	MaxError measurement.
Measurements\MinError	Line tool measurement	MinError measurement.
Measurements\Percentile	Line tool measurement	Percentile measurement.
Measurements\Offset	Line tool measurement	Offset measurement.
Measurements\Angle	Line tool measurement	Angle measurement.

Element	Type	Description
Measurements\MinErrorX	Line tool measurement	Minimum Error in Z measurement.
Measurements\MinErrorZ	Line tool measurement	Minimum Error in Z measurement.
Measurements\MaxErrorX	Line tool measurement	Maximum Error in X measurement.
Measurements\MaxErrorZ	Line tool measurement	Maximum Error in Z measurement.
Features\Line	GeometricFeature	Line LineFeature.
Features\ErrorMinPoint	Geometric-Feature	ErrorMinPoint PointFeature.
Features\ErrorMaxPoint	Geometric-Feature	ErrorMaxPoint PointFeature.

Line Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
Percent (Percentile measurement only)	64f	Error percentile.

● ProfilePanel

A ProfilePanel element defines settings for a profile panel tool and one or more of its measurements.

ProfilePanel Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RefSide	32s	Setting for reference side to use.
MaxGapWidth	64f	Setting for maximum gap width (mm).
LeftEdge	ProfilePanelEdge	Element for left edge configuration.
RightEdge	ProfilePanelEdge	Element for right edge configuration.
Measurements\Gap	Gap/Flush measurement	Gap measurement.
Measurements\Flush	Gap/Flush measurement	Flush measurement.
Measurements\LeftGapX	Gap/Flush measurement	Left Gap X measurement.
Measurements\LeftGapZ	Gap/Flush measurement	Left Gap Z measurement.
Measurements\LeftFlushX	Gap/Flush measurement	Left Flush X measurement.
Measurements\LeftFlushZ	Gap/Flush measurement	Left Flush Z measurement.
Measurements\LeftSurfaceAngle	Gap/Flush measurement	Left Surface Angle measurement.

Element	Type	Description
Measurements\RightGapX	Gap/Flush measurement	Right Gap X measurement.
Measurements\RightGapZ	Gap/Flush measurement	Right Gap Z measurement.
Measurements\Right-FlushX	Gap/Flush measurement	Right Flush X measurement.
Measurements\Right-FlushZ	Gap/Flush measurement	Right Flush Z measurement.
Measurements\RightSur-faceAngle	Gap/Flush measurement	Right Surface Angle measurement.

ProfilePanelEdge

Element	Type	Description
EdgeType	32s	Edge type: 0 – Tangent 1 – Corner
MinDepth	64f	Minimum depth.
MaxVoidWidth	64f	Maximum void width.
SurfaceWidth	64f	Surface width.
SurfaceOffset	64f	Surface offset.
NominalRadius	64f	Nominal radius.
EdgeAngle	64f	Edge angle.
RegionEnabled	Bool	Whether or not to use the region. If the region is disabled, all available data is used.
Region	ProfileRegion 2d	Edge region.

Gap/Flush Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable

Element	Type	Description
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
Axis (Gap measurement only)	32s	Measurement axis: 0 – Edge 1 – Surface 2 – Distance
Absolute (Flush measurement only)	Boolean	Setting for selecting absolute or signed result: 0 – Signed 1 – Absolute

● ProfilePosition

A ProfilePosition element defines settings for a profile position tool and one or more of its measurements.

ProfilePosition Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.

Element	Type	Description
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
Feature	ProfileFeature	Element for feature detection.
Measurements\X	Position tool measurement	X measurement.
Measurements\Z	Position tool measurement	Z measurement.
Features\Point	GeometricFeature	Point PointFeature

Position Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.

- ## ProfileRoundCorner

A ProfileRoundCorner element defines settings for a profile round corner tool and one or more of its measurements.

ProfileRoundCorner Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RefDirection	32s	Setting for reference side to use: 0 – Left 1 – Right
Edge	ProfilePanelEdge	Element for edge configuration
Measurements\X	Round Corner tool measurement	X measurement.
Measurements\Z	Round Corner tool measurement	Z measurement.
Measurements\Angle	Round Corner tool measurement	Angle measurement.
Features\CenterPoint	Geometric Feature	Circle Center PointFeature.
Features\EdgePoint	Geometric Feature	Edge PointFeature.

ProfilePanelEdge

Element	Type	Description
EdgeType	32s	Edge type: 0 – Tangent 1 – Corner
MinDepth	64f	Minimum depth.
MaxVoidWidth	64f	Maximum void width.
SurfaceWidth	64f	Surface width.
SurfaceOffset	64f	Surface offset.
NominalRadius	64f	Nominal radius.
EdgeAngle	64f	Edge angle.
RegionEnabled	Bool	Whether or not to use the region. If the region is disabled, all available data is used.
Region	ProfileRegion2d	Edge region.

Round Corner Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

● ProfileStrip

A ProfileStrip element defines settings for a profile strip tool and one or more of its measurements.

The profile strip tool is dynamic, meaning that it can contain multiple measurements of the same type in the Measurements element.

ProfileStrip Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Profile source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
BaseType	32s	Setting for the strip type: 0 – None 1 – Flat
LeftEdge	Bitmask	Setting for the left edge conditions: 1 – Raising 2 – Falling 4 – Data End 8 – Void
RightEdge	Bitmask	Setting for the right edge conditions: 1 – Raising 2 – Falling 4 – Data End 8 – Void
TiltEnabled	Boolean	Setting for tilt compensation: 0 – Disabled 1 – Enabled
SupportWidth	64f	Support width of edge (mm).

Element	Type	Description
TransitionWidth	64f	Transition width of edge (mm).
MinWidth	64f	Minimum strip width (mm).
MinHeight	64f	Minimum strip height (mm).
MaxVoidWidth	64f	Void max (mm).
Region	ProfileRegion 2d	Region containing the strip.
Measurements\X	Strip tool measurement	X measurement.
Measurements\Z	Strip tool measurement	Z measurement.
Measurements\Width	Strip tool measurement	Width measurement.
Measurements\Height	Strip tool measurement	Width measurement.

Strip Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
SelectType	32s	Method of selecting a groove when multiple grooves are found: 0 – Best 1 – Ordinal, from left 2 – Ordinal, from right
SelectIndex	32s	Index when SelectType is set to 1 or 2.

Element	Type	Description
Location (X, Z, and Height measure-ments only)	32s	Setting for groove location to return from: 0 – Left 1 – Right 2 – Center

Script

A Script element defines settings for a script measurement.

Script Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Code	String	Script code.
Measurements\Output	(Collection)	Dynamic list of Output elements.

Output

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.

SurfaceBoundingBox

A SurfaceBoundingBox element defines settings for a surface bounding box tool and one or more of its measurements.

SurfaceBoundingBox Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.

Element	Type	Description
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
ZRotationEnabled	Boolean	Setting to enable/disable rotation of bounding box
AsymmetryDetectionType	32s	Determine whether to use asymmetry detection and if enabled, which dimension would be the basis of detection. The possible values are: 0 – None 1 – Length 2 – Width
RegionEnabled	Boolean	Setting to enable/disable region.
Region	Region3D	Measurement region.
Measurements\X	Bounding Box tool measurement	X measurement.
Measurements\Y	Bounding Box tool measurement	Y measurement.
Measurements\Z	Bounding Box tool measurement	Z measurement.
Measurements\Width	Bounding Box tool measurement	Width measurement.
Measurements\Length	BoundingBox-Measurement	Length measurement
Measurements\Height	Bounding Box tool measurement	Height measurement.

Element	Type	Description
Measurements\ZAngle	Bounding Box tool measurement	ZAngle measurement.
Measurements\GlobalX	Bounding Box tool measurement	Global X measurement.
Measurements\GlobalY	Bounding Box tool measurement	Global Y measurement.
Measurements\GlobalZAngle	Bounding Box tool measurement	Global Z Angle measurement.
Features\CenterPoint	GeometricFeature	CenterPoint PointFeature
Features\AxisLine	GeometricFeature	AxisLine LineFeature

Bounding Box Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

SurfaceCsHole

A SurfaceCsHole element defines settings for a surface countersunk hole tool and one or more of its measurements.

SurfaceCsHole Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
NominalBevelAngle	64f	Nominal bevel angle (mm).
NominalOuterRadius	64f	Nominal outer radius (mm).
NominalInnerRadius	64f	Nominal inner radius (mm).
BevelRadiusOffset	64f	Bevel radus offset (mm).
Shape	32s	The shape of the countersunk hole: 0 – Cone 1 – Counterbore
PartialDetectionEnabled	Boolean	Setting to enable/disable partial detection: 0 – Disable 1 – Enable
RegionEnabled	Boolean	Setting to enable/disable region: 0 – Disable 1 – Enable

Element	Type	Description
Region	Region3D	Measurement region.
RefRegionsEnabled	Boolean	Setting to enable/disable reference regions: 0 – Disable 1 – Enable
RefRegionCount	32s	Count of the reference regions which are to be used
RefRegions	(Collection)	Reference regions. Contains 2 SurfaceRegion2D elements.
AutoTiltEnabled	Boolean	Setting to enable/disable tilt correction: 0 – Disable 1 – Enable
TiltXAngle	64f	Setting for manual tilt correction angle X.
TiltYAngle	64f	Setting for manual tilt correction angle Y.
CurveFitEnabled	Boolean	Setting to enable/disable curve fitting: 0 – Disable 1 – Enable
CurveOrientation	64f	The orientation of the curvature, in degrees.
PlaneFitRangeEnabled	Boolean	Setting to enable/disable the use of the plane fit range
PlaneFitRange	64f	Setting for the tolerance to use when doing the plane fit
Measurements\X	Countersunk Hole tool measurement	X measurement.
Measurements\Y	Countersunk Hole tool measurement	Y measurement.
Measurements\Z	Countersunk Hole tool measurement	Z measurement.
Measurements\OuterRa-dius	Countersunk Hole tool measurement	Outer Radius measurement.
Measurements\Depth	Countersunk Hole tool measurement	Depth measurement.
Measurements\BevelRa-dius	Countersunk Hole tool measurement	Bevel Radius measurement.
Measurements\BevelAngle	Countersunk Hole tool measurement	Bevel Angle measurement.
Measurements\XAngle	Countersunk Hole tool measurement	X Angle measurement.
Measurements\YAngle	Countersunk Hole tool measurement	Y Angle measurement.
Measurements\Counter-boreDepth	Countersunk Hole tool measurement	CounterboreDepth measurement.

Element	Type	Description
Measurements\AxisTilt	CsHoleMea-surement	Axis tilt measurement
Measurements\AxisOrien-tation	CsHoleMea-surement	Axis orientation measurement.
Features\CenterPoint	GeometricFeature	CenterPoint PointFeature

Countersunk Hole Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Features	Collection	Collection of geometric feature outputs available in the tool. See Features above.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

SurfaceDimension

A SurfaceDimension element defines settings for a surface dimension tool and one or more of its measurements.

SurfaceDimension Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
Measurements\CenterX	Dimension tool measurement	Center X measurement
Measurements\CenterY	Dimension tool measurement	Center Y measurement
Measurements\CenterZ	Dimension tool measurement	Center Z measurement
Measurements\Distance	Dimension tool measurement	Distance measurement
Measurements\PlaneDistance	Dimension tool measurement	Plane Distance measurement

Element	Type	Description
Measurements\Height	Dimension tool measurement	Height measurement
Measurements\Length	Dimension tool measurement	Length measurement
Measurements\Width	Dimension tool measurement	Width measurement

Dimension Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
Absolute (Height, Length, and Width measurements only)	Boolean	Setting for selecting absolute or signed result. 0 – Signed 1 – Absolute

- Tool (type SurfaceEdge)

A Tool element of type SurfaceEdge defines settings for a surface edge tool and one or more of its measurements.

SurfaceEdge Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
@type	String	Type name of the tool.
@version	String	Version string for custom tool.
Name	String	Tool name.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Parameters\UseIntensity	GdkParamBool	Use intensity data.
Parameters\RegionCount	GdkParamInt	Count of regions.
Parameters\Region	GdkParamSurfaceRegion3d	Edge region parameters.
Parameters\Region1	GdkParamSurfaceRegion3d	Second edge region parameters.
Parameters\Region2	GdkParamSurfaceRegion3d	Third eddge region parameters.
Parameters\Region3	GdkParamSurfaceRegion3d	Fourth edge region parameter.
Parameters\SearchDirection	GdkParamInt	Direction of search.
Parameters\FixedAngleValue	GdkParamFloat	Fixed angle value
Parameters\FixedAngleValue.units	String	Units of fixed angle (e.g.: deg)
Parameters\UseFixedAngle	GdkParamBool	Use fixed angle boolean.
Parameters\PathSpacing	GdkParamFloat	Path spacing value
Parameters\PathSpacing.units	String	Units of path spacing (eg: mm)

Element	Type	Description
Parameters\PathWidth	GdkParamFloat	Path width.
Parameters\PathWidth.units	String	Units of path width (e.g.: mm).
Parameters\SelectEdge	GdkParamInt	Edge selection type. Is either: 0 – Best 1 – First 2 – Last
Parameters\EdgeDirection	GdkParamInt	Edge direction type. Is either: 0 – Rising 1 – Falling 2 – Rising or Falling
Parameters\EdgeThreshold	GdkParamFloat	Edge threshold value.
Parameters\EdgeThreshold.units	String	Units of edge threshold (e.g.: mm).
Parameters\IntensityThreshold	GdkParamFloat	Intensity threshold value.
Parameters\UseRelativeThreshold	GdkParamBool	Use relative threshold boolean
Parameters\RelativeThreshold	GdkParamFloat	Relative threshold value.
Parameters\RelativeThreshold.units	String	Units of relative threshold (e.g.: %)
Parameters\EdgeSmoothing	GdkParamFloat	Edge smoothing value.
Parameters\EdgeSmoothing.units	String	Units of edge smoothing (e.g.: mm).
Parameters\EdgeWidth	GdkParamFloat	The step width.
Parameters\EdgeWidth.units	String	Units of edge (e.g.: mm).
Parameters\EdgeMaxGap	GdkParamFloat	Edge max gap value.
Parameters\EdgeMaxGap.units	String	Units of edge max gap (eg: mm).
Parameters\FillBackground	GdkParamBool	Fill background boolean
Parameters\FillValue	GdkParamFloat	Fill value value.
Parameters\FillValue.units	String	Units of fill value (e.g.: mm).
Parameters\IntensityFillValue	GdkParamFloat	Intensity fill value value.
Parameters\IntensityFillValue.min	GdkParamFloat	Intensity fill value minimum value.
Parameters\IntensityFillValue.max	GdkParamFloat	Intensity fill value maximum value.

Element	Type	Description
Parameters\RenderDetail	GdkParamBool	Render detail Boolean.
Measurements\Measurement @type=X	Edge Measurement	Base X measurement.
Measurements\Measurement @type=Y	Edge Measurement	Base Y measurement.
Measurements\Measurement @type=Z	Edge Measurement	Base Z measurement.
Measurements\Measurement @type=ZAngle	Edge Measurement	Base ZAngle measurement.
Measurements\Measurement @type=Height	Edge Measurement	Base Height measurement.
Features\Feature @type=EdgeLine	Gdk Feature	EdgeLine line feature.
Features\Feature @type=CenterPoint	Gdk Feature	CenterPoint point feature.

Edge Measurement Child Elements

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
@type	String	Type name of measurement.
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

SurfaceEllipse

A SurfaceEllipse element defines settings for a surface ellipse tool and one or more of its measurements.

SurfaceEllipse Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RegionEnabled	Boolean	Setting to enable/disable region.
Region	Region3D	Measurement region.
AsymmetryDetectionType	32s	Determine whether to use asymmetry detection and if enabled, which dimension would be the basis of detection. The possible values are: 0 – None 1 – Major 2 – Minor
Measurements\Major	Ellipse tool measurement	Major measurement.
Measurements\Minor	Ellipse tool measurement	Minor measurement.
Measurements\Ratio	Ellipse tool measurement	Ratio measurement.

Element	Type	Description
Measurements\ZAngle	Ellipse tool measurement	ZAngle measurement.
Features\CenterPoint	GeometricFeature	CenterPoint PointFeature
Features\MajorAxisLine	Geometric-Feature	MajorAxisLine LineFeature
Features\MinorAxisLine	Geometric-Feature	MinorAxisLine LineFeature

Ellipse Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

- ## SurfaceHole

A SurfaceHole element defines settings for a surface hole tool and one or more of its measurements.

SurfaceHole Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.

Element	Type	Description
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
NominalRadius	64f	Nominal radius (mm).
RadiusTolerance	64f	Radius tolerance (mm).
PartialDetectionEnabled	Boolean	Setting to enable/disable partial detection: 0 – Disable 1 – Enable
DepthLimitEnabled	Boolean	Setting to enable/disable depth limit: 0 – Disable 1 – Enable
DepthLimit	64f	The depth limit relative to the surface. Data below this limit is ignored.
RegionEnabled	Boolean	Setting to enable/disable region: 0 – Disable 1 – Enable
Region	Region3D	Measurement region.
RefRegionsEnabled	Boolean	Setting to enable/disable reference regions: 0 – Disable 1 – Enable
RefRegionCount	32s	Count of the reference regions that are to be used. (Advanced tab.)

Element	Type	Description
RefRegions	(Collection)	Reference regions. Contains up to two RefRegion elements of type SurfaceRegion2D. (Advanced tab.)
AutoTiltEnabled	Boolean	Setting to enable/disable tilt correction: 0 – Auto Set 1 – Custom
TiltXAngle	64f	Setting for custom tilt correction angle X.
TiltYAngle	64f	Setting for custom tilt correction angle Y.
Measurements\X	Hole tool measurement	X measurement.
Measurements\Y	Hole tool measurement	Y measurement.
Measurements\Z	Hole tool measurement	Z measurement.
Measurements\Radius	Hole tool measurement	Radius measurement.
Features\CenterPoint	GeometricFeature	CenterPoint PointFeature

Hole Tool Measurement

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

SurfaceOpening

A SurfaceOpening element defines settings for a surface opening tool and one or more of its measurements.

SurfaceOpening Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
Type	32s	Type of the opening: 0 – Rounded 1 – Slot
NominalWidth	64f	Nominal width (mm).
NominalLength	64f	Nominal length (mm).
NominalAngle	64f	Nominal angle (degrees).
NominalRadius	64f	Nominal radius (mm).
WidthTolerance	64f	Radius tolerance (mm).
LengthTolerance	64f	Length tolerance (mm).
AngleTolerance	64f	Angle tolerance (degrees).
PartialDetectionEnabled	Boolean	Setting to enable/disable partial detection: 0 – Disable 1 – Enable

Element	Type	Description
DepthLimitEnabled	Boolean	Setting to enable/disable depth limit: 0 – Disable 1 – Enable
DepthLimit	64f	The depth limit relative to the surface. Data below this limit is ignored.
RegionEnabled	Boolean	Setting to enable/disable region: 0 – Disable 1 – Enable
Region	Region3D	Measurement region.
RefRegionsEnabled	Boolean	Setting to enable/disable reference regions (Advanced tab): 0 – Disable 1 – Enable
RefRegionCount	32s	Count of the reference regions that are to be used. (Advanced tab.)
RefRegions	(Collection)	Reference regions. Contains two RefRegion elements of type SurfaceRegion2D.
AutoTiltEnabled	Boolean	Setting to enable/disable tilt correction (Advanced tab): 0 – Disable 1 – Enable
TiltXAngle	64f	Setting for custom tilt correction angle X.
TiltYAngle	64f	Setting for custom tilt correction angle Y.
Measurements\X	Opening tool measurement	X measurement.
Measurements\Y	Opening tool measurement	Y measurement.
Measurements\Z	Opening tool measurement	Z measurement.
Measurements\Width	Opening tool measurement	Width measurement.
Measurements\Length	Opening tool measurement	Length measurement.
Measurements\Angle	Opening tool measurement	Angle measurement.
Features\CenterPoint	GeometricFeature	CenterPoint PointFeature

Opening Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable

Element	Type	Description
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

- SurfacePlane

A SurfacePlane element defines settings for a surface plane tool and one or more of its measurements.

SurfacePlane Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.

Element	Type	Description
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RegionsEnabled	Boolean	Setting to enable/disable regions: 0 – Disable 1 – Enable
RegionCount	32s	Count of the regions.
Regions	(Collection)	Measurement regions. Contains up to four Region elements of type Region3D.
Measurements\XAngle	Plane tool measurement	XAngle measurement.
Measurements\YAngle	Plane tool measurement	YAngle measurement.
Measurements\ZOffset	Plane tool measurement	ZOffset measurement.
Measurements\StdDev	Plane tool measurement	Standard deviation measurement
Measurements\MinError	Plane tool measurement	Minimum error measurement
Measurements\MaxError	Plane tool measurement	Maximum error measurement
Measurements\XNormal	PlaneMea-surement	XNormal measurement
Measurements\YNormal	PlaneMea-surement	YNormal measurement
Measurements\ZNormal	PlaneMea-surement	ZNormal measurement
Measurements\Distance	PlaneMea-surement	Distance from normal measurement
Features\Plane	GeometricFeature	Resulting plane PlaneFeature.

Plane Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable

Element	Type	Description
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

SurfacePosition

A SurfacePosition element defines settings for a surface position tool and one or more of its measurements.

SurfacePosition Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See below in this table.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.

Element	Type	Description
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
Feature	SurfaceFeature	Measurement feature.
Measurements\X	Position tool measurement	X measurement.
Measurements\Y	Position tool measurement	Y measurement.
Measurements\Z	Position tool measurement	Z measurement.
Features\Point	GeometricFeature	Point PointFeature

Position Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

● SurfaceStud

A SurfaceStud element defines settings for a surface stud tool and one or more of its measurements.

SurfaceStud Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Collection of geometric feature outputs available in the tool. See "• Feature Child Elements" on page 732.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
StudRadius	64f	Radius of stud (mm).
StudHeight	64f	Height of stud (mm).
BaseHeight	64f	Height of stud’s base.
TipHeight	64f	Height of stud’s tip.
RegionEnabled	Boolean	Setting to enable/disable region.
Region	Region3D	Measurement region.
RefRegionsEnabled	Boolean	Setting to enable/disable reference regions: 0 – Disable 1 – Enable
RefRegionCount	32s	Count of the reference regions that are to be used. (Advanced tab.)
RefRegions	(Collection)	Reference regions. Contains up to four RefRegion elements of type SurfaceRegion2D. (Advanced tab.)

Element	Type	Description
AutoTiltEnabled	Boolean	Setting to enable/disable tilt correction (Advanced tab): 0 – Auto Set 1 – Custom
TiltXAngle	64f	Setting for custom tilt correction angle X.
TiltYAngle	64f	Setting for custom tilt correction angle Y.
Measurements\BaseX	Stud tool measurement	BaseX measurement.
Measurements\BaseY	Stud tool measurement	BaseY measurement.
Measurements\BaseZ	Stud tool measurement	BaseZ measurement.
Measurements\TipX	Stud tool measurement	TipX measurement.
Measurements\TipY	Stud tool measurement	TipY measurement.
Measurements\TipZ	Stud tool measurement	TipZ measurement.
Measurements\Radius	Stud tool measurement	Radius measurement.
Features\TipPoint	Geometric-Feature	TipPoint PointFeature
Features\BasePoint	Geometric-Feature	BasePoint PointFeature

Stud Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.

Element	Type	Description
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
RadiusOffset (Radius measurement only)	64f	Radius offset of the stud.

Feature Child Elements

Element	Type	Description
@id	32s	The identifier of the geometric feature. -1 if unassigned.
@dataType	String	The data type of the feature. One of: – PointFeature – LineFeature
Name	String	The display name of the feature.
Enabled	Bool	Whether the given feature output is enabled.

- SurfaceVolume

A SurfaceVolume element defines settings for a surface volume tool and one or more of its measurements.

SurfaceVolume Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
Name	String	Tool name.
Features	Collection	Not used.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Anchor\ZAngle	String (CSV)	The Z Angle measurements (IDs) used for anchoring.
Anchor\ZAngle.options	String (CSV)	The Z measurements (IDs) available for anchoring.
StreamOptions	Collection	A collection of StreamOptions elements.

Element	Type	Description
Stream\Step	32s	The stream source step. Possible values are: 1 – Video 2 – Range 3 – Surface 4 – Section
Stream\Id	32u	The stream source ID.
RegionEnabled	Boolean	Setting to enable/disable region.
Region	Region3D	Measurement region.
Measurements\Volume	Volume tool measurement	Volume measurement.
Measurements\Area	Volume tool measurement	Area measurement.
Measurements\Thickness	Volume tool measurement	Thickness measurement.

Volume Tool Measurement

Element	Type	Description
id (attribute)	32s	Measurement ID. Optional (measurement disabled if not set).
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.

Element	Type	Description
Location (Thickness measurement only)	32s	Measurement type: 0 – Maximum 1 – Minimum 2 – 2D Centroid 3 – 3D Centroid 4 – Average 5 – Median

- Tool (type FeatureDimension)

A Tool element of type FeatureDimension defines settings for a feature dimension tool and one or more of its measurements.

Tool Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
@type	String	Type name of the tool.
@version	String	Version string for custom tool.
Name	String	Tool name.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Parameters\RefPoint	GdkParamGeometricFeature	Reference point feature.
Parameters\Feature	GdkParam-Geometric-Feature	Reference feature.
Measurements\Measurement @type=Width	Dimension Measurement	Width measurement.
Measurements\Measurement @type=Length	Dimension Measurement	Length measurement.
Measurements\Measurement @type=Height	Dimension Measurement	Width measurement.

Element	Type	Description
Measurements\Measure-ment @type=Distance	Dimension Measurement	Distance measurement.
Measurements\Measure-ment @type=PlaneDis-tance	Dimension Measurement	Plane distance measurement.

Dimension Measurement Child Elements

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
@type	String	Type name of measurement.
Name	String	Measurement name.
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
Parameters\WidthAbsolute (Width measurement only)	GdkParam-Bool	Absolute width enabled boolean.
Parameters\LengthAbso-lute (Length measurement only)	GdkParam-Bool	Absolute height enabled boolean.
Parameters\HeightAbsolute (Height measurement only)	GdkParam-Bool	Absolute length enabled boolean.

● Tool (type FeatureIntersect)

A Tool element of type FeatureIntersect defines settings for a feature intersection tool and one or more of its measurements.

Tool Child Elements

Element	Type	Description
@isCustom	Bool	Reserved for future use.
@format	32s	Format type of the tool: 0 – Standard built-in tool 1 – GDK user-defined tool 2 – Internal GDK tool
@id	32s	The tool's ID.
@type	String	Type name of the tool.
@version	String	Version string for custom tool.
Name	String	Tool name.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Parameters\Line	GdkParamGeometricFeature	Line feature input.
Parameters\RefLine	GdkParam-Geometric-Feature	Reference line feature input.
Measurements\Measurement @type=\X	Intersect Measurement	X measurement.
Measurements\Measurement @type=Y	Intersect Measurement	Y measurement.
Measurements\Measurement @type=Z	Intersect Measurement	Z measurement.
Measurements\Measurement @type=Angle	Intersect Measurement	Angle measurement.
Features\IntersectPoint	GDK Feature	Intersect point feature.

Intersect Measurement Child Elements

Element	Type	Description
@id	32s	Measurement ID. Optional (measurement disabled if not set).
@type	String	Type name of measurement.
Name	String	Measurement name.

Element	Type	Description
Enabled	Boolean	Measurement enable state: 0 – Disable 1 – Enable
HoldEnabled	Boolean	Output hold enable state: 0 – Disable 1 – Enable
SmoothingEnabled	Boolean	Smoothing enable state: 0 – Disable 1 – Enable
PreserveInvalidsEnabled	Boolean	Preserve invalid measurements enable state 0 – Disable 1 – Enable
SmoothingWindow	32u	Smoothing window.
Scale	64f	Output scaling factor.
Offset	64f	Output offset factor.
DecisionMin	64f	Minimum decision threshold.
DecisionMax	64f	Maximum decision threshold.
Pinned	Boolean	Whether the measurement is pinned to main renderer.
Parameters\AngleRange	GdkParamInt	Angle range option choice. Is one of: 0 – -180 To 180 1 – 0 To 360

- ## Custom

A Custom element defines settings for a user-created GDK-based tool and one or more of its measurements.

Custom Child Elements

Element	Type	Description
@type	String	Type name of the tool.
@version	String	Version string for custom tool.
Name	String	Tool name.
Source	32s	Surface source.
Anchor\X	String (CSV)	The X measurements (IDs) used for anchoring.
Anchor\X.options	String (CSV)	The X measurements (IDs) available for anchoring.
Anchor\Y	String (CSV)	The Y measurements (IDs) used for anchoring.
Anchor\Y.options	String (CSV)	The Y measurements (IDs) available for anchoring.
Anchor\Z	String (CSV)	The Z measurements (IDs) used for anchoring.
Anchor\Z.options	String (CSV)	The Z measurements (IDs) available for anchoring.
Parameters	GDK Parameter	Collection of parameters. The element name in the job file is the name of the parameter.
Measurements	GDK Measurement	Collection of measurements.
Features	GDK Feature	Collection of features.

■ Output

The Output element contains the following sub-elements: Ethernet, Serial, Analog, Digital0, and Digital1. Each of these sub-elements defines the output settings for a different type of output.

For all sub-elements, the source identifiers used for measurement outputs correspond to the measurement identifiers defined in each tool's Measurements element. For example, in the following XML, in the options attribute of the Measurements element, 2 and 3 are the identifiers of measurements that are enabled and available for output. The value of the Measurements element (that is, 2) means that only the measurement with id 2 (Profile Dimension Width) will be sent to output.

```
<ProfileDimension> ...
<Measurements>
    <Width id="2"> ...
    <Height id="3"> ...

<Output>
<Ethernet> ...
    <Measurements options="2,3">2</Measurements>
```

● Ethernet

The Ethernet element defines settings for Ethernet output.

In the Ethernet element, the source identifiers used for video, range, profile, and surface output, as well as range, profile, and surface intensity outputs, correspond to the sensor that provides the data. For example, in the XML below, the options attribute of the Profiles element shows that only two sources are available (see the table below for the meanings of these values). The value in this element—0—indicates that only data from that source will be sent to output.

```
<Output>
<Ethernet>
    ...
    <Ranges options=""/>
    <Profiles options="0,1">0</Profiles>
    <Surfaces options=""/>
    ...
```

Ethernet Child Elements

Element	Type	Description
Ethernet.used	Boolean	Indicates if the output is available on the sensor.
Protocol	32s	The selected Ethernet protocol: 0 – SurfaceMeasure1008S 1 – Modbus 2 – EtherNet/IP 3 – ASCII 4 – PROFINET **Tips** The SurfaceMeasure1008S protocol is always on and its output is always available, regardless of the output you choose. This allows simultaneous connections via an SDK application and a PLC, letting you for example archive or display scan data on a PC while controlling equipment with a PLC.
Protocol.options	32s (CSV)	List of available protocol options.
TimeoutEnabled	Boolean	Enable or disable auto-disconnection timeout. Applies only to the SurfaceMeasure1008S protocol.
Timeout	64f	Disconnection timeout (seconds). Used when TimeoutEnabled is true and the SurfaceMeasure1008S protocol is selected.
Ascii	Section	See "• Ascii" on page 741.
EIP	Section	See "• EIP" on page 741.
Modbus	Section	See "• Modbus" on page 742.
Profinet	Section	See "• Profinet Child Elements" on page 742.
Ptp	Boolean	Enable or disable Precision Time Protocol support.
Videos	32s (CSV)	Selected video sources: 0 – Top 1 – Bottom 2 – Top left 3 – Top right 100 to 131 – G2 buddy sensor device indices for configurations with 2 to 31 buddy G2 sensors to identify a particular sensor’s scan data. Main sensor is 100. First buddied sensor is 101. Second buddied sensor is 102 and so on.
Videos.options	32s (CSV)	List of available video sources (see above).
Ranges	32s (CSV)	Selected range sources: 0 – Top 1 – Bottom 2 – Top left 3 – Top right
Ranges.options	32s (CSV)	List of available range sources (see above).

Element	Type	Description
Profiles	32s (CSV)	Selected profile sources: 0 – Top 1 – Bottom 2 – Top left 3 – Top right Selected video sources: 0 – Top 1 – Bottom 2 – Top left 3 – Top right 100 to 131 – G2 buddy sensor device indices for configurations with 2 to 31 buddy G2 sensors to identify a particular sensor's scan data. Main sensor is 100. First buddied sensor is 101. Second buddied sensor is 102 and so on.
Profiles.options	32s (CSV)	List of available profile sources (see above).
Surfaces	32s (CSV)	Selected surface sources: 0 – Top 1 – Bottom 2 – Top left 3 – Top right
Surfaces.options	32s (CSV)	List of available surface sources (see above).
SurfaceSections	32s (CSV)	Selected surface section sources.
SurfaceSections.options	32s (CSV)	List of available surface section sources.
RangeIntensities	32s (CSV)	Selected range intensity sources. 0 – Top 1 – Bottom 2 – Top left 3 – Top right
RangeIntensities.options	32s (CSV)	List of available range intensity sources (see above).
ProfileIntensities	32s (CSV)	Selected profile intensity sources. 0 – Top 1 – Bottom 2 – Top left 3 – Top right
ProfileIntensities.options	32s (CSV)	List of available profile intensity sources (see above).
SurfaceIntensities	32s (CSV)	Selected surface intensity sources.
SurfaceIntensities.options	32s (CSV)	List of available surface intensity sources (see above).
SurfaceSectionIntensities	32s (CSV)	Selected surface section intensity sources
SurfaceSectionIntensities.options	32s (CSV)	List of available surface section intensity sources.
Tracheids	32s (CSV)	Selected tracheid sources.
Tracheids.options	32s (CSV)	List of available tracheid sources.
Measurements	32u (CSV)	Selected measurement sources.

Element	Type	Description
Measurements.options	32u (CSV)	List of available measurement sources.
Events	32u (CSV)	Selected events
Events.Options	32u (CSV)	CSV list of possible event options: 0 – Exposure Begins 1 – Exposure Ends
Features	32u (CSV)	Selected feature sources.
Features.options	32u (CSV)	List of available feature sources.
ToolData	32u (CSV)	Selected tool data sources.
ToolData.options	32u (CSV)	List of available tool data sources.

- **Ascii**

Ascii Child Elements

Element	Type	Description
Operation	32s	Operation mode: 0 – Asynchronous 1 – Polled
ControlPort	32u	Control service port number.
HealthPort	32u	Health service port number.
DataPort	32u	Data service port number.
Delimiter	String	Field delimiter.
Terminator	String	Line terminator.
InvalidValue	String	String for invalid output.
CustomDataFormat	String	Custom data format.
CustomFormatEnabled	Bool	Enables custom data format.
StandardFormatMode	32u	The formatting mode used if not a custom format: 0 – Standard 1 – Standard with Stamp

- **EIP**

EIP Child Elements

Element	Type	Description
BufferEnabled	Bool	Enables EtherNet/IP output buffering.
EndianOutputType	32s	Endian output type: 0 – Big endian 1 – Little endian
ImplicitOutputEnabled	Bool	Enables Implict (I/O) Messaging.
ImplicitTriggerOverride	32s	Requested trigger type by client: 0 – No 1 – Cyclic 2 – Change of State

- **Modbus**

Modbus Child Elements

Element	Type	Description
BufferEnabled	Bool	Enables Modbus output buffering.

Profinet Child Elements

Element	Type	Description
IpAddress	String	Address in dotted notation (e.g. 1.1.1.1).
PrefixLength	32u	Length of prefix for the subnet.
SubnetMask	String	Address in dotted notation (e.g. 1.1.1.1).
Gateway	String	Address in dotted notation (e.g. 1.1.1.1).
DeviceName	String	Profinet name for the device.

Digital0 and Digital1

The Digital0 and Digital1 elements define settings for a sensor's two digital outputs.

Digital0 and Digital1 Child Elements

Element	Type	Description
Digital0.used	Boolean	Indicates if the output is available on the sensor.
Event	32s	Triggering event: 0 – None (disabled) 1 – Measurements 2 – Software 3 – Alignment state 4 – Acquisition start 5 – Acquisition end
SignalType	32s	Signal type: 0 – Pulse 1 – Continuous
ScheduleEnabled	Bool	Enables scheduling.
PulseWidth	64f	Pulse width (μs).
PulseWidth.min	64f	Minimum pulse width (μs).
PulseWidth.max	64f	Maximum pulse width (μs).
PassMode	32s	Measurement pass condition: 0 – AND of measurements is true 1 – AND of measurements is false 2 – Always assert
Delay	64f	Output delay (μs or mm, depending on delay domain defined below).
DelayDomain	32s	Output delay domain: 0 – Time (μs) 1 – Encoder (mm)

Element	Type	Description
Inverted	Bool	Whether the sent bits are flipped.
Measurements	32u (CSV)	Selected measurement sources.
Measurements.options	32u (CSV)	List of available measurement sources.

9.2.4 Transform

The transformation component contains information about the physical system setup that is used to:

- Transform data from sensor coordinate system to another coordinate system (e.g., world)
- Define encoder resolution for encoder-based triggering
- Define the travel offset (Y offset) between sensors for staggered operation

You can access the Transform component of the active job as an XML file, either using path notation, via "_live.job/transform.xml", or directly via "_live.tfm".

You can access the Transform component in user-created job files in non-volatile storage, for example, "productionRun01.job/transform.xml". You can only access transformations in user-created job files using path notation.

See the following sections for the elements contained in this component.

Transformation Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<Transform version="100">
<EncoderResolution>1</EncoderResolution>
<Speed>100</Speed>
<Devices>
    <Device role="0">
        <X>-2.3650924829</X>
        <Y>0.0</Y>
        <Z>123.4966803469</Z>
        <XAngle>5.7478302588</XAngle>
        <YAngle>3.7078302555</XAngle>
        <ZAngle>2.7078302556</XAngle>
    </Device>
    <Device id="1">
        <X>0</X>
        <Y>0.0</Y>
        <Z>123.4966803469</Z>
        <XAngle>5.7478302588</XAngle>
        <YAngle>3.7078302555</XAngle>
        <ZAngle>2.7078302556</XAngle>
    </Device>
</Devices>
</Transform>
```

The Transform element contains the alignment record for both the Main and the Buddy sensor.

Transform Child Elements

Element	Type	Description
@version	32u	Major transform version (100).
@versionMinor	32u	Minor transform version (0).
EncoderResolution	64f	Encoder Resolution (mm/tick).
Speed	64f	Travel Speed (mm/s).
Devices	(Collection)	Contains two Device elements.

■ Device

A Device element defines the transformation for a sensor. There is one entry element per sensor, identified by a unique role attribute (0 for main and 1 for buddy):

Device Child Elements

Element	Type	Description
@role	32s	Role of device described by this section: 0 – Main 1 – Buddy
X	64f	Translation on the X axis (mm).
Y	64f	Translation on the Y axis (mm).
Z	64f	Translation on the Z axis (mm).
XAngle	64f	Rotation around the X axis (degrees).
YAngle	64f	Rotation around the Y axis (degrees).
ZAngle	64f	Rotation around the Z axis (degrees).

Tips

The rotation (counter-clockwise in the X-Z plane) is performed before the translation.

9.2.5 Part Models

Part models represent models created using the part matching feature.

You can access a model in the active job using path notation. For example, to access a model called scan.mdl, use "_live.job/scan.mdl".

You can access part models in user-created job files in non-volatile storage, for example, "productionRun01.job/model1.mdl". You can only access part models in user-created job files using path notation.

See the following sections for the elements contained in a model.

Part models contain the following subcomponents. You can access the subcomponents using path notation, for example, "productionRun01.job/myModel.mdl/config.xml".

Part Model Child Elements

Element	Type	Description
Configuration	config.xml	Model configuration XML. It is always present. (See "■Configuration" on page 746.)
Edge Points	edge-height-top	Edge points for the top heightmap. (See "■Edge Points" on page 745.)
Edge Points	edge-height-bottom	Edge points for the bottom heightmap.
Edge Points	edge-intensity-top	Edge points for the top intensity map.
Edge Points	edge-intensity-bottom	Edge points for the bottom intensity map.

Tips
The edge points file exists only when the model contains the source data for the edge points.

■ Edge Points

Edge Points Data

Field	Type	Offset	Description
id	16s	0	Sender ID -1 – Part matching
source	8s	2	Source 0 – Model 1 – Target
imageType	8s	3	Image type 0 – Height map 1 – Intensity map
imageSource	8s	4	Image source 0 – Top 1 – Bottom
width	32u	5	Width of model space, in units of xScale
length	32u	9	Length of model space, un units of yScale
xScale	32u	13	X scale (nm)
yScale	32u	17	Y scale (nm)
xOffset	32s	21	X offset (μm)
yOffset	32s	25	Y offset μm
zAngle	32s	29	Z rotation (microdegrees)
pointCount	32u	33	Number of edge points
points[pointCount]	(32u, 32u)	37	Edge points collection. Each point is a tuple of x and y values, in units of xScale and yScale, respectively.

■ Configuration

Configuration Child Elements

Element	Type	Description
@version	32u	Major version (1).
@versionMinor	32u	Minor version (0).
Edges	Collection	Collection of Edge items (described below).
EdgeSensitivity	64f	Sensitivity recorded during model edges generation (read-only).
TransformedDataRegion	Region3d	Data region of the model.
ZAngle	64f	Additional rotation applied to the model (degrees).
TargetEdgeSensitivity	64f	Sensitivity used to generate target edges.
ImageType	32s	Selects type of image used to generate edges: 0 – Height map 1 – Intensity map
ImageType.options	32s (CSV)	List of available image types.

10 Integrations

Several integration tools are provided in the Utilities package available from the Mitutoyo web site center, in the Software subsection for your sensor model and SurfaceMeasure1008S software release.

- GenICam GenTL driver (see below)
- Rockwell EtherNet/IP files

10.1 Protocols

SurfaceMeasure1008S supports protocols for communicating with sensors over Ethernet (TCP/IP) and serial output. For a protocol to output data, it must be enabled and configured in the active job.

Tips

- The SurfaceMeasure1008S protocol is always on and its output is always available, regardless of the output you choose. This allows simultaneous connections via an SDK application and a PLC, letting you for example archive or display scan data on a PC while controlling equipment with a PLC.
- The SurfaceMeasure1008S emulator and accelerator (software and GoMax) do not support the PROFINET protocol.
- If you switch jobs or make changes to a job using the SDK or a protocol (from a PLC), the switch or changes are not automatically displayed in the web interface: you must refresh the browser to see these.

● Protocols available over Ethernet

- SurfaceMeasure1008S
- Modbus
- EtherNet/IP
- PROFINET
- ASCII

For an overview of the Ethernet ports used by sensors, see "2.5.3 Required Ports" on page 49.

● Protocols available over serial

- ASCII

10.1.1 SurfaceMeasure1008S Protocol

This section describes the TCP and UDP commands and data formats used by a client computer to communicate with SurfaceMeasure1008S sensors using SurfaceMeasure1008S protocol. It also describes the connection types (Discovery, Control, Data, and Health), and data types. The protocol enables the client to:

- Discover Main and Buddy sensors on an IP network and re-configure their network addresses.

- Configure Main and Buddy sensors.
- Send commands to run sensors, provide software triggers, read/write files, etc.
- Receive data, health, and diagnostic messages.

To use the protocol, it must be enabled and configured in the active job.

Tips
Sensors send UDP broadcasts over the network over the Internal Discovery channel (port 2016) at regular intervals during operation to perform peer discovery.

Tips
The SurfaceMeasure1008S SDK provides open source C language libraries that implement the network commands and data formats defined in this section. For more information, see "11.1 GoSDK" on page 947.

For information on configuring the protocol using the web interface, see "4.8.2 Ethernet Output" on page 327.
For information on job file structures (for example, if you wish to create job files programmatically), see "9.2 Job File Structure" on page 655.

Data Types

The table below defines the data types and associated type identifiers used in this section.
All values except for IP addresses are transmitted in little endian format (least significant byte first) unless stated otherwise. The bytes in an IP address "a.b.c.d" will always be transmitted in the order a, b, c, d (big endian).

Data Types

Type	Description	Null Value
char	Character (8-bit, ASCII encoding)	-
byte	Byte.	-
8s	8-bit signed integer.	-128
8u	8-bit unsigned integer.	255U
16s	16-bit signed integer.	-32768 (0x8000)
16u	16-bit unsigned integer.	65535 (0xFFFF)
32s	32-bit signed integer.	-2147483648 (0x80000000)
32u	32-bit unsigned integer.	4294967295 (0xFFFFFFFF)
32f	32-bit floating point.	-3.402823466e+38F
64s	64-bit signed integer.	-9223372036854775808 (0x8000000000000000)
64u	64-bit unsigned integer.	18446744073709551615 (0xFFFFFFFFFFFFFFFF)
64f	64-bit floating point	-1.7976931348623157e+308
Point16s	Two 16-bit signed integers	-
Point64f	Two 64-bit floating point values	-

Type	Description	Null Value
Point3d64f	Three 64-bit floating point values	-
Point3d32f	Three 32-bit floating point values	-
Rect64f	Four 64-bit floating point values	-
Rect3d64f	Eight 64-bit floating point values	-
Facet3d32u	Three 32-bit unsigned integers	-
Transform3d64f	Twelve 64-bit floating point values ie. { xx, xy, xz, xt,yx, yy, yz, yt,zx, zy, zz, zt }	-

Commands

The following sections describe the commands available on the Discovery, Control, and Upgrade channels.

When a client sends a command over the Control or Upgrade channel, the sensor sends a reply whose identifier is the same as the command's identifier. The identifiers are listed in the tables of each of the commands.

- Status Codes

Each reply on the Discovery, Control, and Upgrade channels contains a status field containing a status code indicating the result of the command. The following status codes are defined:

Status Codes

Label	Value	Description
OK	1	Command succeeded.
Failed	0	Command failed.
Invalid State	-1000	Command is not valid in the current state.
Item Not Found	-999	A required item (e.g., file) was not found.
Invalid Command	-998	Command is not recognized.
Invalid Parameter	-997	One or more command parameters are incorrect.
Not Supported	-996	The operation is not supported.
Simulation Buffer Empty	-992	The simulation buffer is empty.

Discovery Commands

Sensors ship with the following default network configuration:

Setting	Default
DHCP	0 (disabled)
IP Address	192.168.1.10
Subnet Mask	255.255.255.0
Gateway	0.0.0.0 (disabled)

Use the Get Address and Set Address commands to modify a sensor's network configuration. These commands are UDP broadcast messages:

Destination Address	Destination Port
255.255.255.255	3220

When a sensor accepts a discovery command, it will send a UDP broadcast response:

Destination Address	Destination Port
255.255.255.255	Port of command sender.

The use of UDP broadcasts for discovery enables a client computer to locate a sensor when the senor and client are configured for different subnets. All you need to know is the serial number of the sensor in order to locate it on an IP network.

- **Get Address**

The Get Address command is used to discover sensors across subnets.

Command

Field	Type	Offset	Description
length	64s	0	Command length.
type	64s	8	Command type (0x1).
signature	64s	16	Message signature (0x0000504455494D4C)
deviceId	64s	24	Serial number of the device whose address information is queried. 0 selects all devices.

Reply

Field	Type	Offset	Description
length	64s	0	Reply length.
type	64s	8	Reply type (0x1001).
status	64s	16	Operation status.
signature	64s	24	Message signature (0x0000504455494D4C)
deviceId	64s	32	Serial number.
dhcpEnabled	64s	40	0 – Disabled 1 – Enabled
reserved[4]	byte	48	Reserved.
address[4]	byte	52	The IP address in left to right order.
reserved[4]	byte	56	Reserved.

Field	Type	Offset	Description
subnetMask[4]	byte	60	The subnet mask in left to right order.
reserved[4]	byte	64	Reserved.
gateway[4]	byte	68	The gateway address in left to right order.
reserved[4]	byte	72	Reserved.
reserved[4]	byte	76	Reserved.

- **Set Address**

The Set Address command modifies the network configuration of a sensor. On receiving the command, the sensor will perform a reset. You should wait 30 seconds before re-connecting to the sensor.

Command

Field	Type	Offset	Description
length	64s	0	Command length.
type	64s	8	Command type (0x2).
signature	64s	16	Message signature (0x0000504455494D4C)
deviceId	64s	24	Serial number of the device whose address information is queried. 0 selects all devices.
dhcpEnabled	64s	32	0 – Disabled 1 – Enabled
reserved[4]	byte	40	Reserved.
address[4]	byte	44	The IP address in left to right order.
reserved[4]	byte	48	Reserved.
subnetMask[4]	byte	52	The subnet mask in left to right order.
reserved[4]	byte	56	Reserved.
gateway[4]	byte	60	The gateway address in left to right order.
reserved[4]	byte	64	Reserved.
reserved[4]	byte	68	Reserved.

Reply

Field	Type	Offset	Description
length	64s	0	Reply length.
type	64s	8	Reply type (0x1002).
status	64s	16	Operation status. For a list of status codes, see "• Status Codes" on page 749
signature	64s	24	Message signature (0x0000504455494D4C).
deviceId	64s	32	Serial number.

- **Get Info**

  The Get Info command is used to retrieve sensor information.

Command

Field	Type	Offset	Description
length	64s	0	Command length.
type	64s	8	Command type (0x5).
signature	64s	16	Message signature (0x0000504455494D4C).
deviceId	64s	24	Serial number of the device whose address information is queried. 0 selects all devices.

Reply

Field	Type	Offset	Description
length	64s	0	Reply length.
type	64s	8	Reply type (0x1005).
status	64s	16	Operation status. For a list of status codes, see "• Status Codes" on page 749
signature	64s	24	Message signature (0x0000504455494D4C).
attrCount	16u	32	Byte count of the attributes (begins after this field and ends before propertyCount).
id	32u	34	Serial number.
version	32u	38	Version as a 4-byte integer (encoded in little-endian).
uptime	64u	42	Sensor uptime (microseconds).
ipNegotiation	byte	50	IP negotiation type: 0 – Static 1 – DHCP
addressVersion	byte	51	IP address version (always 4).
address[4]	byte	52	IP address.
reserved[12]	byte	56	Reserved.
prefixLength	32u	68	Subnet prefix length (in number of bits).
gatewayVersion	byte	72	Gateway address version (always 4).
gatewayAddress[4]	byte	73	Gateway address.
reserved[12]	byte	77	Reserved.
controlPort	16u	89	Control channel port.
upgradePort	16u	91	Upgrade channel port.
healthPort	16u	93	Health channel port.
dataPort	16u	95	Data channel port.
webPort	16u	97	Web server port.
propertyCount	8u	99	Number of sensor ID properties.
properties[property-Count]	Property	100	List of sensor ID properties.

Property

Field	Type	Description
nameLength	8u	Length of the name.
name[nameLength]	char	Name string.
valueLength	8u	Length of the value.
value[valueLength]	char	Value string.

● Control Commands

A client sends control commands for most operations over the Control TCP channel (port 3190).

The Control channel and the Upgrade channel (port 3192) can be connected simultaneously. For more information on Upgrade commands, see 📖 "●Upgrade Commands" on page 795.

• States

A sensor system can be in one of three states: Conflict, Ready, or Running. The client sends the Start and Stop control commands to change the system's current state to Running and Ready, respectively. The sensor can also be configured to boot in either the Ready or Running state, by enabling or disabling autostart, respectively, using the Set Auto Start Enabled command.

In the Ready state, a sensor can be configured. In the Running state, a sensor responds to input signals, performs measurements, drives its outputs, and sends data messages to the client.

The state of the sensor can be retrieved using the Get States or Get System Info command.

The Conflict state indicates that a sensor has been configured with a Buddy sensor but the Buddy sensor is not present on the network. The sensor will not accept some commands until the Set Buddy command is used to remove the configured Buddy.

• Progressive Reply

Some commands send replies progressively, as multiple messages. This allows the sensor to stream data without buffering it first, and allows the client to obtain progress information on the stream.

A progressive reply begins with an initial, standard reply message. If the status field of the reply indicates “success”, the reply is followed by a series of “continue” reply messages.

A continue reply message contains a block of data of variable size, as well as status and progress information. The series of continue messages is ended by either an error, or a continue message containing 0 bytes of data.

- **Protocol Version**

The Protocol Version command returns the protocol version of the connected sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4511)

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4511).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
majorVersion	8u	10	Major version.
minorVersion	8u	11	Minor version.

- **Get Address**

The Get Address command is used to get a sensor address.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x3012)

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x3012).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
dhcpEnabled	byte	10	0 – DHCP not used 1 – DHCP used
address[4]	byte	11	IP address (most significant byte first).
subnetMask[4]	byte	15	Subnet mask.
gateway[4]	byte	19	Gateway address.

- **Set Address**

The Set Address command modifies the network configuration of a sensor. On receiving the command, the sensor will perform a reset. You should wait 30 seconds before re-connecting to the sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x3013)
dhcpEnabled	byte	6	0 – DHCP not used 1 – DHCP used
address[4]	byte	7	IP address (most significant byte first).
subnetMask[4]	byte	11	Subnet mask.
gateway[4]	byte	15	Gateway address.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x3013).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Get System Info V2**

The Get System Info command reports information about the local node, remote nodes and assigned buddies.

Firmware version refers to the version of the sensor's firmware installed on each individual sensor. The client can upgrade the sensor's firmware by sending the Start Upgrade command (see 📖 "• Start Upgrade" on page 795). Firmware upgrade files are available from the downloads section. For more information on getting the latest firmware, see 📖 "■Support Files" on page 112.

Every sensor contains factory backup firmware. If a firmware upgrade command fails (e.g., power is interrupted), the factory backup firmware will be loaded when the sensor is reset or power cycled. In this case, the sensors will fall back to the factory default IP address. To avoid IP address conflicts in a multi-sensor system, connect to one sensor at a time and re-attempt the firmware upgrade.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4010)

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4010).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749
localInfoSize	16u	10	Size of localInfo structure. Current: 116.
localInfo	Local Info	12	Info for this device.
remoteCount	32u	-	Number of discovered sensors.
remoteInfoSize	16u	-	Size of remoteInfo structure. Current 124.
remoteInfo[remoteCount]	Remote Info	-	List of info for discovered sensors.
buddyInfoCount	32u	-	Number of buddies assigned (can be 0).
buddyInfoSize	16u	-	Size of buddyInfo structure. Current: 8.
Buddies[buddyCount]	Buddy Info	-	List of info for the assigned buddies.

Local Info

Field	Type	Offset	Description
deviceId	32u	0	Serial number of the device.
address[4]	byte	4	IP address (most significant byte first).
modelName[32]	char	8	Model name; "part number" starting with GoSdk 5.3.17.23. Should not be parsed.
firmwareVersion[4]	byte	40	Firmware version (most significant byte first).

Field	Type	Offset	Description
state	32s	44	Sensor state -1 – Conflict 0 – Ready 1 – Running For more information on states, see "• States" on page 753
role	32s	48	Sensor role 0 – Main 1 – Buddy
modelNum-ber[32]	char	52	Model number that can be parsed.
modelDisplay-Name[32]	char	56	User-friendly model display name that can be used to rename sensors more appropriately for custom-branding naming.

Remote Info

Field	Type	Offset	Description
deviceId	32u	0	Serial number of the remote device.
address[4]	byte	4	IP address (most significant byte first).
modelName[32]	char	8	Remote model name; "remote part number" starting with GoSdk 5.3.17.23.
firmwareVer-sion[4]	byte	40	Remote firmware version (most significant byte first).
state	32s	44	Remote sensor state -1 – Conflict 0 – Ready 1 – Running For more information on states, see "• States" on page 753
role	32s	48	Sensor role 0 – Main 1 – Buddy
mainId	32u	52	Serial number of the main device, or zero.
buddyableStatus	32s	56	Whether or not the device can be buddied: 1 – Can be buddied Errors: 0 – Unbuddiable (General Error) -100 – Already buddied -99 – Invalid State (e.g. running) -98 – Version Mismatch -97 – Model Mismatch
modelNum-ber[32]	char	60	Model number that can be parsed.

Field	Type	Offset	Description
modelDisplay-Name[32]	char	92	Remote user-friendly model display name that can be used to rename sensors more appropriately for custom-branding naming.

Buddy Info

Field	Type	Offset	Description
deviceId	32u	2	Serial number of the device.
state	k32s	6	Buddy state 2 - Connecting 1 – Connected Errors: 0 – Unbuddiable (General Error) -100 – Already buddied -99 – Invalid State (e.g. running) -98 – Version Mismatch -97 – Model Mismatch -95 – Device Missing -92 – Standalone Sensor -91 – Restricted Sensor Mismatch

- **Get States**

The Get States command returns various system states.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4525)

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4525).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749
count	32u	10	Number of state variables.
sensorState	32s	14	Sensor state -1 – Conflict 0 – Ready 1 – Running For more information on states, see 📖 "• States" on page 753

Field	Type	Offset	Description
loginState	32s	18	Device login state 0 – No user 1 – Administrator 2 – Technician
alignmentRefer-ence	32s	22	Alignment reference 0 – Fixed 1 – Dynamic
alignmentState	32s	26	Alignment state 0 – Unaligned 1 – Aligned
recordingEn-abled	32s	30	Whether or not recording is enabled 0 – Disabled 1 – Enabled
playbackSource	32s	34	Playback source 0 – Live data 1 – Recorded data
uptimeSec	32su	38	Uptime (whole seconds component)
uptimeMicrosec	32u	42	Uptime (remaining microseconds component)
playbackPos	32u	46	Playback position
playbackCount	32u	50	Playback frame count
autoStartEn-abled	32u	54	Auto-start enable (boolean)
isAccelerator	32u	58	Is the device an accelerator instance?
voltage	32u	62	Voltage setting 0 – 48V 1 – 24V
cableLength	32u	66	Cable length (maximum Is 60.0 meters, default is 5.0 meters)
quickEditEn-abled	32u	70	Quick Edit state
securityLevel	32s	74	Security Level 0 – No security, any user type can access system. 1 – Basic security level, only authorized user types can access system.
brandingType	32s	78	Branding Type 0 – None/ SurfaceMeasure1008S (default) 1 – White Label 2 – Custom

- **Log In/Out**

The Log In/Out command is used to log in or out of a sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4003).
userType	32s	6	Defines the user type 0 – None (log out) 1 – Administrator 2 – Technician
password[64]	char	10	Password (required for log-in only).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4003).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Change Password**

The Change Password command is used to change log-in credentials for a user.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4004).
user type	32s	6	Defines the user type 0 – None (log out) 1 – Administrator 2 – Technician
password[64]	char	10	New password.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4004).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

Tips

Passwords can only be changed if a user is logged in as an administrator.

- **Assign Buddies**

The Assign Buddies command is used to set the list of buddies assigned to the system.

This command can be used to both add and remove buddies by changing the list of buddies. A serial number of 0 can be used to add device slots that are not assigned a physical sensor. Collections associated with the devices (e.g. <Device> element in the configuration) grow or shrink accordingly. Items are added to or removed from the end of these collections. For example: the system starts with 2 devices, [A, B]. A new list [A, B, C] is sent. The configuration for A and B are preserved, and a new record is created for C. If now the system changes back to [A, B], the record for C is deleted. Adding or removing items in the middle of the list has the same behaviour. Example: the system starts with 3 devices, [A, B, C]. A new list [A, C] is sent. The configuration for B is now used for C, and the configuration for C is deleted. To ensure consistency when adding and removing devices, add only to the end of the list and remove using the Remove Buddies command.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4011).
buddyCount	32u	6	Number of buddies or 0 to unbuddy all devices.
buddies[buddyCount]	32u	10	Serial Numbers of the buddies to assign (can be 0).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4011).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Remove Buddies**

The Remove Buddies command is used to remove one or more buddies using 0-based buddy indices.

Use this command to remove a buddy devices along with its associated configuration resources. If the system starts with 3 devices: [A, B, C], and this command is called to remove B, the configuration items for A and C remain unchanged.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4013).
buddyCount	32u	6	Number of buddies.
buddyIds[buddy-Count]	32u	10	Indices of the buddies to remove. Note that the first buddy has index 0 (i.e. it's the index of bud-dies, not all devices including the main).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4013).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Set Buddy**

The Set Buddy command is used to assign or unassign a Buddy sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4005).
buddyId	32u	6	Id of the sensor to acquire as buddy. Set to 0 to remove buddy.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4005).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **List Files**

  The List Files command returns a list of the files in the sensor's file system.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x101A).
extension[64]	char	6	Specifies the extension used to filter the list of files (does not include the "."). If an empty string is used, then no filtering is performed.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x101A).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749
count	32u	10	Number of file names.
file-Names[count][64]	char	14	File names.

- **Copy File**

  The Copy File command copies a file from a source to a destination within the connected sensor (a .job file, a component of a job file, or another type of file; for more information, see 📖 "9.2 Job File Structure" on page 655).

  To make a job active (to load it), copy a saved job to "_live.job".

  To "save" the active job, copy from "_live.job" to another file.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x101B).
source[64]	char	6	Source file name.
destination[64]	char	70	Destination file name.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x101B).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Read File**

Downloads a file from the connected sensor (a .job file, a component of a job file, or another type of file; for more information, see "9.2 Job File Structure" on page 655).

To download the live configuration, pass "_live.job" in the name field.

To read the configuration of the live configuration only, pass "_live.job/config.xml" in the name field.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x1007).
name[64]	char	6	Source file name.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x1007).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
length	32u	10	File length.
data[length]	byte	14	File contents.

- **Write File**

The Write File command uploads a file to the connected sensor (a .job file, a component of a job file, or another type of file; for more information, see "9.2 Job File Structure" on page 655).

To make a job file live, write to "_live.job". Except for writing to the live file, the file is permanently stored on the sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x1006).
name[64]	char	6	Source file name.
length	32u	70	File length.
data[length]	byte	74	File contents.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x1006).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Delete File**

The Delete File command removes a file from the connected sensor (a .job file, a component of a job file, or another type of file; for more information, see "9.2 Job File Structure" on page 655).

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x1008).
name[64]	char	6	Source file name.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x1008).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **User Storage Used**

The User Storage Used command returns the amount of user storage that is used.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x1021).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x1021).
status	32s	6	Reply status.
spaceUsed	64u	10	The used storage space in bytes.

- **User Storage Free**

The User Storage Free command returns the amount of user storage that is free.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x1022).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x1022).
status	32s	6	Reply status.
spaceFree	64u	10	The free storage space in bytes.

- **Get Default Job**

The Get Default Job command gets the name of the job the sensor loads when it powers up.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4100).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4100).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749
name[64]	char	10	The file name (null-terminated) of the job the sensor loads when it powers up.

- **Set Default Job**

The Set Default Job command sets the job the sensor loads when it powers up.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4101).
fileName[64]	char	6	File name (null-terminated) of the job the sensor loads when it powers up.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4101).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Get Loaded Job**

The Get Loaded Job command returns the name and modified status of the currently loaded file.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4512).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4512).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749
fileName[64]	char	10	Name of the currently loaded job.
changed	8u	74	Whether or not the currently loaded job has been changed (1: yes; 0: no).

- **Get Alignment Reference**

The Get Alignment Reference command is used to get the sensor's alignment reference.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4104).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4104).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
reference	32s	10	Alignment reference 0 – Fixed 1 – Dynamic

- **Set Alignment Reference**

The Set Alignment Reference command is used to set the sensor's alignment reference.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4103).
reference	32s	6	Alignment reference 0 – Fixed 1 – Dynamic

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4103).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Clear Alignment**

The Clear Alignment command clears sensor alignment.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4102).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4102).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Get Timestamp**

The Get Timestamp command retrieves the sensor's timestamp, in clock ticks. All devices in a system are synchronized with the system clock; this value can be used for diagnostic purposes, or used to synchronize the start time of the system.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x100A).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x100A).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749
timestamp	64u	10	Timestamp, in clock ticks.

- **Get Encoder**

  This command retrieves the current system encoder value.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x101C).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x101C).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749
encoder	64s	10	Current encoder position, in ticks.

- **Reset Encoder**

  The Reset Encoder command is used to reset the current encoder value.

Tips

The encoder value can be reset only when the encoder is connected directly to a sensor. When the encoder is connected to the master, the value cannot be reset via this command.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x101E).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x101E).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Start**

  The Start command starts the sensor system (system enters the Running state). For more information on states, see "• States" on page 753

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x100D).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x100D).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Scheduled Start**

  The scheduled start command starts the sensor system (system enters the Running state) at target time or encoder value (depending on the trigger mode). For more information on states, see "• States" on page 753

Command

Field	Type	Offset	Description
length	32u	0	Command size – in bytes.
id	16u	4	Command identifier (0x100F).
target	64s	6	Target scheduled start value (in ticks or µs, depending on the trigger type).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size – in bytes.
id	16u	4	Reply identifier (0x100F).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Stop**

The Stop command stops the sensor system (system enters the Ready state). For more information on states, see "• States" on page 753

Command

Field	Type	Type	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x1001).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x1001).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Get Auto Start Enabled**

The Get Auto Start Enabled command returns whether the system automatically starts after booting.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x452C).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x452C).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
enable	8u	10	0: disabled 1: enabled

- **Set Auto Start Enabled**

  The Set Auto Start Enabled command sets whether the system automatically starts after booting (enters Running state; for more information on states, see "• States" on page 753)

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x452B).
enable	8u	6	0: disabled 1: enabled

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x452B).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

- **Get Voltage Settings**

  The Get Voltage Settings command returns the sensor's voltage and cable length settings.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4539).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4539).
Voltage	16u	10	0: 48 Volts; 1: 24 Volts.
Cable Length	32u	12	0 – 100: Meters

- **Set Voltage Settings**

The Set Voltage Settings command sets the sensor’s voltage and cable length settings.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4538).
Voltage	16u	6	0: 48 Volts; 1: 24 Volts.
Cable Length	32u	8	0 – 100: Meters

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4538).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

- **Get Quick Edit Enabled**

The Get Quick Edit Enabled command returns whether Quick Edit mode is enabled on the sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4541).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4541).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.
Enable	8u	10	0: disabled; 1: enabled.

- **Set Quick Edit Enabled**

The Set Quick Edit Enabled command enables or disables Quick Edit mode on the sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4540).
enable	8u	6	0: disabled; 1: enabled.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4540).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

- **Start Alignment**

The Start Alignment command is used to start the alignment procedure on a sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4600).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4600).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.
opId	32u	10	Operation ID. Use this ID to correlate the command/reply on the Command channel with the correct Alignment Result message on the Data channel. A unique ID is returned each time the client uses this command.

- **Start Exposure Auto-set**

  The Start Exposure Auto-set command is used to start the exposure auto-set procedure on a sensor.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4601).
index	32s	6	Device index of sensor to auto-set. 0 – Main 1-31 – Buddy device

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4601).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.
opId	32u	10	Operation ID. Use this ID to correlate the command/reply on the Command channel with the correct Exposure Calibration Result message on the Data channel. A unique ID is returned each time the client uses this command.

- **Software Trigger**

  The Software Trigger command causes the sensor to take a snapshot while in software mode and in the Running state.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4510).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4510).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

- **Schedule Digital Output**

  The Schedule Digital Output command schedules a digital output event. The digital output must be configured to accept software-scheduled commands and be in the Running state.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4518).
index	16u	6	Index of the output (starts from 0).
target	64s	8	Specifies the time (clock ticks) when or position (μm) at which the digital output event should happen. The target value is ignored if ScheduleEnabled is set to false. (〔Scheduled〕 is unchecked in 〔Digital〕 in the 〔Output〕 panel.) The output will be triggered immediately.
value	8u	16	Specifies the target state: 0 – Set to low (continuous) 1 – Set to high (continuous) Ignored if output type is pulsed.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4518).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

- **Schedule Analog Output**

The Schedule Analog Output command schedules an analog output event. The analog output must be configured to accept software-scheduled commands and be in the Running state.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4519).
index	16u	6	Index of the output. Must be 0.
target	64s	8	Specifies the time (clock ticks) or position (encoder ticks) of when the event should happen. The target value is ignored if ScheduleEnabled is set to false. (〔Scheduled〕 is unchecked in 〔Analog〕 in the 〔Output〕 panel.) The output will be triggered immediately.
value	32s	16	Output current (microamperes).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4519).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

Tips

The analog output takes about 75 us to reach 90% of the target value for a maximum change, then roughly another 40 us to settle completely.

- **Ping**

The Ping command can be used to test the control connection. This command has no effect on sensors.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x100E).
timeout	64u	6	Timeout value (microseconds).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x100E).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

Tips

If a non-zero value is specified for timeout, the client must send another ping command before the timeout elapses; otherwise the server would close the connection. The timer is reset and updated with every command.

- **Reset**

The Reset command reboots the Main sensor and any Buddy sensors. All sensors will automatically reset 3 seconds after the reply to this command is transmitted.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4300).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4300).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

- **Backup**

The Backup command creates a backup of all files stored on the connected sensor and downloads the backup to the client.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x1013).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x1013).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.
length	32u	10	Data length.
data[length]	byte	14	Data content.

- **Restore**

The Restore command uploads a backup file to the connected sensor and then restores all sensor files from the backup.

Tips

The sensor must be reset or power-cycled before the restore operation can be completed.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x1014).
length	32u	6	Data length.
data[length]	byte	10	Data content.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x1014).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

- **Restore Factory**

The Restore Factory command restores the connected sensor to factory default settings.

Tips

The command erases the non-volatile memory of the main device.

This command has no effect on connected Buddy sensors.

Note that the sensor must be reset or power-cycled before the factory restore operation can be completed.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4301).
resetIp	8u	6	Specifies whether IP address should be restored to default: 0 – Do not reset IP 1 – Reset IP

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4301).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

- **Get Recording Enabled**

The Get Recording Enabled command retrieves whether recording is enabled.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4517).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4517).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.
enable	8u	10	0: disabled; 1: enabled.

- **Set Recording Enabled**

  The Set Recording Enabled command enables recording for replay later.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4516).
enable	8u	6	0: disabled; 1: enabled.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4516).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

- **Clear Replay Data**

  The Clear Replay Data command clears the sensors replay data..

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4513).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4513).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

- **Get Playback Source**

The Get Playback Source command gets the data source for data playback.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4524).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4524).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.
source	32s	10	Source 0 – Live 1 – Replay buffer

- **Set Playback Source**

The Set Playback Source command sets the data source for data playback.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4523).
source	32s	6	Source 0 – Live 1 – Replay buffer

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4523).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

- **Simulate**

  The Simulate command simulates the last frame if playback source is live, or the current frame if playback source is the replay buffer.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4522).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4522).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.
bufferValid	8u	10	Whether or not the buffer is valid.

Tips

A reply status of -996 means that the current configuration (mode, sensor type, etc.) does not support simulation.

A reply status of -992 means that the simulation buffer is empty. Note that the buffer can be valid even if the simulation buffer is actually empty due to optimization choices. This scenario means that the simulation buffer would be valid if data were recorded.

- **Seek Playback**

  The Seek Playback command seeks to any position in the current playback dataset. The frame is then sent.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4503).
frame	32u	6	Frame index.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4503).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

- **Step Playback**

The Step Playback command advances playback by one frame.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4501).
direction	32s	6	Define step direction 0 – Forward 1 – Reverse

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4501).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

Tips

When the system is running in the Replay mode, this command advances replay data (playback) by one frame. This command returns an error if no live playback data set is loaded. You can use the Copy File command to load a replay data set to _live.rec.

- **Playback Position**

The Playback Position command retrieves the current playback position.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4502).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4502).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.
Frame Index	32u	10	Current frame index (starts from 0).
Frame Count	32u	14	Total number of available frames/objects.

- **Clear Measurement Stats**

The Clear Measurement Stats command clears the sensor's measurement statistics.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4526).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4526).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749.

- **Read Live Log**

The Read Live Log command returns an XML file containing the log messages between the passed start and end indexes.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x101F).
Start	32u	6	First log to read
End	32u	10	Last log to read

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x101F).
status	32s	6	Reply status.
length	32u	10	File length
data[length]	byte	14	XML Log File

- **Clear Log**

The Clear Log command clears the sensor's log.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x101D).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x101D).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

- **Simulate Unaligned**

The Simulate Unaligned command simulates data before alignment transformation.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x452A).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x452A).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

- **Acquire**

The Acquire command acquires a new scan.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4528).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4528).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

Tips
The command returns after the scan has been captured and transmitted.

- **Acquire Unaligned**

The Acquire Unaligned command acquires a new scan without performing alignment transformation.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4527).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4527).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

Tips
The command returns after the scan has been captured and transmitted.

- **Create Model**

The Create Model command creates a new part model from the active simulation scan.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4602).
modelName[64]	char	6	Name of the new model (without .mdl extension)

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4602).

status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749.

- **Detect Edges**

The Detect Edges command detects and updates the edge points of a part model.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4604).
modelName[64]	char	6	Name of the model (without .mdl extension)
sensitivity	16u	70	Sensitivity (in thousandths).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4604).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Add Tool**

The Add Tool command adds a tool to the live job.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4530).
typeName[64]	char	6	Type name of the tool (e.g., ProfilePosition)
name[64]	char	70	User-specified name for tool instance

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4530).
status	32s	6	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Add Measurement**

  The Add Measurement command adds a measurement to a tool instance.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4531).
toolIndex	32u	6	Index of the tool instance the new measurement is added to.
typeName[64]	char	10	Type name of the measurement (for example, X).
name[64]	char	74	User-specified name of the measurement instance.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4531).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

Tips

This command can only be used with dynamic tools (tools with a dynamic list of measurements). The maximum number of instances for a given measurement type can be found in the ToolOptions node.

- **Read File (Progressive)**

  The progressive Read File command reads the content of a file as a stream.

  This command returns an initial reply, followed by a series of "continue" replies if the initial reply's status field indicates “success”. The continue replies contain the actual data, and have 0x5000 as their identifier.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4529).
name[64]	char	6	Source file name.

Initial Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4529).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

Field	Type	Offset	Description
progressTotal	32u	10	Progress indicating completion (100%).
progress	32u	14	Current progress.

Continue Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x5000).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
progressTotal	32u	10	Progress indicating completion (100%).
progress	32u	14	Current progress.
size	32u	18	Size of the chunk in bytes.
data[size]	byte	22	Chunk data.

- **Export CSV (Progressive)**

The progressive Export CSV command exports replay data as a CSV stream.

This command returns an initial reply, followed by a series of "continue" replies if the initial reply's status field indicates success. The continue replies contain the actual data, and have 0x5000 as their identifier.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4507).

Initial Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4507).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
progressTotal	32u	10	Progress indicating completion (100%).
progress	32u	14	Current progress.

Continue Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x5000).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
progressTotal	32u	10	Progress indicating completion (100%).

Field	Type	Offset	Description
progress	32u	14	Current progress.
size	32u	18	Size of the chunk in bytes.
data[size]	byte	22	Chunk data.

Tips

All recorded range or profile data is exported to the CSV stream. Only the current surface scan, as determined by the playback position, is exported to the CSV stream.

- **Export Bitmap (Progressive)**

The progressive Export Bitmap command exports replay data as a bitmap stream.

This command returns an initial reply, followed by a series of "continue" replies if the initial reply's status field indicates success. The continue replies contain the actual data, and have 0x5000 as their identifier.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4508).
type	32s	6	Data type: 0 – Range or video 1 – Intensity
source	32s	10	Data source to export.

Initial Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4508).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
progressTotal	32u	10	Progress indicating completion (100%).
progress	32u	14	Current progress.

Continue Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x5000).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749
progressTotal	32u	10	Progress indicating completion (100%).
progress	32u	14	Current progress.
size	32u	18	Size of the chunk in bytes.
data[size]	byte	22	Chunk data.

- **Get Flag**

The Get Flag command returns the given flag value as a string.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4533).
name[256]	Char	6	A string representing the flag name whose value is to be retrieved.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4533).
valueLength	32u	10	The length of the string representing the flag's value.
value[val-ueLength]	Char	14	The value of the flag.

- **Set Flag**

The Set Flag command sets the string value for the given flag name.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4534).
Variable-name[256]	Char	6	A string representing the flag name whose value is to be retrieved.
valueLength	32u	262	The length of the flag's value string.
value[val-ueLength]	Char	266	The string representing the flag's value.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4534).
status	32s	6	Reply status. For a list of status codes, see "• Status Codes" on page 749

- **Get Runtime Variable Count**

The Get Runtime Variable Count command gets the number of runtime variables that can be accessed.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4537).

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4537).
status	32s	6	Reply status.
valueLength	32u	10	The count of runtime variables.

- **Set Runtime Variables**

The Set Runtime Variables command sets the runtime variables at the given index for the given length.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4536).
index	32u	6	The starting index of the variables to set.
length	32u	10	The number of values to set from the starting index.
values[length]	32s	14	The runtime variable values to set.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4536).
status	32s	6	Reply status.

- **Get Runtime Variables**

The Get Runtime Variables command gets the runtime variables for the given index and length.

Command

Field	Type	Offset	Description
length	32u	0	Command size including this field, in bytes.
id	16u	4	Command identifier (0x4535).
index	32u	6	The starting index of the variables to retrieve.
length	32u	10	The number of values to retrieve from the starting index.

Reply

Field	Type	Offset	Description
length	32u	0	Reply size including this field, in bytes.
id	16u	4	Reply identifier (0x4535).
status	32s	6	Reply status.
index	32u	10	The starting index of the variables being returned.
length	32u	14	The number of values being returned.
values[length]	32s	18	The runtime variable values.

● Upgrade Commands

A client sends firmware upgrade commands over the Upgrade TCP channel (port 3192).

The Control channel (port 3190) and the Upgrade channel can be connected simultaneously. For more information on Control commands, see 📖 "●Control Commands" on page 753.

After connecting to a sensor, you can use the Protocol Version command to retrieve the protocol version. Protocol version refers to the version of the SurfaceMeasure1008S Protocol supported by the connected sensor (the sensor to which a command connection is established), and consists of major and minor parts. The minor part is updated when backward-compatible additions are made to the protocol. The major part is updated when breaking changes are made to the protocol.

- **Start Upgrade**

The Start Upgrade command begins a firmware upgrade for the sensors in a system. All sensors automatically reset 3 seconds after the upgrade process is complete.

Command

Field	Type	Offset	Description
length	64s	0	Command size including this field, in bytes.
id	64s	8	Command identifier (0x0000).
length	64s	16	Length of the upgrade package (bytes).
data[length]	byte	24	Upgrade package data.

Reply

Field	Type	Offset	Description
length	64s	0	Reply size including this field, in bytes.
id	64s	8	Reply identifier (0x0000).
status	64s	16	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Start Upgrade Extended**

  The Start Upgrade Extended command begins a firmware upgrade for the sensors in a system. All sensors automatically reset 3 seconds after the upgrade process is complete.

Command

Field	Type	Offset	Description
length	64s	0	Command size including this field, in bytes.
id	64s	8	Command identifier (0x0003).
skipValidation	64s	16	Whether or not to skip validation (0 – do not skip, 1 – skip).
length	64s	24	Length of the upgrade package (bytes).
data[length]	byte	32	Upgrade package data.

Reply

Field	Type	Offset	Description
length	64s	0	Reply size including this field, in bytes.
id	64s	8	Reply identifier (0x0003).
status	64s	16	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

- **Get Upgrade Status**

  The Get Upgrade Status command determines the progress of a firmware upgrade.

Command

Field	Type	Offset	Description
length	64s	0	Command size including this field, in bytes.
id	64s	8	Command identifier (0x1)

Reply

Field	Type	Offset	Description
length	64s	0	Reply size including this field, in bytes.
id	64s	8	Reply identifier (0x1).
status	64s	16	Reply status. For a list of status codes, see 📖 "• Status Codes" on page 749

Field	Type	Offset	Description
state	64s	24	Upgrade state: -1 – Failed 0 – Completed 1 – Running 2 – Completed, but should run again
progress	64s	32	Upgrade progress (valid when in the Running state)

- **Get Upgrade Log**

  The Get Upgrade Log command can retrieve an upgrade log in the event of upgrade problems.

Command

Field	Type	Offset	Description
length	64s	0	Command size including this field, in bytes.
id	64s	8	Command identifier (0x2)

Reply

Field	Type	Offset	Description
length	64s	0	Reply size including this field, in bytes.
id	64s	8	Reply identifier (0x2).
status	64s	16	Reply status. For a list of status codes, see "• Status Codes" on page 749
length	64s	24	Length of the log (bytes).
log[length]	char	32	Log content.

Results

The following sections describe the results (data and health) that a sensor sends.

Data Results

A client can receive data messages from a sensor by connecting to the Data TCP channel (port 3196).

The Data channel and the Health channel (port 3194) can be connected at the same time. The sensor accepts multiple connections on each port. For more information on the Health channel,

see 📖 "●Health Results" on page 811.

Messages that are received on the Data and Health channels use a common structure, called Surface-Measure1008S Data Protocol (GDP). Each message consists of a 6-byte header, containing size and control fields, followed by a variable-length, message-specific content section. The structure of the GDP message is defined below.

SurfaceMeasure1008S Data Protocol

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last Message flag Bits 0-14: Message type identifier. (See individual data result sections.)

Messages are always sent in groups. The Last Message flag in the control field is used to indicate the final message in a group. If there is only one message per group, this bit will be set in each message.

- **Stamp**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 1
count (C)	32u	6	Count of stamps in this message.
size	16u	10	Stamp size, in bytes (min: 56, current: 56).
source	8u	12	Source (0 – Main, 1 – Buddy).
reserved	8u	13	Reserved.
stamps[C]	Stamp	14	Array of stamps (see below).

Stamp

Field	Type	Offset	Description
frameIndex	64u	0	Frame index (counts up from zero).
timestamp	64u	8	Timestamp (μs).
encoder	64s	16	Current encoder value (ticks).
encoderAtZ	64s	24	Encoder value latched at z/index mark (ticks).

Field	Type	Offset	Description
status	64u	32	Bit field containing various frame information: Bit 0: sensor digital input state Bit 4: master digital input state Bit 8-9: inter-frame digital pulse trigger. (Master digital input if master is connected, otherwise sensor digital input. Value is cleared after each frame and clamped at 3 if more than 3 pulses are received).
serialNumber	32u	40	Sensor serial number. (In a dual-sensor system, the serial number of the main sensor.)
reserved[3]	32u	44	Reserved.
ptpTimestamp	64u	56	PTP Timestamp (μs).

- **Video**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 2.
attributesSize	16u	6	Size of attributes, in bytes (min: 20, current: 20).
height (H)	32u	8	Image height, in pixels.
width (W)	32u	12	Image width, in pixels.
pixelSize	8u	16	Pixel size, in bytes.
pixelFormat	8u	17	Pixel format: 1 – 8-bit greyscale 2 – 8-bit color filter 3 – 8-bits-per-channel color (B, G, R, X)
colorFilter	8u	18	Color filter array alignment: 0 – None 1 – Bayer BG/GR 2 – Bayer GB/RG 3 – Bayer RG/GB 4 – Bayer GR/BG
source	8u	19	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right 100 to 131 – G2 buddy sensor device indices for configurations with 2 to 31 buddy G2 sensors to identify a particular sensor's scan data. Main sensor is 100. First buddied sensor is 101. Second buddied sensor is 102 and so on.
cameraIndex	8u	20	Camera index.

Field	Type	Offset	Description
exposureIndex	8u	21	Exposure index.
exposure	32u	22	Exposure (ns).
flippedX	8u	26	Indicates whether the video data must be flipped horizontally to match up with profile data.
flippedY	8u	27	Indicates whether the video data must be flipped vertically to match up with profile data.
streamStep	32s	28	Data stream step number. For video, values are: 0 – video stream step 8 – tool data stream step
streamStepId	32s	32	Data stream step identifier within the stream step.
transposed	8u	36	Indicates whether the video data must be transposed to match up with profile data.
pixels[H][W]	(Variable)	37	Image pixels. (Depends on pixelSize above.)

- **Profile Point Cloud**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 5.
attributeSize	16u	6	Size of attributes, in bytes (min: 32, current: 56).
count (C)	32u	8	Number of profile arrays.
width (W)	32u	12	Number of points per profile array.
xScale	32u	16	X scale (nm).
zScale	32u	20	Z scale (nm).
xOffset	32s	24	X offset (µm).
zOffset	32s	28	Z offset (µm).
Source	8u	32	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right 100 to 131 – G2 buddy sensor device indices for configurations with 2 to 31 buddy G2 sensors to identify a particular sensor’s scan data. Main sensor is 100. First buddied sensor is 101. Second buddied sensor is 102 and so on.
exposure	32u	33	Exposure (ns).
cameraIndex	8u	37	Camera index.
reserved[2]	8u	38	Reserved.
streamStep	32s	40	Stream step
streamStepId	32s	44	Data stream step identifier within the stream step.

Field	Type	Offset	Description
Reserved	32s	48	Reserved
Reserved	32s	52	Reserved
ranges[C][W]	Point16s	56	Profile ranges.

- **Uniform Profile**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 6.
attributeSize	16u	6	Size of attributes, in bytes (min: 32, current: 56).
count (C)	32u	8	Number of profile arrays.
width (W)	32u	12	Number of points per profile array.
xScale	32u	16	X scale (nm).
zScale	32u	20	Z scale (nm).
xOffset	32s	24	X offset (µm).
zOffset	32s	28	Z offset (µm).
source	8u	32	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right
exposure	32u	33	Exposure (ns).
reserved[3]	8u	37	Reserved.
streamStep	32s	40	Data stream step number. For a profile, values are: 2 – profile stream step 8 – tool data stream step
streamStepId	32s	44	Data stream step identifier within the stream step.
Reserved	32s	48	Reserved
Reserved	32s	52	Reserved
ranges[C][W]	16s	56	Profile ranges

- **Profile Intensity**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 7.
attributesSize	16u	6	Size of attributes, in bytes (min: 24, current: 56).
count (C)	32u	8	Number of profile intensity arrays.
width (W)	32u	12	Number of points per profile intensity array.

Field	Type	Offset	Description
xScale	32u	16	X scale (nm).
xOffset	32s	20	X offset (µm).
source	8u	24	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right
exposure	32u	25	Exposure (ns).
cameraIndex	8u	29	Camera index.
reserved[2]	8u	30	Reserved.
streamStep	32s	32	Data stream step number. For video, values are: 2 – profile stream step 8 – tool data stream step
streamStepId	32s	36	Data stream step identifier within the stream step.
Reserved	32s	48	Reserved.
Reserved	32s	52	Reserved.
points[C][W]	8u	40	Intensity arrays.

- **Uniform Surface**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 8.
attributeSize	16u	6	Size of attributes, in bytes (min: 44, current: 68).
length (L)	32u	8	Surface length (rows).
length (W)	32u	12	Surface width (columns).
xScale	32u	16	X scale (nm).
yScale	32u	20	Y scale (nm).
zScale	32u	24	Z scale (nm).
xOffset	32s	28	X offset (µm).
yOffset	32s	32	Y offset (µm).
zOffset	32s	36	Z offset (µm).
source	8u	40	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right
exposure	32u	41	Exposure (ns).
reserved[7]	8u	45	Reserved.

Field	Type	Offset	Description
streamStep	32s	52	Data stream step number. For a surface, values are: 3 – surface stream step 8 – tool data stream step
streamStepId	32s	56	Data stream step identifier within the stream step.
Reserved	32s	60	Reserved
Reserved	32s	64	Reserved
ranges[L][W]	16s	68	Surface ranges.

- **Surface Point Cloud**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 28.
attributeSize	16u	6	Size of attributes, in bytes (min: 44, current: 60).
length (L)	32u	8	Surface length (rows).
length (W)	32u	12	Surface width (columns).
xScale	32u	16	X scale (nm).
yScale	32u	20	Y scale (nm).
zScale	32u	24	Z scale (nm).
xOffset	32s	28	X offset (μm).
yOffset	32s	32	Y offset (μm).
zOffset	32s	36	Z offset (μm).
source	8u	40	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right
exposure	32u	41	Exposure (ns).
isAdjacent	Bool	45	Is the data Adjacant/Sorted? (That is, graphable?)
streamStep	32s	46	Data stream step number. For a surface, values are: 3 – surface stream step 8 – tool data stream step
streamStepId	32s	50	Data stream step identifier within the stream step.
Reserved	32s	54	Reserved
Reserved	32s	56	Reserved
ranges[L][W]	Point3d16s	60	Surface ranges. Tuple (x, y, z) 16s

- **Surface Intensity**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 9.
attributeSize	16u	6	Size of attributes, in bytes (min: 32, current: 56).
length (L)	32u	8	Surface length (rows).
width (W)	32u	12	Surface width (columns).
xScale	32u	16	X scale (nm).
yScale	32u	20	Y scale (nm).
xOffset	32s	24	X offset (µm).
yOffset	32s	28	Y offset (µm).
source	8u	32	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right
exposure	32u	33	Exposure (ns).
reserved[3]	8u	37	
streamStep	32s	40	Data stream step number. For surface, values are: 3 – surface stream step 8 – tool data stream step
streamStepId	32s	44	Data stream step identifier within the stream step.
Reserved	32s	48	Reserved
Reserved	32s	52	Reserved.
intensities[H][W]	8u	56	Surface intensities.

- **Surface Section**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 20.
attributeSize	16u	6	Size of attributes, in bytes (min: 45, current: 61).
count (C)	32u	8	Number of profile arrays.
width (W)	32u	12	Number of points per profile array.
xScale	32u	16	X scale (nm).
zScale	32u	20	Z scale (nm).
xOffset	32s	24	X offset (µm).
zOffset	32s	28	Z offset (µm).

Field	Type	Offset	Description
source	8u	32	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right
sectionId	32u	33	Section Id
exposure	32u	37	Exposure (ns).
poseAngle	32s	41	Z angle of the pose (microdegrees).
poseX	32s	45	X offset of the pose (μm)
poseY	32s	49	Y offset of the pose (μm)
streamStep	32s	53	Stream step.
streamStepId	32s	57	Stream step ID.
ranges[C][W]	16s	61	Profile ranges.

Tips

The pose can be used to transform the section data into the surface frame of reference, via a rotation and then a translation.

- **Surface Section Intensity**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 21.
attributesSize	16u	6	Size of attributes, in bytes (min: 37, current: 53).
count (C)	32u	8	Number of profile intensity arrays
width (W)	32u	12	Number of points per profile intensity array
xScale	32u	16	X scale (nm).
xOffset	32s	20	X offset (μm).
source	8u	24	Source 0 – Top 1 – Bottom 2 – Top Left 3 – Top Right
sectionId	32u	25	Section Id.
exposure	32u	29	Exposure (ns).
poseAngle	32s	33	Z angle of the pose (microdegrees).
poseX	32s	37	X offset of the pose (μm).
poseY	32s	41	Y offset of the pose (μm).
streamStep	32s	45	Stream step.
streamStepId	32s	49	Stream step ID.
points[C][W]	8u	53	Intensity arrays.

- **Measurement**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 10.
count (C)	32u	6	Count of measurements in this message.
reserved[2]	8u	10	Reserved.
id	16u	12	Measurement identifier.
measurements[C]	Measurement	14	Array of measurements (see below).

Measurement

Field	Type	Offset	Description
value	32s	0	Measurement value.
decision	8u	4	Measurement decision bitmask. Bit 0: 1 – Pass 0 – Fail Bits 1-7: 0 – Measurement value OK 1 – Invalid value 2 – Invalid anchor
reserved[3]	8u	5	Reserved.

- **Alignment Result**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 11.
attributesSize	16u	6	Size of attributes, in bytes (min: 8, current: 16).
opId	32u	8	Operation ID.

Field	Type	Offset	Description
status	32s	12	Operation status. 1 – OK 0 – General failure -1 – No data in the field of view for stationary alignment -2 – No profiles with sufficient data for line fitting for travel alignment -3 – Invalid target detected. Examples include: - Calibration disk diameter too small. - Calibration disk touches both sides of the field of view. - Too few valid data points after outlier rejection. -4 – Target detected in an unexpected position. -5 – No reference hole detected in bar alignment. -6 – No change in encoder value during travel calibration -7 – Too few profiles in target during travel calibration -988 – User aborted -993 – Timed out -997 – Invalid parameter

- **Exposure Calibration Result**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 12.
attributesSize	16u	6	Size of attributes, in bytes (min: 8, current: 16).
opId	32u	8	Operation ID.
status	32s	12	Operation status.
exposure	32u	16	Exposure result (ns).

- **Edge Match Result**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 16.
decision	8u	6	Overall match decision.
xOffset	32s	7	Target x offset in model space (μm).
yOffset	32s	11	Target y offset in model space (μm).
zAngle	32s	15	Target z rotation in model space (microdegrees).

Field	Type	Offset	Description
quality	32s	19	Match quality (thousandth).
qualityDecision	8u	23	Quality match decision.
reserved[2]	8u	24	Reserved.

- **Bounding Box Match Result**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 17.
decision	8u	6	Overall match decision.
xOffset	32s	7	Target x offset in model space (μm).
yOffset	32s	11	Target y offset in model space (μm).
zAngle	32s	15	Target z rotation in model space (microdegrees).
width	32s	19	Width axis length (μm)
widthDecision	8u	23	Width axis decision.
length	32s	24	Length axis length (μm)
lengthDecision	8u	28	Length axis decision.

- **Ellipse Match Result**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 18.
decision	8u	6	Overall match decision.
xOffset	32s	7	Target x offset in model space (μm).
yOffset	32s	11	Target y offset in model space (μm).
zAngle	32s	15	Target z rotation in model space (microdegrees).
minor	32s	19	Minor axis length (μm)
minorDecision	8u	23	Minor axis decision.
major	32s	24	Major axis length (μm)
majorDecision	8u	28	Major axis decision.

- **Event**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 22.
attributesSize	16u	6	Size of attributes, in bytes (min: 8, current: 16).

Field	Type	Offset	Description
eventType	32u	8	The type of event: 0 – Exposure Begin 1 – Exposure End
length	32u	12	The number of bytes containing additional data.
data[length]	8u	16	Additional data.

- **Feature Point**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 24.
id	16u	6	Feature Id
Point.x	64s	8	X Coordinate of Point (Scaled by 10^6)
Point.y	64s	16	Y Coordinate of Point (Scaled by 10^6)
Point.z	64s	24	Z Coordinate of Point (Scaled by 10^6)

- **Feature Line**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 25.
id	16u	6	Feature Id
Point.x	64s	8	X Coordinate of Point (Scaled by 10^6)
Point.y	64s	16	Y Coordinate of Point (Scaled by 10^6)
Point.z	64s	24	Z Coordinate of Point (Scaled by 10^6)
Direction.x	64s	32	X Component of Direction Vector (Scaled by 10^6)
Direction.y	64s	40	Y Component of Direction Vector (Scaled by 10^6)
Direction.z	64s	48	Z Component of Direction Vector (Scaled by 10^6)

- **Feature Plane**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 26.
id	16u	6	Feature Id
Normal.x	64s	8	X Component of Normal Vector (Scaled by 10^6)

Field	Type	Offset	Description
Normal.y	64s	16	Y Component of Normal Vector (Scaled by 10^6)
Normal.z	64s	24	Z Component of Normal Vector (Scaled by 10^6)
originDistance	64s	32	Distance to Origin (Scaled by 10^6)

- **Feature Circle**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 27.
id	16u	6	Feature Id
Point.x	64s	8	X Coordinate of Point (Scaled by 10^6)
Point.y	64s	16	Y Coordinate of Point (Scaled by 10^6)
Point.z	64s	24	Z Coordinate of Point (Scaled by 10^6)
Normal.x	64s	32	X Component of Normal Vector (Scaled by 10^6)
Normal.y	64s	40	Y Component of Normal Vector (Scaled by 10^6)
Normal.z	64s	48	Z Component of Normal Vector (Scaled by 10^6)
radius	64s	56	Radius of Circle (Scaled by 10^6)

- **Generic Message**

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. For this message, set to 29.
attributeSize	16u	6	Size of attributes, in bytes (min: 32, current: 40).
streamStep	32s	8	Data stream step.
streamStepId	32s	12	Data stream step ID.
userType	32u	16	User-define data type ID
isObject	8u	20	0 – Content is raw byte buffer 1 – Content is an kObject
contentLength	32u	21	Length of content array, in bytes
Content[contentLength]	byte	25	Content array. If isObject is true, the byte buffer should be deserialized using kDat6Serializer.

● Health Results

A client can receive health messages from a sensor by connecting to the Health TCP channel (port 3194).

The Data channel (port 3196) and the Health channel can be connected at the same time. The sensor accepts multiple connections on each port. For more information on the Data channel, see 📖 "●Data Results" on page 798.

Messages that are received on the Data and Health channels use a common structure, called SurfaceMeasure1008S Data Protocol (GDP). Each message consists of a 6-byte header, containing size and control fields, followed by a variable-length, message-specific content section. The structure of the GDP message is defined below.

SurfaceMeasure1008S Data Protocol

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last Message flag Bits 0-14: Message type identifier. (See individual data result sections.)

Messages are always sent in groups. The Last Message flag in the control field is used to indicate the final message in a group. If there is only one message per group, this bit will be set in each message.

A Health Result contains a single data block for health indicators. Each indicator reports the current status of some aspect of the sensor system, such as CPU usage or network throughput.

Health Result

Field	Type	Offset	Description
size	32u	0	Count of bytes in message (including this field).
control	16u	4	Bit 15: Last message flag. Bits 0-14: Message type identifier. Always 0.
count (C)	32u	6	Count of indicators in this message.
source	8u	10	Source (0 – Main, 1 – Buddy).
reserved[3]	8u	11	Reserved
indicators[C]	Indicator	14	Array of indicators (see format below).

The indicators block contains a 2-dimensional array of indicator data. Each row in the array has the following format:

Indicator Format

Field	Type	Offset	Description
id	32u	0	Unique indicator identifier (see 📖 "• Indicator identifiers" on page 812 table below).
instance	32u	4	Indicator instance.
value	64s	8	Value (identifier-specific meaning).

The following health indicators are defined for sensor systems.

Tips

When a sensor is accelerated, some health indicators report values from the PC that is accelerating the sensor, or a combination of both. In the table below, values are reported from the sensor unless otherwise indicated.

Tips

Undocumented indicators may be included in addition to the indicators defined below.

Indicator identifiers

Indicator	ID	Instance	Value
Encoder Value	1003	-	Current system encoder tick.
Encoder Frequency	1005	-	Current system encoder frequency (ticks/s).
Laser Safety	1010	-	Laser safety status. 0: laser is disabled 1: laser is enabled
App Version	2000	-	Firmware application version.
Internal Temperature	2002	-	Internal temperature (centidegrees Celsius).
Uptime	2017	-	Time elapsed since node boot-up or reset (seconds).
Projector Temperature	2404	-	Projector module temperature (centidegrees Celsius). Only available on projector based devices.
Control Temperature	2028	-	Control module temperature (centidegrees Celsius). Available only on 3B-class devices.
Memory Usage	2003	-	Amount of memory currently used (bytes).
Memory Capacity	2004	-	Total amount of memory available (bytes).
Storage Usage	2005	-	Amount of non-volatile storage used (bytes).
Storage Capacity	2006	-	Total amount of non-volatile storage available (bytes).
Alignment State	20008	-	Alignment state: 0 – not aligned 1 - aligned
CPU Usage	2007	-	CPU usage (percentage of maximum).
Net Out Capacity	2009	-	Total available outbound network throughput (bytes/s).
Net Out Link Status	2034	-	Current Ethernet link status.
Sync Source*	2043	-	Synchronization source. 1 - Master device 2 - Sensor

Indicator	ID	Instance	Value
Digital Inputs*	2024	-	Current digital input status (one bit per input).
Event Count	2102	-	Total number of events triggered.
Camera Search Count	2217	-	Number of search states. (Only important when tracking is enabled.)
Camera Trigger Drops	2201	-	Number of dropped triggers.
Sensor Watch-dog Reset	3006	-	Number of restarts caused by a fatal error condi-tion, such as watchdog resets or crash resets.
Platform CUDA Status	3007	-	Status of CUDA/GPU support on the sensor (accelerated and non-accelerated) platform. 0 = CUDA/GPU execution supported in current platform environment.
Analog Output Drops	21014(previ-ously 2501)	Output Index	Number of dropped outputs.
Digital Output Drops	21015 (previ-ously 2601)	Output Index	Number of dropped outputs.
Serial Output Drops	21016 (previ-ously 2701)	Output Index	Number of dropped outputs.
Sensor State*	20000	-	Sensor state. -1 – Conflict 0 – Ready 1 – Running
Current Sensor Speed*	20001	-	Current sensor speed. (Hz)
Maximum Speed*	20002	-	The sensor’s maximum speed.
Spot Count*	20003	-	Number of spots found in the last unresampled profile/surface.
Max Spot Count*	20004	-	Maximum number of spots that can be found.
Scan Count*	20005	-	Number of surfaces detected from a top device.
Master Status*	20006	0 for main 1 for buddy	Master connection status: 0 – Not connected 1 – Connected The indicator with instance = buddy does not exist if the buddy is not connected.
Cast Start State*	20007		The state of the second digital input. (NOTE: Only available on XLine capable licensed devices)
Point Count	20015	-	Number of points found in last resampled Profile/ Surface.
Max Point Count	20016	-	Maximum number of points that can be found.
Laser Overheat*	20020	-	Indicates whether laser overheat has occurred. 0 – Has not overheated 1 – Has overheated Only available on certain 3B laser devices.

Indicator	ID	Instance	Value
Laser Overheat Duration*	20021	-	The length of time in which the laser overheating state occurred. Only available on certain 3B laser devices.
Playback Position*	20023	-	The current replay playback position.
Playback Count*	20024	-	The number of frames present in the replay.
FireSync Version	20600	-	The FireSync version used by the SurfaceMeasure1008S build. The low-level firmware version used by the sensor.
Processing Drops**	21000	-	The sum of various processing drop indicators including drops due to insufficient CPU and buffer overflows.
Last Processing Latency	21001	-	Last delay from camera exposure to availability of all results.
Max Processing Latency	21002	-	Maximum value of processing latency.
Ethernet Output	21003	-	Number of bytes transmitted.
Ethernet Rate	21004	-	The average number of bytes per second being transmitted.
Ethernet Drops	21005	-	Number of dropped Ethernet packets.
Digital Output Pass	21006	Output Index	Number of pass digital output pulse.
Digital Output Fail	21007	Output Index	Number of fail digital output pulse.
Trigger Drops**	21010		Number of dropped triggers. The sum of various triggering-related drop indicators.
Output Drops**	21011		Number of dropped output data. The sum of all output drops (analog, digital, serial, host server, and ASCII server).
Controlled Trigger Drops	21017		Trigger drops from the Controlled Triggering System (Grouped with “Trigger Drops” indicator)
Surface Processing Time	21018		Processing time of frame on 35xx/32xx (microseconds)
Max Frame Rate	21019		32xx/35xx max configurable frame rate given above in Surface Processing Time (scaled by 1x10-6)
Range Valid Count**	21100	-	Number of valid ranges.
Range Invalid Count**	21101	-	Number of invalid ranges.
Anchor Invalid Count**	21200	-	Number of frames with anchoring invalid.
Light Operational Time	21201	-	Total running time of G2 laser or G3 projector light (on SurfaceMeasure1008S firmware 5.3 or later), in minutes.
First Log Id	21301		ID of the first available log entry.

Indicator	ID	Instance	Value
Last Log Id	21300		ID of the last available log entry. It is inclusive: for example, if first = 3 and last = 5, the available log IDs are 3, 4, 5. If no log is available, the last ID is less than the first ID.
Z-Index Drop Count	22000	-	The number of dropped surfaces due to a lack of z-encoder pulse during rotational part detection.
Tool Run Time	22004	Tool Index	The most recent time taken to execute the tool.
Part Total Emit-ted	22006	-	Total number of parts emitted by profile part detection.
Part Length Limit	22007	-	Number of parts emitted due to reaching the length limit.
Part Min Area Drops	22008	-	Number of parts dropped due to being smaller than the minimum area.
Part Backtrack Drops	22009	-	Number of parts dropped due to backtracking.
Parts Currently Active	22010	-	Number of parts currently being tracked.
Part Length	22011	-	Length of largest active part.
Part Start Y	22012	-	Start Y position of the largest active part.
Part Tracking State	22013	-	Tracking state of the largest active part.
Part Capacity Exceeded	22014	-	Part detection part or run capacity has been exceeded.
Part X Position	22015	-	Center X position of the largest active part.
Tool Runtime Minimum	22016	-	Minimum time spent for tool to process a sample
Tool Runtime Maximum	22017	-	Maximum time spent for tool to process a sam-ple
Tool Runtime Average	22018	-	Average time for tool to process a sample
Tool Runtime Percent Average	22019	-	Average percentage of total time spent running this tool
Bar Alignment Status	22020	-	Status of the buffered bar alignment when align-ing: 1 – buffer leveling in progress 2 – buffer searching in progress 3 – buffer scanning in progress 4 – buffer padding in progress 5 – buffering complete; processing alignment on buffered data 11 – alignment leveling in progress 12 – alignment searching in progress 13 – alignment fitting in progress 14 – alignment complete 15 – alignment completed but failed 16 – alignment cancelled

Indicator	ID	Instance	Value
Value	30000	Measurement ID	Measurement Value.
Pass	30001	Measurement ID	Number of pass decision.
Fail	30002	Measurement ID	Number of fail decision.
Min	30003	Measurement ID	Minimum measurement value.
Max	30004	Measurement ID	Maximum measurement value.
Average	30005	Measurement ID	Average measurement value.
Std. Dev.	30006	Measurement ID	Measurement value standard deviation.
Invalid Count	30007	Measurement ID	Number of invalid values.
Overflow	30008	Measurement ID	Number of times this measurement has overflown on any output. Multiple simultaneous overflows result in only a single increment to this counter. Overflow conditions include: -Value exceeds bit representation available for given protocol -Analog output (mA) falls outside of acceptable range (0-20 mA) When a measurement value overflow occurs, the value is set to the null value appropriate for the given protocol's measurement value output type. The Overflow health indicator increments.

* When the sensor is accelerated, the indicator's value is reported from the accelerating PC.

** When the sensor is accelerated, the indicator's value is the sum of the values reported from the sensor and the accelerating PC.

10.1.2 Modbus Protocol

Modbus is designed to allow industrial equipment such as Programmable Logic Controllers (PLCs), sensors, and physical input/output devices to communicate over an Ethernet network.

Modbus embeds a Modbus frame into a TCP frame in a simple manner. This is a connection-oriented transaction, and every query expects a response.

This section describes the Modbus TCP commands and data formats. Modbus TCP communication lets the client:

- Switch jobs.
- Align and run sensors.
- Receive measurement results, sensor states, and stamps.

To use the Modbus protocol, it must be enabled and configured in the active job. For information on configuring the protocol using the Web interface, see "4.8.2 Ethernet Output" on page 327.

If buffering is enabled with the Modbus protocol, the PLC must read the Buffer Advance output register (see "• States" on page 753) to advance the queue before reading the measurement results.

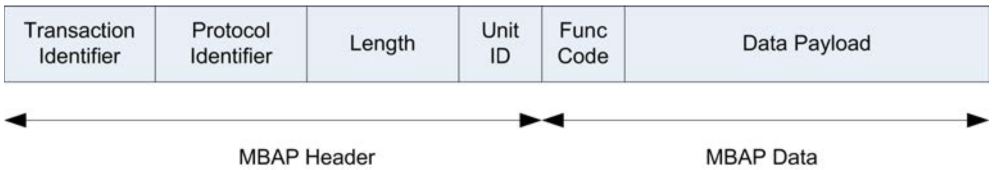
Concepts

A PLC sends a command to start each sensor. The PLC then periodically queries each sensor for its latest measurement results. In Modbus terminology, the PLC is a Modbus Client. Each sensor is a Modbus Server which serves the results to the PLC.

The Modbus protocol uses TCP for connection and messaging. The PLC makes a TCP connection to the sensor on port 502. Control and data messages are communicated on this TCP connection. Up to eight clients can be connected to the sensor simultaneously. A connection closes after 10 minutes of inactivity.

Messages

All Modbus TCP messages consist of an MBAP header (Modbus Application Protocol), a function code, and a data payload.



The MBAP header contains the following fields:

Modbus Application Protocol Header

Field	Length (Bytes)	Description
Transaction ID	2	Used for transaction pairing. The Modbus Client sets the value and the Modbus Server (the sensor) copies the value into its responses.
Protocol ID	2	Always set to 0.
Length	2	Byte count of the rest of the message, including the Unit identifier and data fields.
Unit ID	1	Used for intra-system routing purpose. The Modbus Client sets the value and the Modbus Server (the sensor) copies the value into its responses.

Modbus Application Protocol Specification describes the standard function codes in detail. Surface-Measure1008S supports the following function codes:

Modbus Function Code

Function Code	Name	Data Size (bits)	Description
3	Read Holding Registers	16	Read multiple data values from the sensor.
4	Read Input Reg-isters	16	Read multiple data values from the sensor.
6	Write Single Register	16	Send a command or parameter to the sensor.
16	Write Multiple Registers	16	Send a command and parameters to the sensor.

The data payload contains the registers that can be accessed by Modbus TCP messages. If a message accesses registers that are invalid, a reply with an exception is returned. Modbus Application Protocol Specification defines the exceptions and describes the data payload format for each function code.

The sensor data includes 16-bit, 32-bit, and 64-bit data. All data are sent in big endian format, with the 32-bit and 64-bit data spread out into two and four consecutive registers.

32-bit Data Format

Register	Name	Bit Position
0	32-bit Word 1	31 .. 16
1	32-bit Word 0	15 .. 0

64-bit Data Format

Register	Name	Bit Position
0	64-bit Word 3	63 .. 48
1	64-bit Word 2	47 .. 32
2	64-bit Word 1	31 .. 16
3	64-bit Word 0	15 .. 0

■ Registers

Modbus registers are 16 bits wide and are either control registers or output registers.

Control registers are used to control the sensor states (e.g., start, stop, or calibrate a sensor).

The output registers report the sensor states, stamps, and measurement values and decisions. You can read multiple output registers using a single Read Holding Registers or a single Read Input Registers command. Likewise, you can control the state of the sensor using a single Write Multiple Register command.

Control registers are write-only, and output registers are read-only.

Register Map Overview

Register Address	Name	Read/Write	Description
0 - 124	Control Registers	WO	Registers for Modbus commands. See 📖 "●Control Registers" on page 819 for detailed descriptions.
300 - 899	Sensor States	RO	Report sensor states. See 📖 "• State" on page 820 for detailed descriptions.
900 - 999	Stamps	RO	Return stamps associated with each profile or surface. See 📖 "• State" on page 820 for detailed descriptions.
1000 - 1998	Measurements & Decisions	RO	333 measurement and decision pairs. See 📖 "• Measurement Registers" on page 822 for detailed descriptions.

Control Registers

Control registers are used to operate the sensor. Register 0 stores the command to be executed. Subsequent registers contain parameters for the commands if applicable. The sensor executes a command when the value in register 0 is changed. To set the parameters before a command is executed, you should set up the parameters and the command using a single Write Multiple Register command.

Control Register Map

Register Address	Name	Read/Write	Description
0	Command Register	WO	Takes a 16-bit command. For a list of the available commands, see table below.
1 – 64	Command Parameters	WO	For［Load Job］(5) command: Null-terminated filename. Each 16-bit register holds a single character. Specifies the filename. If the file extension ".job" is missing, it is automatically appended to the filename. For［Set Runtime Variables ］(6) command: Registers 1-8 are used to set the values of the runtime variables.

The 16-bit values used for Command Register are described below.

Command Register Values

Value	Name	Description
0	Stop Running	Stops the sensor. No effect if sensor is already stopped.
1	Start Running	Starts the sensor. No effect if sensor is already started.
2	Align (stationary target)	Starts the stationary alignment process. State register 301 will be set to 1 (busy). When the alignment process is complete, the register is set back to zero.
3	Align (moving target)	Starts moving alignment process and also calibrate encoder resolution. State register 301 will be set to 1 (busy). When the alignment process is complete, the register is set back to zero.
4	Clear Alignment	Clears the alignment.
5	Load Job	Activates the specified job file. Set registers 1-64 to the null-terminated filename, one filename character per 16-bit register, including the null terminator character. The ".job" extension is optional; if it is missing, it is automatically appended to the file name.
6	Set Runtime Variables	Sets the runtime variables. Set registers 1 through 8 to the values of all four 32-bit runtime variables.
7	Software trigger	Software trigger the sensor to capture one frame. The sensor must already be running, in trigger mode “Software”. Otherwise, software trigger has no effect.

Output Registers

Output registers are used to output states, stamps, and measurement results. Each register address holds a 16-bit data value.

- **State**

State registers report the current sensor state.

State Register Map

Register Address	Name	Type	Description
300	Sensor State	16u	Sensor State: 0 - Stopped 1 - Running
301	Modbus Command in Progress	16u	1 when the sensor is busy performing the last command, 0 when done. Registers 302 and 311-371 below are only valid when there is no command in progress.
302	Alignment State	16u	Current Alignment State: 0 - Not aligned 1- Aligned (Valid when register 301 = 0.)
303	Encoder Position High	64u	Current encoder position (64-bit value, requiring four 16-bit registers)
304	Encoder		
305	Encoder		
306	Encoder Low		
307	Time High	64s	Uptime timestamp (64-bit value, requiring four 16-bit registers)
308	Time		
309	Time		
310	Time Low		
311	Job File Name Length	16u	Number of characters in the current job file name. (Valid when register 301 = 0.)
312 – 371	Live Job Name	16u	Name of currently loaded job file. Does not include the extension. Each 16-bit register contains a single character. (Valid when register 301 = 0.)
375	Runtime Variable 0 High	32s	Runtime variable value stored in two register locations.
376	Runtime Variable 0 Low		
...	...	...	...
381	Runtime Variable 3 High	32s	Runtime variable value stored in two register locations.
382	Runtime Variable 3 Low		

- **Stamp**

  Stamps contain trigger timing information used for synchronizing a PLC's actions. A PLC can also use this information to match up data from multiple sensors.

  In Profile mode, the stamps are updated after each profile is processed. In Surface mode, the stamps are updated after each surface has been processed.

Stamp Register Map

Register Address	Name	Type	Description
960-975	reserved		Not used.
976	Buffer Advance Register	16u	If buffering is enabled, this address must be read by the PLC Modbus client first to advance the buffer. After the buffer advance read operation, the Modbus client can read the updated Measurements & Decisions in addresses 1000-1059.
977	Buffer Count	16u	Number of buffered messages currently in the queue.
978	Buffer Overflow Flag	16u	Buffer Overflow Indicator: 0 - No overflow 1 - Overflow. (Indicates data is being lost.)
979	Inputs	16u	Digital input state of the last frame.
980	zPosition High	64u	Encoder position at time of last index pulse. 64-bit value, requiring four 16-bit registers.
981	zPosition		
982	zPosition		
983	zPosition Low		
984	Exposure High	32u	Laser exposure (μs) of the last frame. Stored in two register locations.
985	Exposure Low		
986	Temperature High	32u	Sensor temperature in degrees Celcius * 100 (centidegrees) of the last frame. Stored in two register locations.
987	Temperature Low		
988	Encoder Position High	64u	Encoder position of the last frame when the image data was scanned/taken. 64-bit value, requiring four 16-bit registers.
989	Encoder Position		
990	Encoder Position		
991	Encoder Position Low		
992	Time High	64u	Time stamp in microseconds of the last frame. 64-bit value, requiring four 16-bit registers.
993	Time		
994	Time		
995	Time Low		

Register Address	Name	Type	Description
996	Frame Index High	64u	The frame number of the last frame. 64-bit value, requiring four 16-bit registers.
997	Frame Index		
998	Frame Index		
999	Frame Index Low		

- **Measurement Registers**

  Measurement results are reported in pairs of values and decisions. Measurement values are 32 bits wide and decisions are 8 bits wide.

  The measurement ID is used to find the register address of each pair. The register address of the first word can be calculated as (1000 + 3 * ID). For example, a measurement with ID set to 4 can be read from registers 1012 (high word) and 1013 (low word), and the decision at 1015.

  In Profile mode, the measurement results are updated after each profile is processed. In Surface mode, the measurement results are updated after each discrete part has been processed.

Measurement Register Map

Register Address	Name	Type	Description
1000	Measurement 0 High	32s	Measurement value in µm (0x80000000 if invalid)
1001	Measurement 0 Low		
1002	Decision 0	16u	Measurement decision. A bit mask, where: Bit 0: 1 - Pass 0 - Fail Bits 1-7: 0 - Measurement value OK 1 - Invalid value 2 - Invalid anchor
1003	Measurement 1 High		
1004	Measurement 1 Low		
1005	Decision 1		
1006	Measurement 2 High		
1007	Measurement 2 Low		
1008	Decision 2		
...	...	...	...
1996	Measurement 332 High		
1997	Measurement 332 Low		
1998	Decision 332		

10.1.3 EtherNet/IP Protocol

EtherNet/IP is an industrial protocol that allows bidirectional data transfer with PLCs. It encapsulates the object-oriented Common Industrial Protocol (CIP). EtherNet/IP communication enables the client to:

- Switch jobs.
- Align and run sensors.
- Receive sensor states, stamps, and measurement results.
- Set and retrieve runtime variables.

This section describes the EtherNet/IP messages and data formats.The commands described in the sections below are those specific to the SurfaceMeasure1008S protocol and not the complete EIP reference command set.

Note that in firmware version 5.2, the identity information was updated as follows:

Attribute	Firmware 5.2 and later
Product Code	Now 1.
Major Revision	Now 1.
Minor Revision	Now 1.

This update may require a change on a device attempting to connect to a sensor via EtherNet/IP. A compatible EDS file can be downloaded from the website at https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/. If the existing EDS must be maintained, the device can be configured to disable electronic keying, ignoring the product code and version numbers.

To use the EtherNet/IP protocol, it must be enabled and configured in the active job. For information on configuring the protocol using the Web interface, see "4.8.2 Ethernet Output" on page 327.

Sensors support unconnected or connected explicit messaging (with TCP), as well as implicit (or I/O) messaging. For information on explicit messaging assemblies and objects, see "■Explicit Messaging" on page 823. For information on implicit messaging assemblies and objects, see "■Implicit Messaging" on page 830.

■ Explicit Messaging

To EtherNet/IP-enabled devices on the network, the sensor information is seen as a collection of objects, which have attributes that can be queried.

Sensors support all required objects for explicit messaging, such as the Identity object, TCP/IP object, and Ethernet Link object. In addition, an Assembly object is used for sending sensor and sample data and receiving commands. The Assembly object contains four assemblies: the command assembly (32 bytes), the runtime variable configuration assembly (64 bytes), the sensor state assembly (100 bytes), and the sample state assembly object (380 bytes). The data attribute (0x03) of the assembly objects is a byte array containing information about the sensor. The data attribute can be accessed with the Get Attribute and Set Attribute commands.

The PLC sends a command to start a sensor. The PLC then periodically queries the attributes of the assembly objects for its latest measurement results. In EtherNet/IP terminology, the PLC is a scanner and the sensor is an adapter.

The following sections describe the explicit messaging assemblies and objects.

- Identity Object (Class 0x01)

Attribute	Name	Type	Value	Description	Access
1	Vendor ID	UINT	1256	ODVA-provided vendor ID	Get
2	Device Type	UINT	43	Device type	Get
3	Product Code	UINT	1	Product code	Get
4	Revision	USINT	1.1	Byte 0 - 1 Byte 1 - 1	Get
6	Serial number	UDINT	32-bit value	Sensor serial number	Get
7	Product Name	SHORT STRING 32	" SurfaceMeasure1008S"	SurfaceMeasure1008S product name	Get

- TCP/IP Object (Class 0xF5)

The TCP/IP Object contains read-only network configuration attributes such as IP Address. TCP/IP configuration via Ethernet/IP is not supported. See Volume 2, Chapter 5-3 of the CIP Specification for a complete listing of TCP/IP object attributes.

Attribute	Name	Type	Value	Description	Access
1	Status	UDINT	0	TCP interface status	Get
2	Configuration Capability	UINT	0		Get
3	Configuration Control	UINT	0	Product code	Get
4	Physical Link Object	Structure (See description)		See 5.3.3.2.4 of CIP Specification Volume 2: Path size (UINT) Path (Padded EPATH)	Get
5	Interface Configuration	Structure (See description)		See 5.3.3.2.5 of CIP Specification Volume 2: IP address (UDINT) Network mask (UDINT) Name server (UDINT) Secondary name (UDINT) Domain name (UDINT)	Get

- Ethernet Link Object (Class 0xF6)

The Ethernet Link Object contains read-only attributes such as MAC Address (Attribute 3). See Volume 2, Chapter 5-4 of the CIP Specification for a complete listing of Ethernet Link object attributes.

Attribute	Name	Type	Value	Description	Access
1	Interface Speed	UDINT	1000	Ethernet interface data rate (mbps)	Get

Attribute	Name	Type	Value	Description	Access
2	Interface Flags	UDINT		See 5.4.3.2.1 of CIP Specification Volume 2: Bit 0: Link Status 0 – Inactive 1 - Active Bit 1: Duplex 0 – Half Duplex 1 – Full Duplex	Get
3	Physical Address	Array of 6 USINTs		MAC address (for example: 00 16 20 00 2E 42)	Get

- Assembly Object (Class 0x04)

For explicit messaging, the Ethernet/IP object model includes the following assemblies: command, run-time variable configuration, sensor state, and sample state.

All assembly object instances are static. Data in a data byte array in an assembly object are stored in the big endian format.

- **Command Assembly**

The command assembly object is used to start, stop, and align the sensor, and also to switch jobs on the sensor.

Command Assembly

Information	Value
Class	0x4
Instance	0x310
Attribute Number	3
Length	32 bytes
Supported Service	0x10 (SetAttributeSingle)

Attributes 1 and 2 are not implemented, as they are not required for the static assembly object.

Attribute 3

Attribute	Name	Type	Value	Description	Access
3	Command	Byte Array	See Below	Command parameters Byte 0 - Command. See table below for specification of the values.	Get, Set

Command Definitions

Value	Name	Description
0	Stop Running	Stop the sensor. No action if the sensor is already stopped
1	Start Running	Start the sensor. No action if the sensor is already started.

Value	Name	Description
2	Stationary Alignment	Start the stationary alignment process. Byte 1 of the sensor state assembly will be set to 1 (busy) until the alignment process is complete, then back to zero.
3	Moving Alignment	Start the moving alignment process. Byte 1 of the sensor state assembly will be set to 1 (busy) until the alignment process is complete, then back to zero.
4	Clear Alignment	Clear the alignment.
5	Load Job	Load the job. Set bytes 1-31 to the file name (one character per byte. File name must be null-terminated. The job name and extension are case-sensitive. If the extension ".job" is missing, it is automatically appended to the file name.
6	Reserved	Do not use.
7	Software trigger	Sends a software trigger to the sensor to capture one frame. The sensor must already be running, and its trigger mode must be set to "Software". Otherwise, software trigger has no effect.

- **Runtime Variable Configuration Assembly**

  The runtime variable configuration assembly object contains the sensor's intended runtime variables.

Runtime Variable Configuration Assembly

Information	Value
Class	0x04
Instance	0x311
Attribute Number	3
Length	64 bytes
Supported Service	0x10 (SetAttributeSingle)

Attribute 3

Attribute	Name	Type	Value	Description	Access
3	Command	Byte Array	See below	**Runtime variable configuration information. See below for more details.**	**Get**

Sensor State Information

Byte	Name	Type	Description
0-3	Runtime Variable 0	32s	Stores the intended value of the Runtime Variable at index 0.
4-7	Runtime Variable 1	32s	Stores the intended value of the Runtime Variable at index 1.
8-11	Runtime Variable 2	32s	Stores the intended value of the Runtime Variable at index 2.
12-15	Runtime Variable 3	32s	Stores the intended value of the Runtime Variable at index 3.
16-63	Reserved		

- **Sensor State Assembly**

  The sensor state assembly object contains the sensor's states, such as the current sensor temperature, frame count, and encoder values.

Sensor State Assembly

Information	Value
Class	0x04
Instance	0x320
Attribute Number	3
Length	100 bytes
Supported Service	0x0E (GetAttributeSingle)

Attributes 1 and 2 are not implemented, as they are not required for the static assembly object.

Attribute 3

Attribute	Name	Type	Value	Description	Access
3	Command	Byte Array	See below	Sensor state information. See below for more details.	Get

Sensor State Information

Byte	Name	Type	Description
0	Sensor State		Sensor state: 0 - Stopped 1 - Running
1	EtherNet/IP Command in Progress		Command busy status: 0 - Not busy 1 - Busy performing the last command Bytes 2 and 19-83 below are only valid when there is no command in progress.
2	Alignment State		Alignment status: 0 - Not aligned 1 - Aligned The value is only valid when byte1 is set to 0.
3-10	Encoder	64s	Current encoder position
11-18	Time	64s	Current timestamp
19	Current Job File-name Length	8u	Number of characters in the current job filename. (e.g., 11 for "current.job"). The length includes the .job extension. Valid when byte 1 = 0.
20-83	Current Job File-name		Name of currently loaded job, including the ".job" extension. Each byte contains a single charac-ter. Valid when byte 1 = 0.
84-87	Runtime Vari-able 0	32s	Runtime variable value at index 0
…	…		

Byte	Name	Type	Description
96-99	Runtime Vari-able 3	32s	Runtime variable value at index 3

- **Sample State Assembly**
  The sample state object contains measurements and their associated stamp information.

Sample State Assembly

Information	Value
Class	0x04
Instance	0x321
Attribute Number	3
Length	380 bytes
Supported Service	0x0E (GetAttributeSingle)

Attribute 3

Attribute	Name	Type	Value	Description	Access
3	Command	Byte Array	See below	Sample state information. See below for more details.	Get

Sample State Information

Byte	Name	Type	Description
0-1	Inputs	16u	Digital input state of the last frame.
2-9	Z Index Position		64sEncoder position at time of last index pulse of the last frame.
10-13	Exposure	32u	Laser exposure in µs of the last frame.
14-17	Temperature	32u	Sensor temperature in degrees Celsius * 100 (centidegrees) of the last frame.
18-25	Encoder Position	64s	Encoder position of the last frame when the image data was scanned/taken.
26-33	Time	64u	Time stamp in microseconds of the last frame.
34-41	Frame Counter	64u	The frame number of the last frame.
42	Buffer Count	8u	Represents the number of frames waiting to be output if buffering is enabled.
43	Buffer Overflowing	8u	Indicates whether the output buffer has over-flowed: 0 - No overflow 1 - Overflow
44 - 79	Reserved		Reserved bytes.
80-83	Measurement 0	32s	Measurement value in µm (0x80000000 if invalid).

Byte	Name	Type	Description
84	Decision 0	8u	Measurement decision. A bit mask, where: Bit 0: 1 - Pass 0 - Fail Bits 1-7: 0 - Measurement value OK 1 - Invalid value 2 - Invalid anchor
...	...		
375-378	Measurement 59	32s	Measurement value in µm (0x80000000 if invalid).
379	Decision 59	8u	Measurement decision. A bit mask, where: Bit 0: 1 - Pass 0 - Fail Bits 1-7: 0 - Measurement value OK 1 = Invalid value 2 = Invalid anchor

Measurement results are reported in pairs of values and decisions. Measurement values are 32 bits wide and decisions are 8 bits wide.

The measurement ID defines the byte position of each pair within the state information. The position of the first word can be calculated as (80 + 5 * ID). For example, a measurement with ID set to 4 can be read from byte 100 (high word) to 103 (low word) and the decision at 104.

In Profile mode, the measurement results are updated after each profile is processed. In Surface mode, the measurement results are updated after each discrete part has been processed. If buffering is enabled in the Ethernet Output panel, reading the Extended Sample State Assembly Object automatically advances the buffer. See 📖"4.8.2 Ethernet Output" on page 327 for information on the Output panel.

Implicit Messaging

Implicit messaging uses UDP and is faster than explicit messaging, and is ideal for time-critical applications. However, implicit messaging is layered on top of UDP. UDP is connectionless and data delivery is not guaranteed. For this reason, implicit messaging is only suitable for applications where occasional data loss is acceptable.

The following sections describe the implicit messaging assemblies.

Assembly Object (Class 0x04)

For implicit messaging, the Ethernet/IP object model includes the following assemblies: implicit messaging command and implicit messaging output.

All assembly object instances are static. Data in a data byte array in an assembly object are stored in the big endian format.

- **Implicit Messaging Command Assembly**

Implicit Messaging Command Assembly

Information	Value
Class	0x04
Instance	0x64
Attribute Number	3
Length	32 bytes

Implicit Messaging Command Assembly Information

Byte	Name	Type	Description
0	Command	8u	A bit mask where setting the following bits will only perform the action with highest priority*: 1 – Stop sensor 2 – Start sensor 4 – Perform stationary alignment 8 – Perform moving alignment 16 – Clear alignment 32 – Set runtime variables 64 – Load job file 128 – Software trigger *The priority of commands is currently as follows: 1. Stop sensor 2. Start sensor 3. Perform stationary alignment 4. Perform moving alignment 5. Clear alignment 6. Set runtime variables 7. Load job file 8. Software trigger

Byte	Name	Type	Description
1-31	Reserved (except for configuring runtime variables and loading job file)		If you are setting the runtime variables, use bytes 4-19 to define the values of each of the four runtime variables in little endian format. If you are loading job file, use bytes 1-31 for the filename, one character per byte. The job name and extension are case-sensitive. The filename must be null terminated and must end with ".job".

- **Implicit Messaging Output Assembly**

Implicit Messaging Output Assembly

Information	Value
Class	0x04
Instance	0x322
Attribute Number	3
Length	376 bytes

Implicit Messaging Output Assembly Information

Byte	Name	Type	Description
0	Sensor State	8u	Sensor state is a bit mask where: Bit 0: 1 – Running 0 – Stopped Bit 1: 1 – Conflict due to unreachable buddy 0 – No conflict Bit 2: 1 - Job not loaded 0 - No error loading job. Default power up state. Bit 3: 1 - Laser safety on 0 - Laser safety off Bits [4-7]: Not used.

Byte	Name	Type	Description
1	Alignment and Command state	8u	A bit mask where: Bit 0: 1 – Explicit or Implicit Command in progress 0 – No Explicit or Implicit command is in progress Bit 1 1 – Aligned 0 – Not aligned Bit 2: Unused Bit 3: 1 - Explicit or Implicit Command completed 0 - No Explicit or Implicit command completed recently Bit [4-7]: Unused
2-3	Inputs	16u	Digital input state of the last frame.
4-11	Z Index Position	64s	Encoder position at time of last index pulse of the last frame.
12-15	Exposure	32u	Exposure in µs of the last frame.
16-19	Temperature	32u	Sensor temperature in degrees celsius * 100 (centidegrees) of the last frame.
20-27	Encoder Position	64s	Encoder position of the last frame when the image data was scanned/taken.
28-35	Time	64u	Time stamp in microseconds of the last frame.
36-43	Frame Index	64u	The frame number of the last frame.
44-51	Current Encoder Position	64s	The current encoder position.
52-55	Reserved		
56	Decision 0	8u	Measurement decision is a bit mask where: Bit 0: 1 – Pass 0 – Fail Bits [1-7]: 0 – Measurement value OK 1 – Invalid Value 2 – Invalid Anchor
…	…		
119	Decision 63	8u	Measurement decision is a bit mask where: Bit 0: 1 – Pass 0 – Fail Bits [1-7]: 0 – Measurement value OK 1 – Invalid Value 2 – Invalid Anchor

Byte	Name	Type	Description
120-123	Measurement 0	32s	Measurement value in µm. (0x80000000 if invalid)
…	…		
372-375	Measurement 63	32s	Measurement value in µm. (0x80000000 if invalid)

■ Rockwell Allen-Bradley Instructions

This section describes how to set up network communications over the EtherNet/IP industrial communication protocol with Allen-Bradley PLCs that are EtherNet/IP-capable. SurfaceMeasure1008S supports two EtherNet/IP messaging methods: implicit messaging via UDP and explicit messaging via TCP.

Implicit messaging has advantages and disadvantages. Implicit messaging uses UDP and is faster than explicit messaging and is ideal for time-critical applications. Since implicit messaging is layered on top of UDP, it is connectionless and data delivery is not guaranteed. For this reason, implicit messaging is only suitable for applications where occasional data loss is acceptable. Two connection types are available for implicit communication: a Monitor Data connection or a Monitor Data and Control Data connection.

Explicit messaging is more suitable for deterministic and verified communication transfer where no losses are acceptable. Add-On Profile (AOP) is not available for the SurfaceMeasure1008S, and it is not possible to use the EDS file for automatic configuration.

For these reasons, Mitutoyo recommends in most application using a closed ethernet subnet (i.e., network switch, PLC, SurfaceMeasure1008S(s), and setup PC only) to minimize losses and collisions and cyclical implicit messaging over the EtherNet/IP protocol unless a specific control command such as job loading and/or transfer verification is required.

● Software and Hardware Setup

The following software and hardware were used during development.

Requirements	Details
SurfaceMeasure1008S Firmware	5.2 and higher
SurfaceMeasure1008S Series	G1, G2, and G3 sensors.
Required Files	GocatorEip.eds
	LMI.ico
	Gocator_EthernetIP.ACD
Other	Allen-Bradley L16ER-BB1B PLC Allen-Bradley Studio 5000 programming tool V21.11 or newer D-Link Unmanaged Industrial Gigabit Ethernet Switch DGS-108

Tips

The Ethernet card to which the SurfaceMeasure1008S is connected should be added as a module to the Backplane. Verify that the IP Address is on the correct subnet. Note the IP address should be that of the PLC’s Ethernet modules, not that of the SurfaceMeasure1008S’s.

- Byte Order Options

SurfaceMeasure1008S supports outputting in either Big Endian or Little Endian byte ordering options.

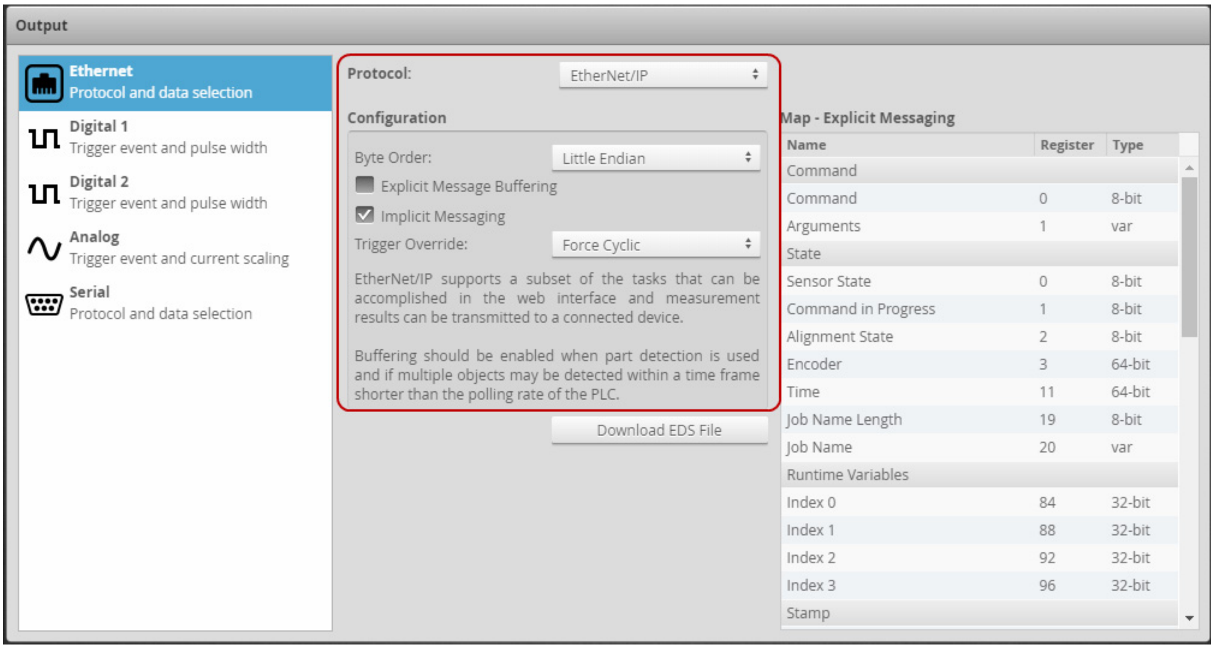
Big Endian Byte Order: The most significant byte (the "big end") of the data is placed at the byte with the lowest address. The rest of the data is placed in order of decreasing significance in the next three bytes of memory.

Little Endian Byte Order: The least significant byte (the "little end") of the data is placed at the byte with the lowest address. The rest of the data is placed in order of increasing significance in the next three bytes in memory.

Most Allen-Bradley PLCs default to Little Endian addressing formats, but you should verify this when configuring the PLC.

- Setting Up Implicit Messaging on the SurfaceMeasure1008S

To output in EtherNet/IP implicit messaging mode on the sensor, you configure the sensor using the [Protocol] setting and the [Configuration] area on the [Output] page. Note that the type of implicit messaging (cyclic versus change of state) is determined by the [Trigger Override] setting.



To configure the sensor for EtherNet/IP implicit messaging mode:

1. **On the [Output] page, in the [Ethernet] category, choose [EtherNet/IP] as the protocol.**
2. **Choose [Little Endian] from the [Byte Order] dropdown box.**
3. **Make sure that [Explicit Message Buffering] is unchecked.**
4. **Check the [Implicit Messaging] option.**
5. **Set the [Trigger Override] dropdown to the type of implicit messaging you are using.**
   » For cyclic messaging, set [Trigger Override] to [Force Cyclic].
   » For change of state messaging, set [Trigger Override] to [Force Change of State].

When you set up the PLC to communicate with a SurfaceMeasure1008S using change of state implicit messaging, an event task must be created on the PLC to rapidly check whether the sensor is running; if the frame count increases, data is copied to an array. The event task period must allow the event task to be executed at a higher rate than SurfaceMeasure1008S frame rate. For more information, see 📖 "●Setting Up Implicit Messaging on the PLC" on page 836.

Before setting up implicit messaging on the PLC, you must download the EDS file from the website at https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/ to the PC.

● Setting Up Implicit Messaging on the PLC

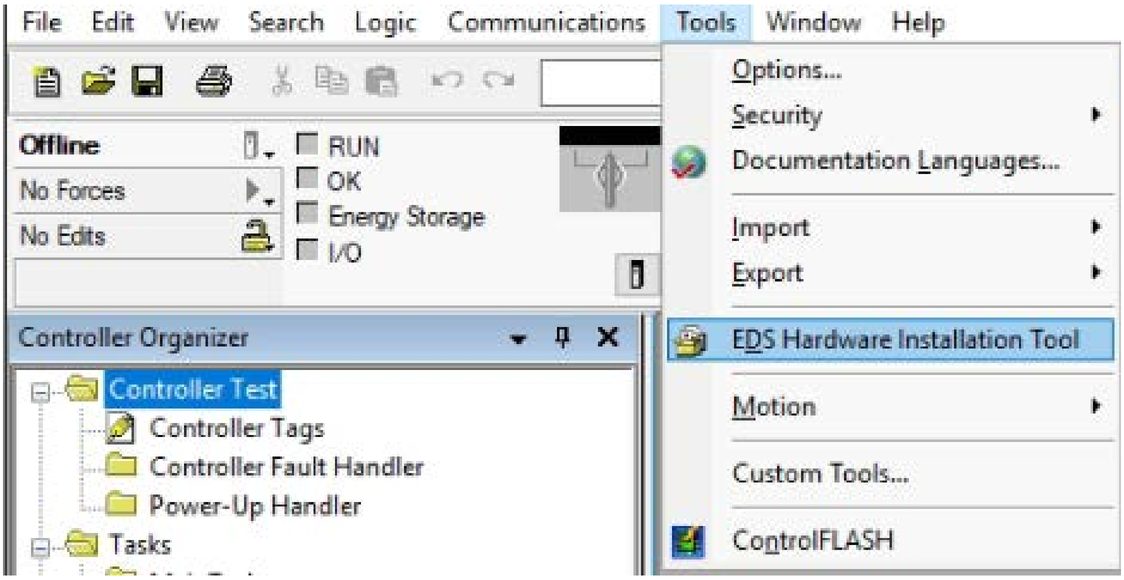
This section describes setting up implicit messaging on the PLC.

• Install EDS File

The EDS file is contained in the utilities package (14405-x.x.x.x_SOFTWARE_GO_Utilities.zip).

1 **Access the website at** https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/ **and download the appropriate package.**

2 **In Studio 5000, under the [Tools] menu, click [EDS Hardware Installation Tool].**

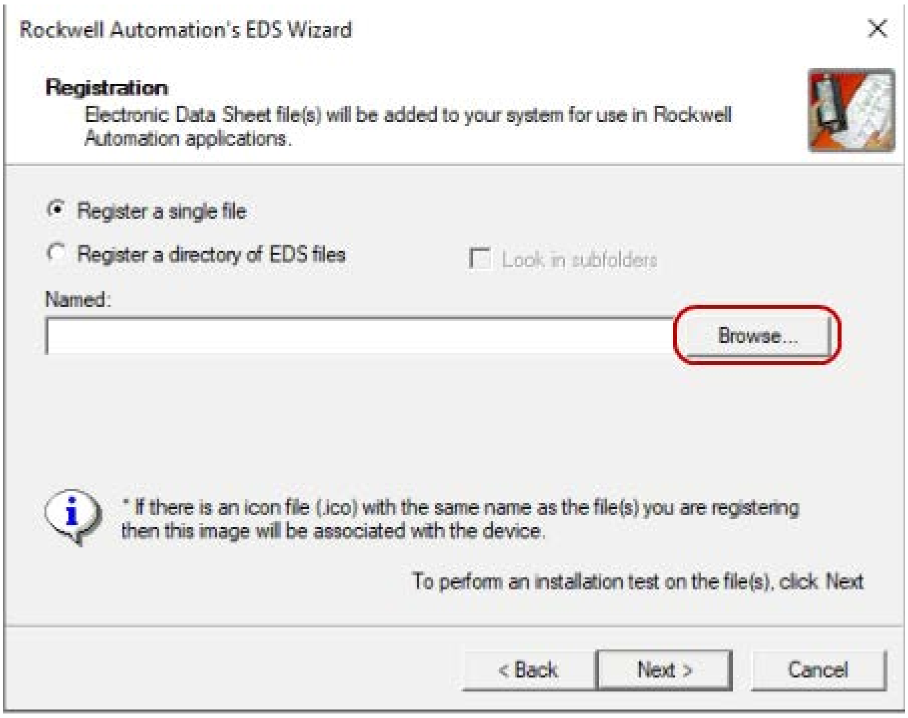


» The EDS setup tool (the Rockwell Automation EDS Wizard) launches.

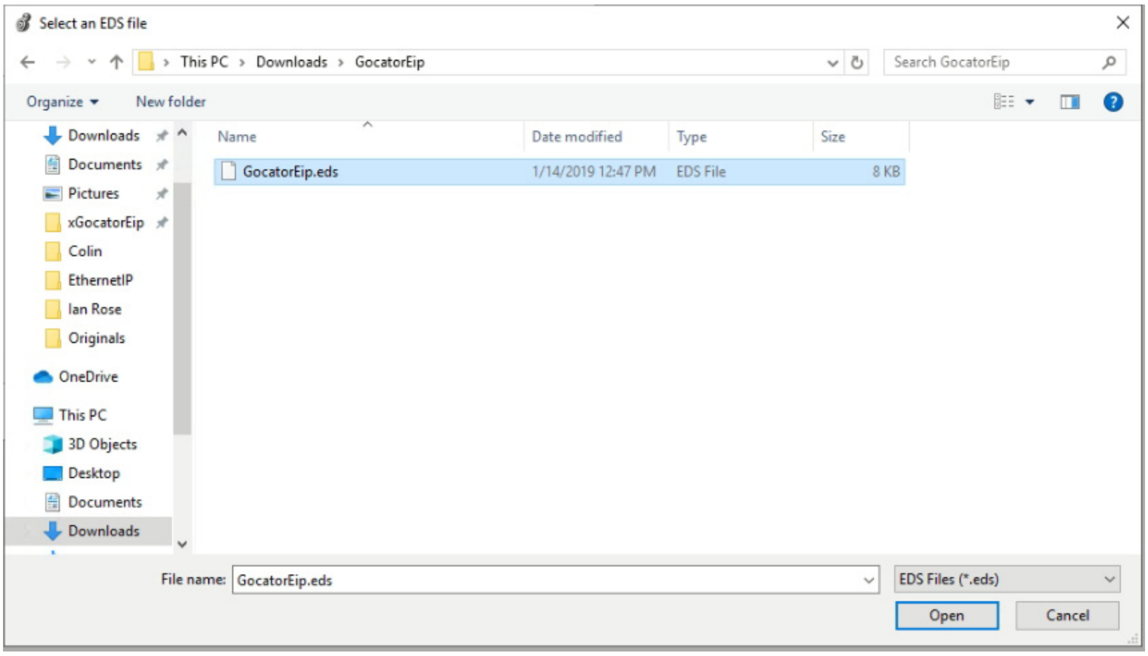
3 **In the wizard, click [Next].**

4 **Choose［Register an EDS file(s)］and click［Next］**

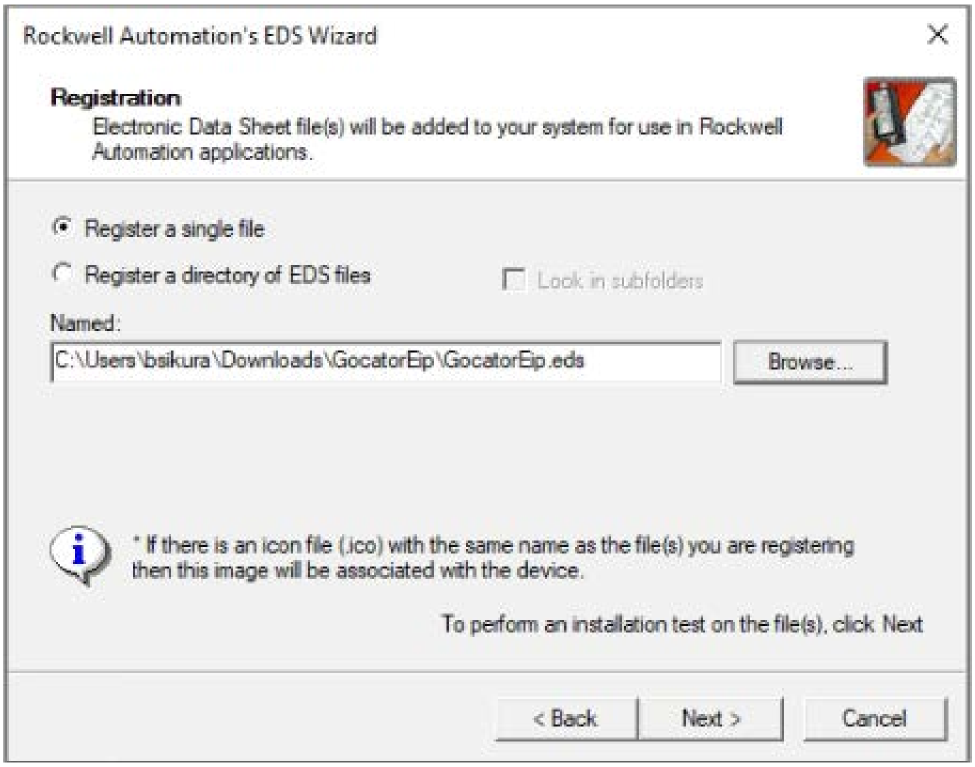
5 **Choose［Register a single file］and then click［Browse］.**



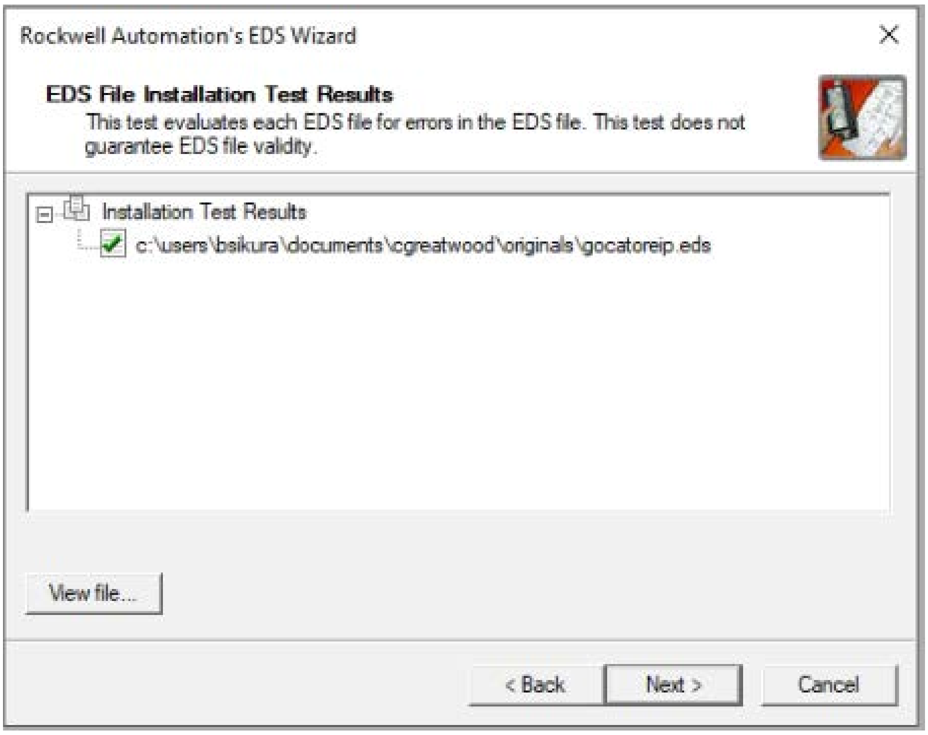
6 **Navigate to the unzipped .eds file you downloaded and unzipped, select it, and click [Open].**



7 **Click [Next].**



8 **If your EDS file has no errors or conflicts (a green checkmark is displayed next to the .eds file), click [Next].**

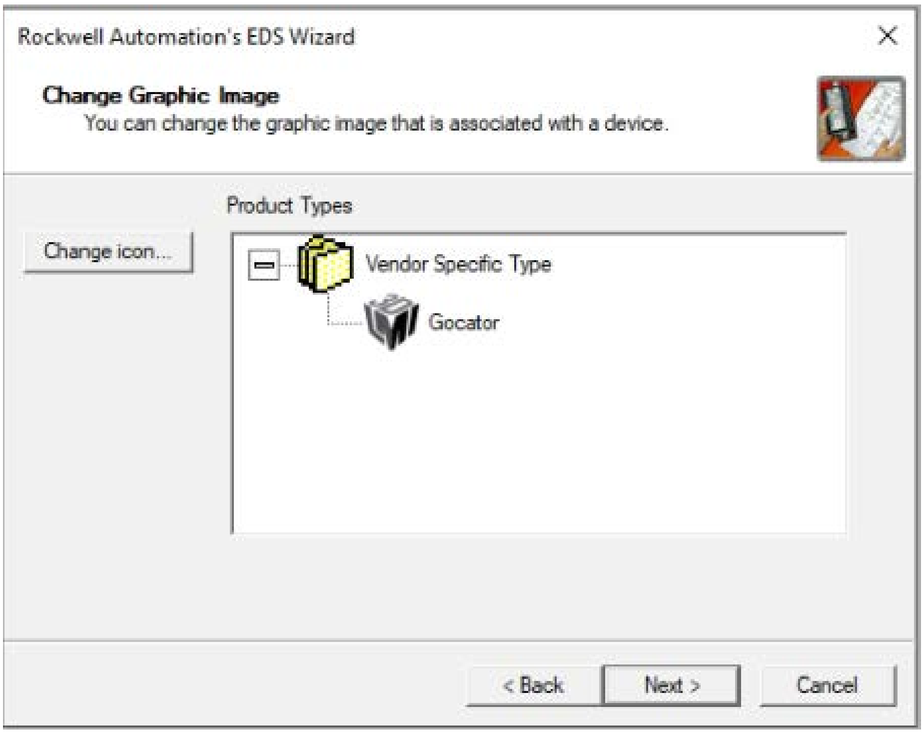


9 **Verify that the tool automatically selects the Mitutoyo logo from the unzipped folder.**

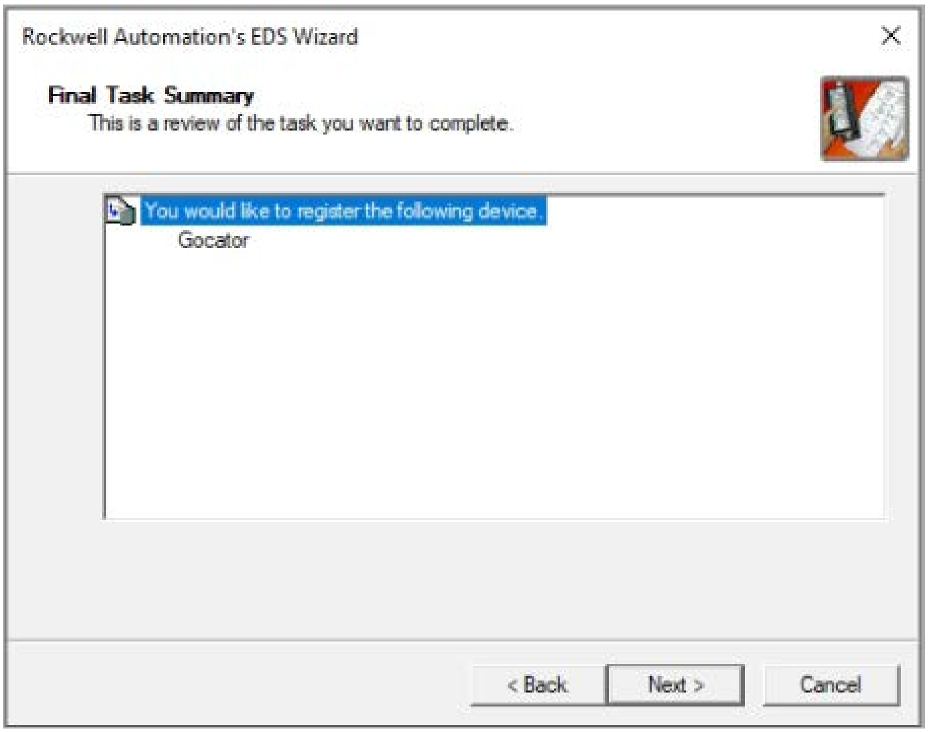
The .ico file contained in the zip folder you downloaded previously contains the logo.

10 **If the tool does not automatically select the Mitutoyo logo, navigate to the file, select it, and then click [Next].**

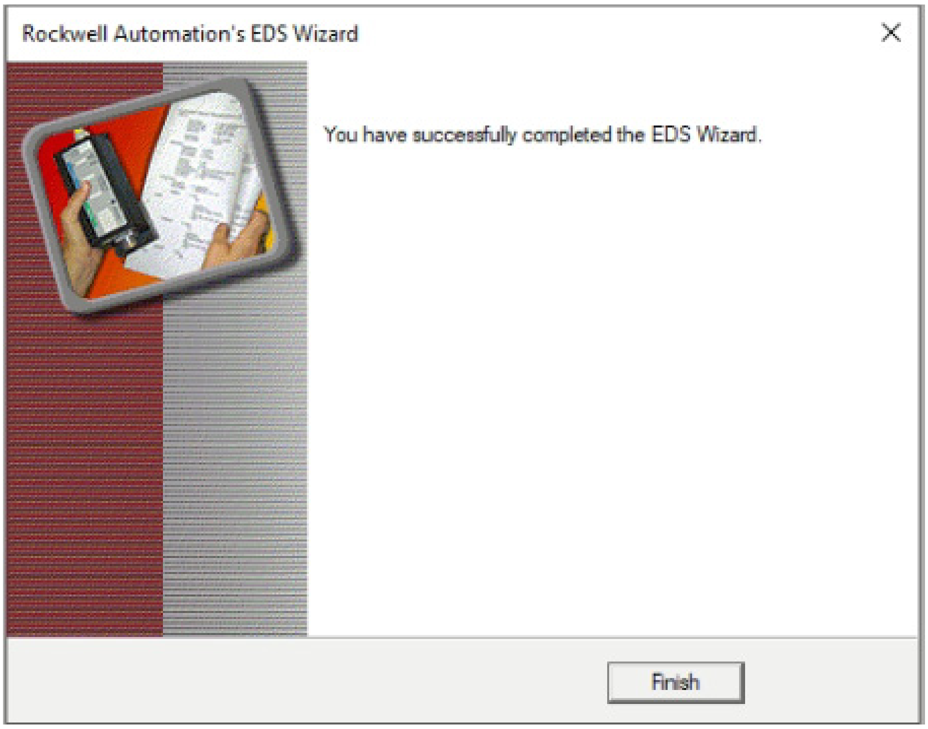
Proper icon selection is important, as this will make it easier for maintenance/future engineers to identify the sensor product from a long list of connected devices in a PLC program.



11 **Click [Next].**

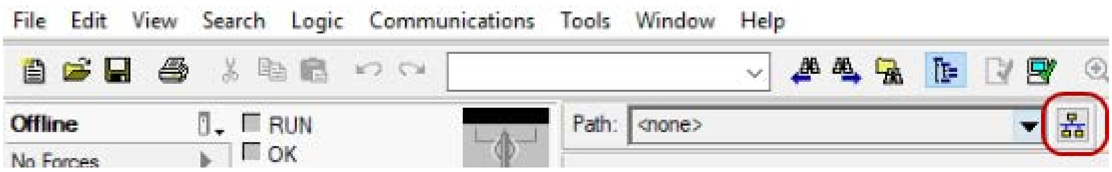


12 **Click［Finish］.**

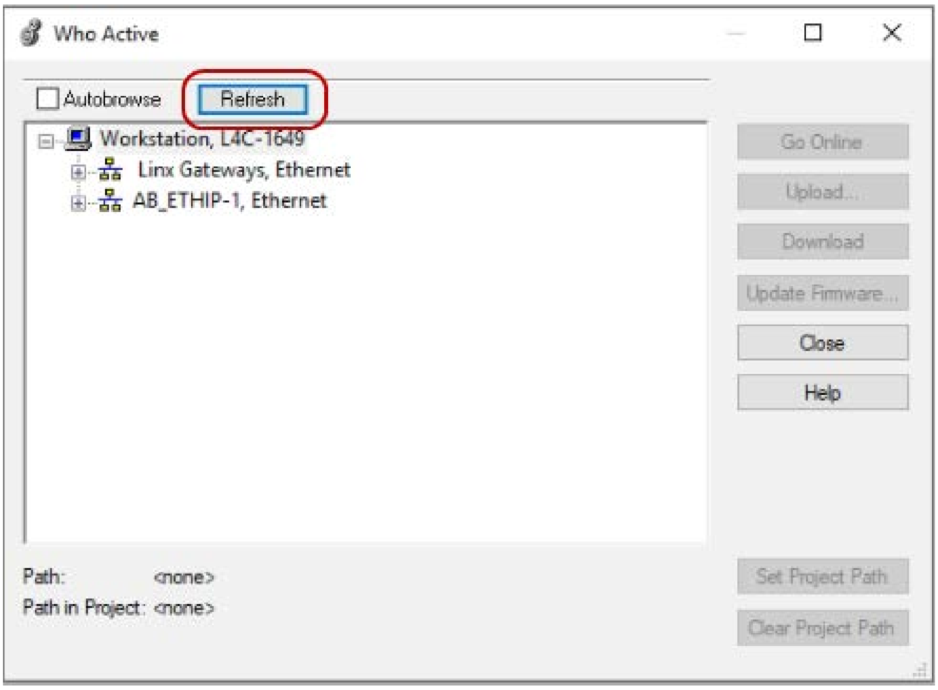


- **Add SurfaceMeasure1008S IO Device to PLC Program**

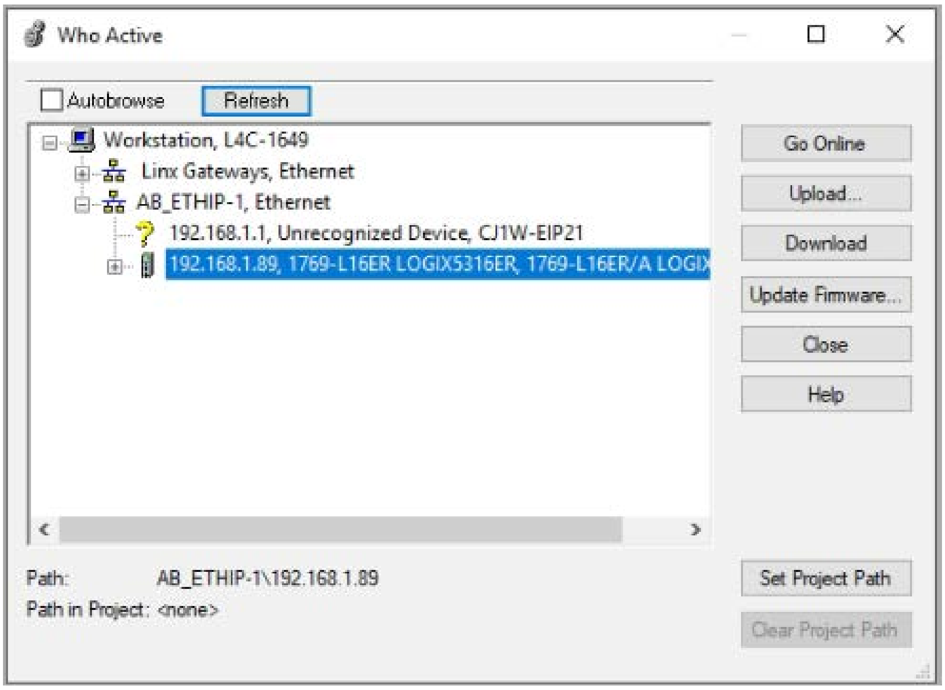
1 **Click the［Who Active］button to the right of the Path field.**



2 **Click［Refresh］in RSLinx the［Who Active］dialog to update your available devices.**



3 **In the tree structure, navigate to and select your PLC controller ethernet node.**

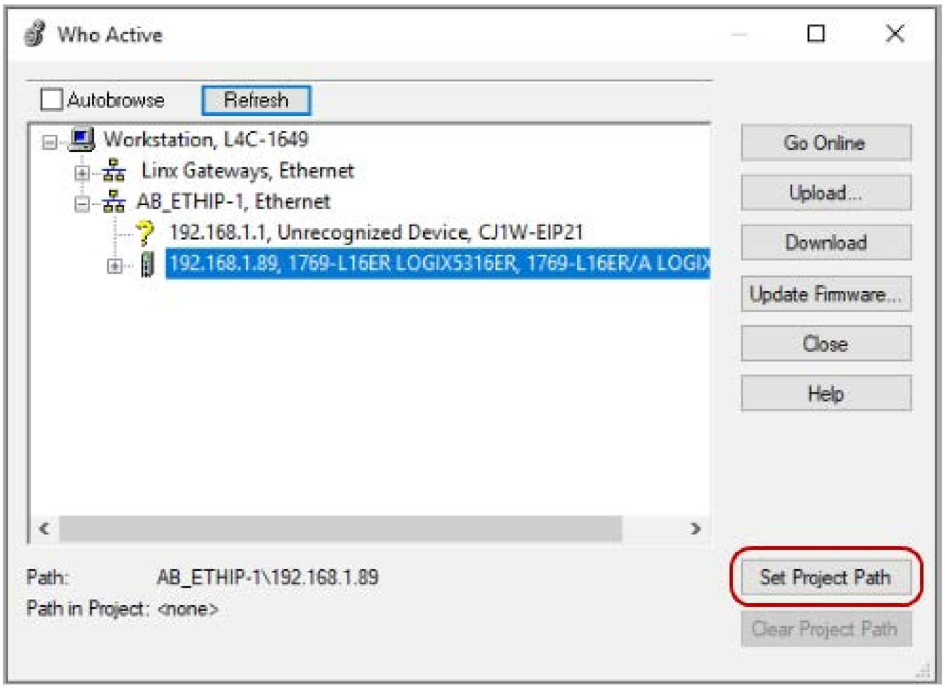


4 **If you do not see the [Go Online] option at this point, make sure that RSLinx has been started and is running in the background on your setup PC.**

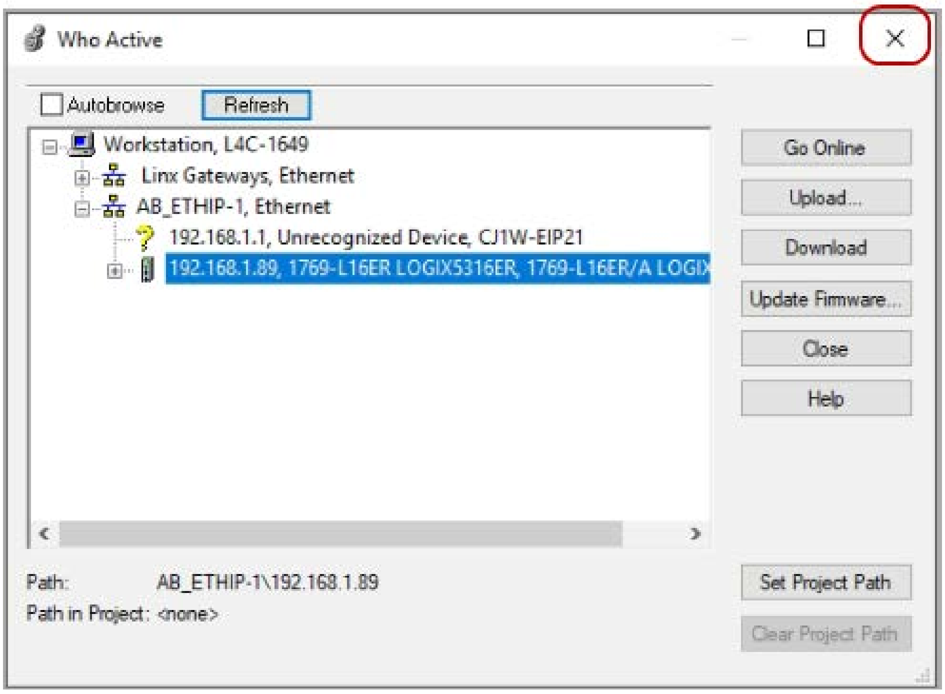
Device discovery will not complete if RSLinx is not running. Run or restart RSLinx.

5 **Click [Set Project Path].**

This will set your project path when you attempt to download to the PLC later.

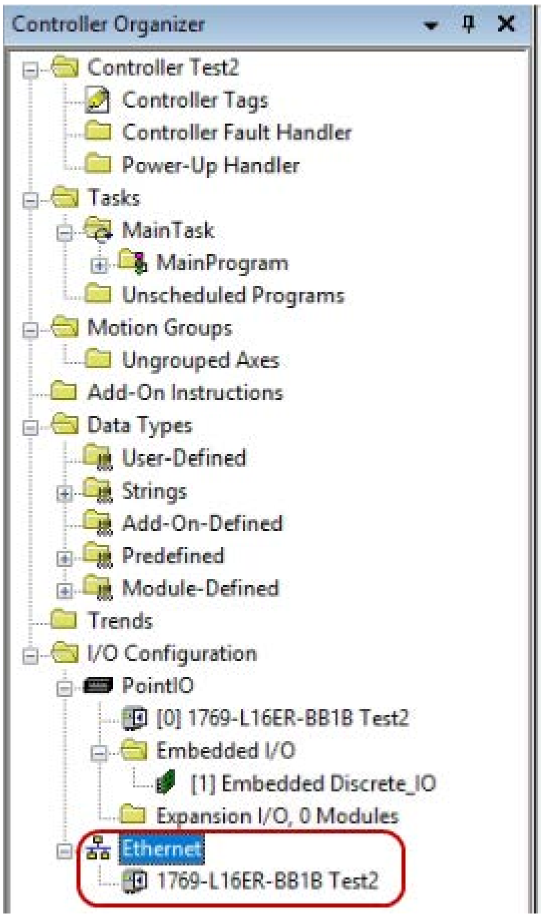


6 **Click X to exit your node setup.**

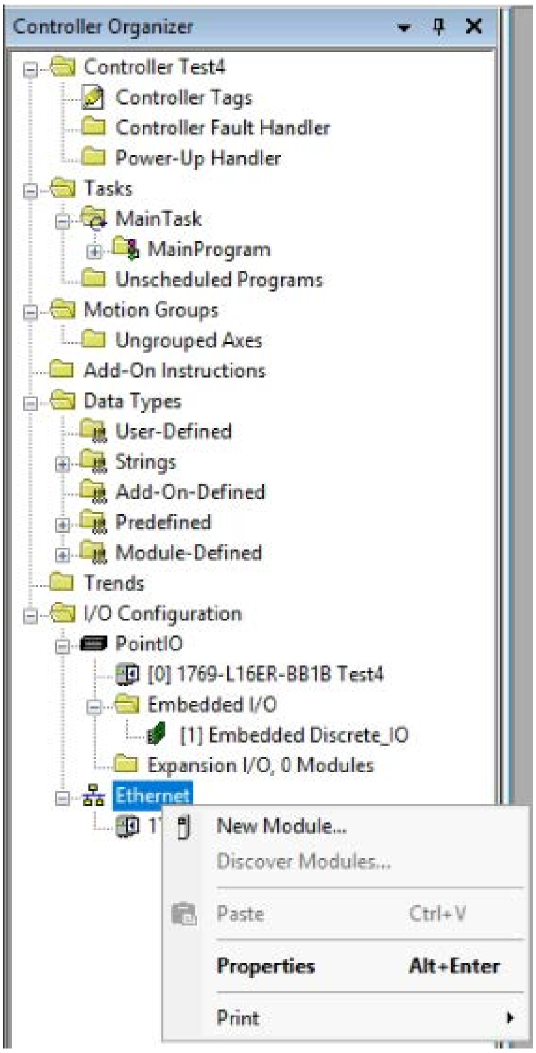


7 **In Studio 5000, verify that the path is updated to the IP address of your controller.**

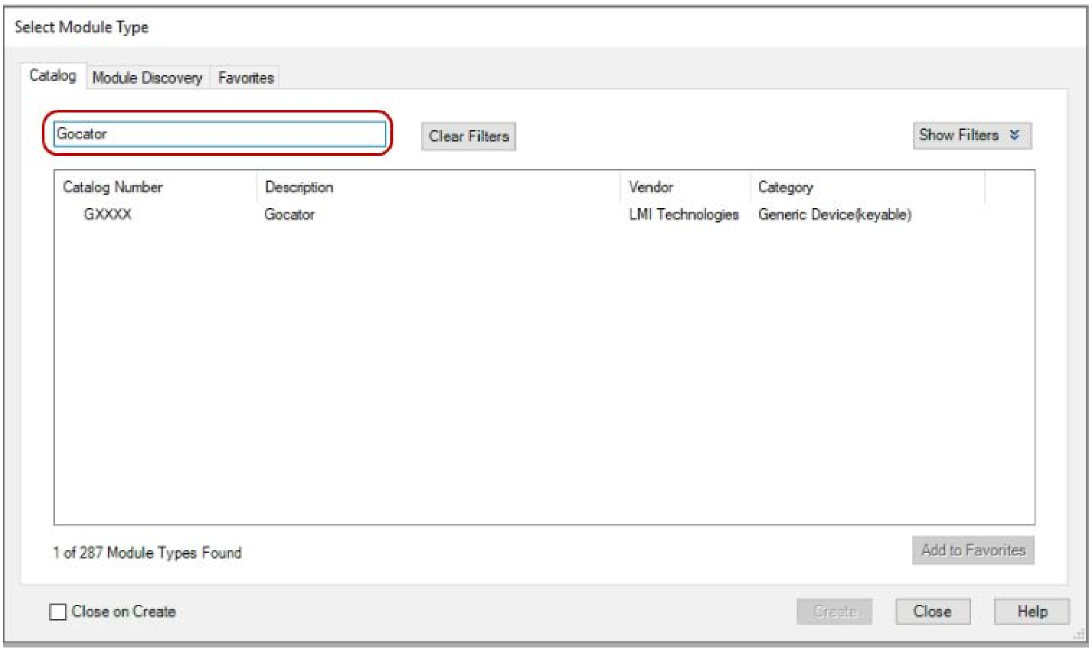
8 **In the Controller Organizer, choose［Ethernet］under the［IO Configuration］node.**



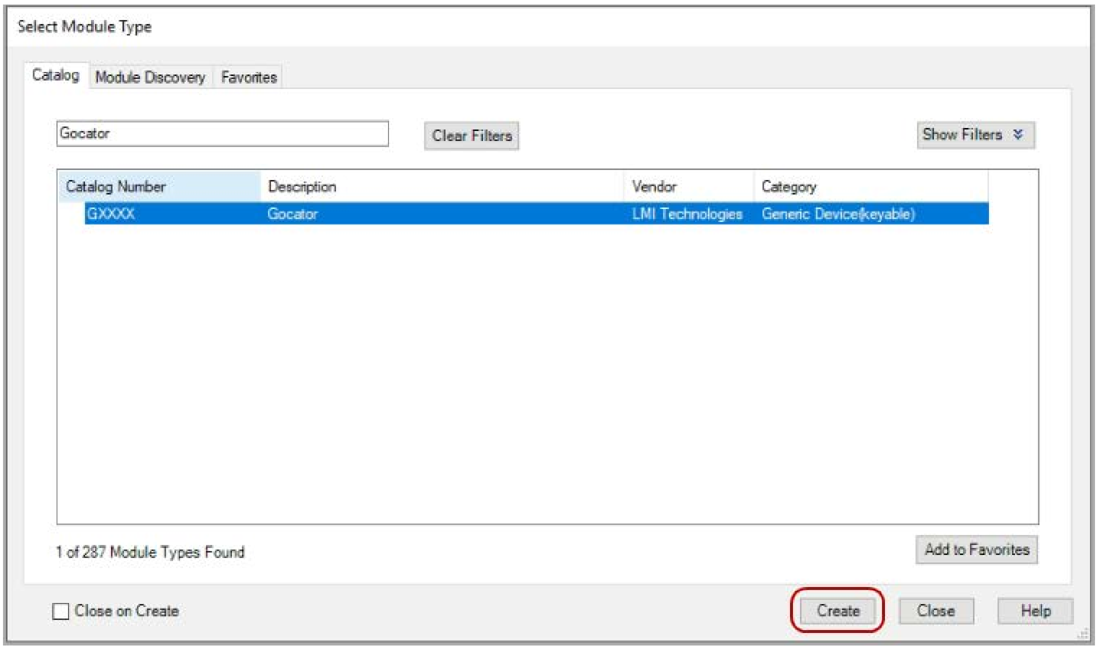
9 **Right-click the Ethernet network node and click［New Module］.**



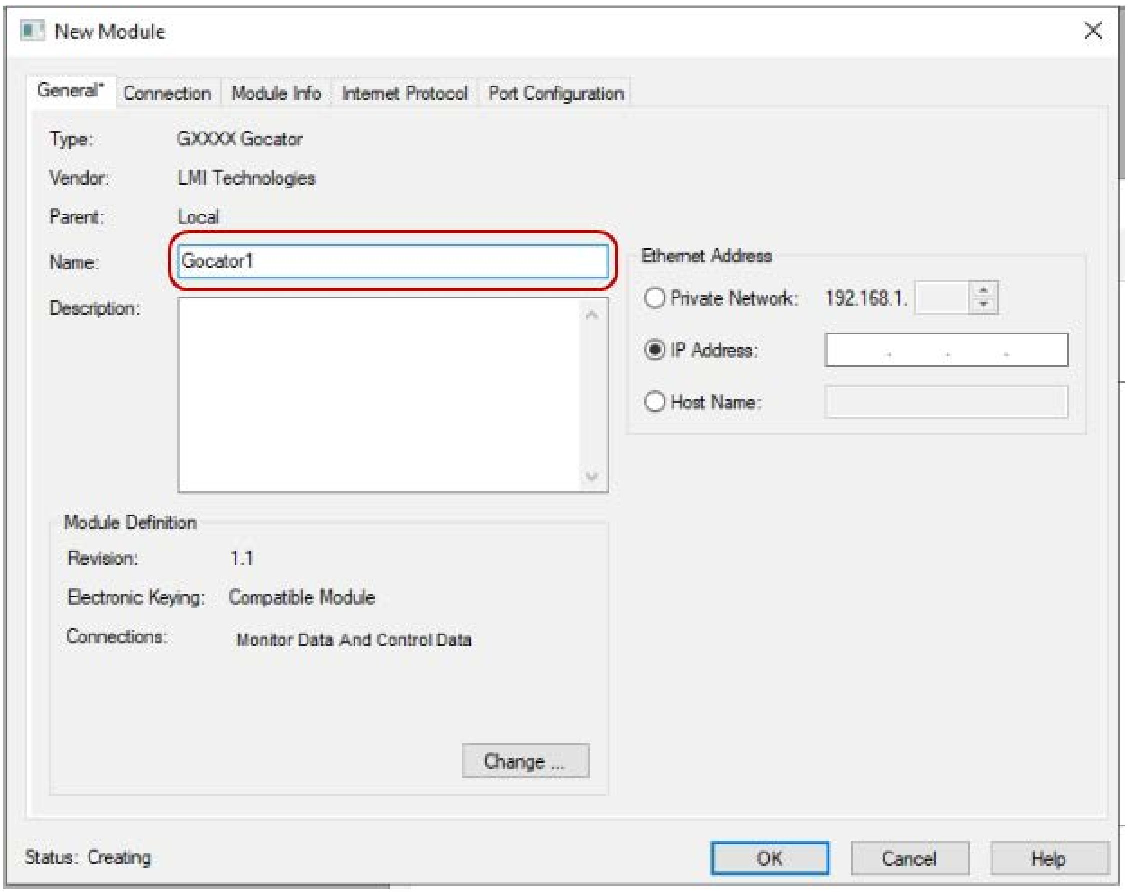
10 **Type “SurfaceMeasure1008S” into the search bar of the dialog that appears.**



11 **In the list under the search bar, select the new SurfaceMeasure1008S device file and click ［Create］.**

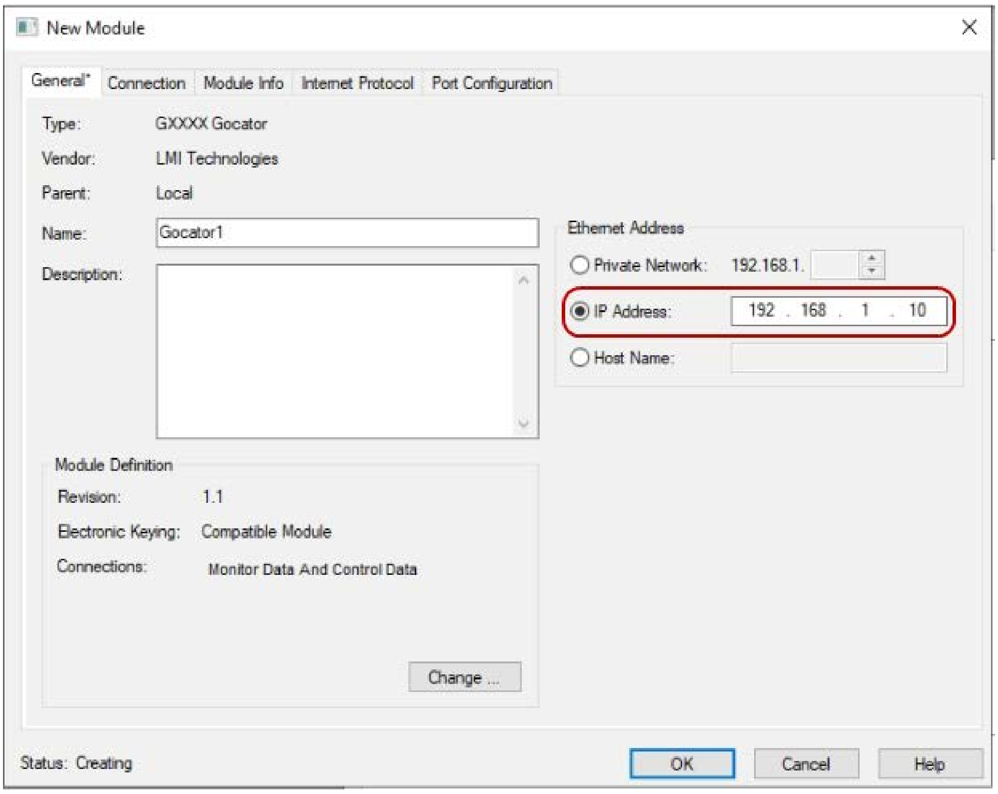


12 **In the New Module dialog, in the [Name] field, give the new IO device a unique name.**



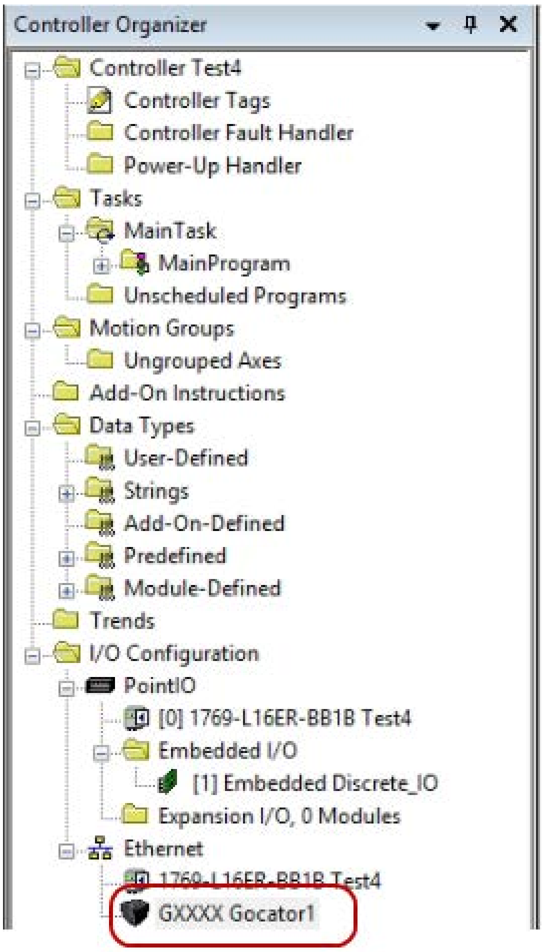
13 Type in the static IP address of the first sensor that you are trying to set up, and then click [OK].

The default IP address for all SurfaceMeasure1008S sensors from the factory is 192.168.1.10. You can verify the IP address of the sensor by logging into the web user interface in a browser or by using the kDiscovery utility available in the Utilities package available from Mitutoyo's Download Center.

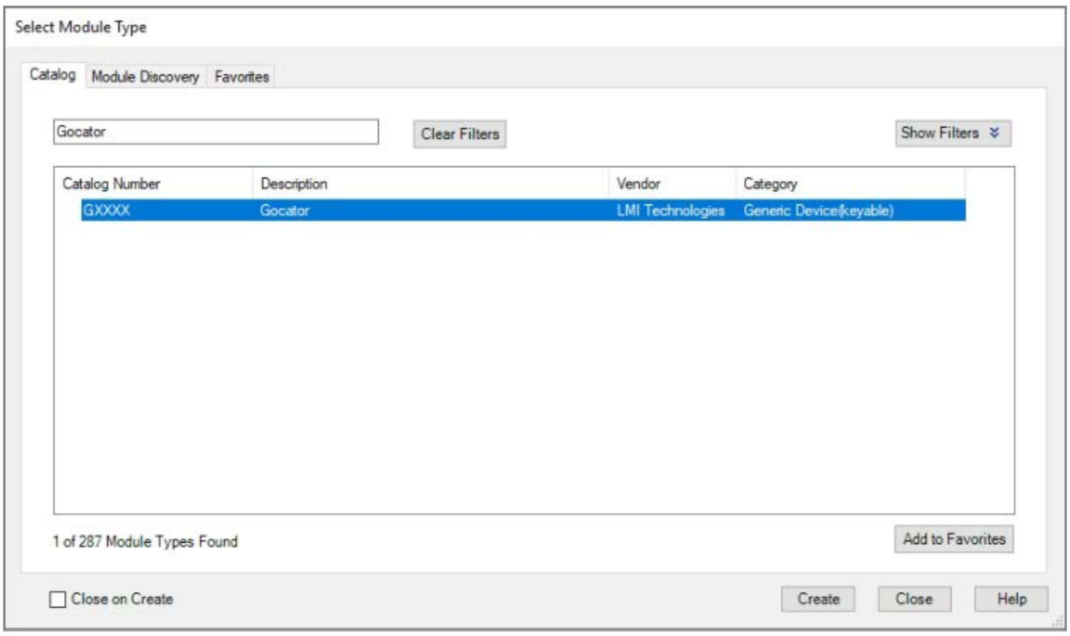


14 In your Program tree, verify that you now have a new IO device.

The naming format shown should be device devicename (i.e., GXXX SurfaceMeasure1008S_1)

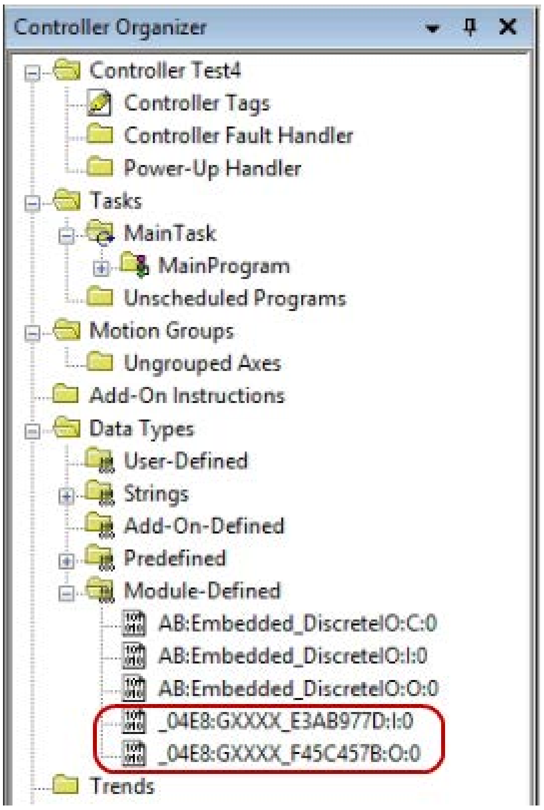


15 In the Select Module Type dialog, click [Close].



16 In the Controller Organizer, under [Data-Types], expand [Module-Defined] and verify that you have two new data blocks.

These will correspond to the Input and Output data coming from and going to the SurfaceMeasure1008S, respectively, for a Monitor Data and Control Data connection type.



When the SurfaceMeasure1008S is in Implicit Messaging mode, data will be streamed and stored in the SurfaceMeasure1008S_1:I tag when both the PLC is in Run mode and the SurfaceMeasure1008S is started. The tag address header is formatted as devicename:I and/or devicename:O for inputs and outputs, respectively.

For the data format, see 📖 "• Implicit Messaging Output Assembly" on page 831.

The EDS file now contains detailed tag descriptions as shown below that can be used directly in the PLC program.

Name	Data Type
ConnectionFaulted	BOOL
Sensor_State	SINT
Run_State	BOOL
State_Issue1	BOOL
State_Issue2	BOOL
State_Issue3	BOOL
State_Issue4	BOOL
State_Issue5	BOOL
State_Issue6	BOOL
State_Issue7	BOOL
Alignment_and_Command_State	SINT
Command_in_Progress	BOOL
Aligned	BOOL
Inputs	INT
Z_Index_Position_0	DINT
Z_Index_Position_1	DINT
Exposure	DINT
Temperature	DINT
Encoder_Position_0	DINT
Encoder_Position_1	DINT
Time_0	DINT
Time_1	DINT
Frame_0	DINT
Frame_1	DINT
Decision0	SINT
Decision1	SINT
Decision2	SINT
Decision3	SINT
Decision4	SINT
Decision5	SINT
Decision6	SINT
Decision7	SINT
Decision8	SINT
Decision9	SINT
Decision10	SINT
Decision11	SINT
Decision12	SINT
Decision13	SINT

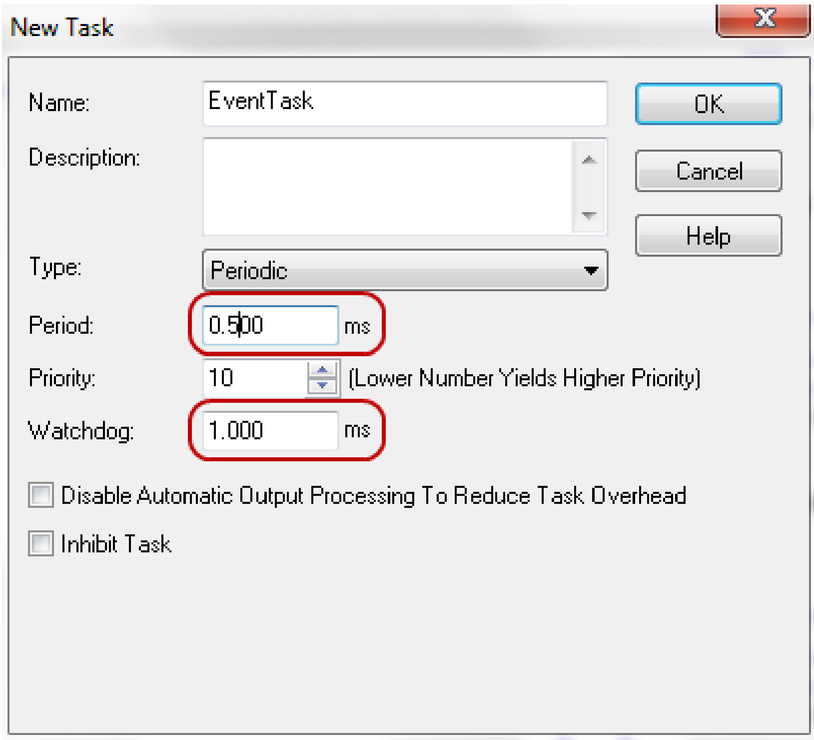
Name	Data Type
Decision14	SINT
Decision15	SINT
Decision16	SINT
Decision17	SINT
Decision18	SINT
Decision19	SINT
Decision20	SINT
Decision21	SINT
Decision22	SINT
Decision23	SINT
Decision24	SINT
Decision25	SINT
Decision26	SINT
Decision27	SINT
Decision28	SINT
Decision29	SINT
Decision30	SINT
Decision31	SINT
Decision32	SINT
Decision33	SINT
Decision34	SINT
Decision35	SINT
Decision36	SINT
Decision37	SINT
Decision38	SINT
Decision39	SINT
Decision40	SINT
Decision41	SINT
Decision42	SINT
Decision43	SINT
Decision44	SINT
Decision45	SINT
Decision46	SINT
Decision47	SINT
Decision48	SINT
Decision49	SINT
Decision50	SINT
Decision51	SINT

Name	Data Type
Decision52	SINT
Decision53	SINT
Decision54	SINT
Decision55	SINT
Decision56	SINT
Decision57	SINT
Decision58	SINT
Decision59	SINT
Decision60	SINT
Decision61	SINT
Decision62	SINT
Decision63	SINT
Measurement0	DINT
Measurement1	DINT
Measurement2	DINT
Measurement3	DINT
Measurement4	DINT
Measurement5	DINT
Measurement6	DINT
Measurement7	DINT
Measurement8	DINT
Measurement9	DINT
Measurement10	DINT
Measurement11	DINT
Measurement12	DINT
Measurement13	DINT
Measurement14	DINT
Measurement15	DINT
Measurement16	DINT
Measurement17	DINT
Measurement18	DINT
Measurement19	DINT
Measurement20	DINT
Measurement21	DINT
Measurement22	DINT
Measurement23	DINT
Measurement24	DINT
Measurement25	DINT

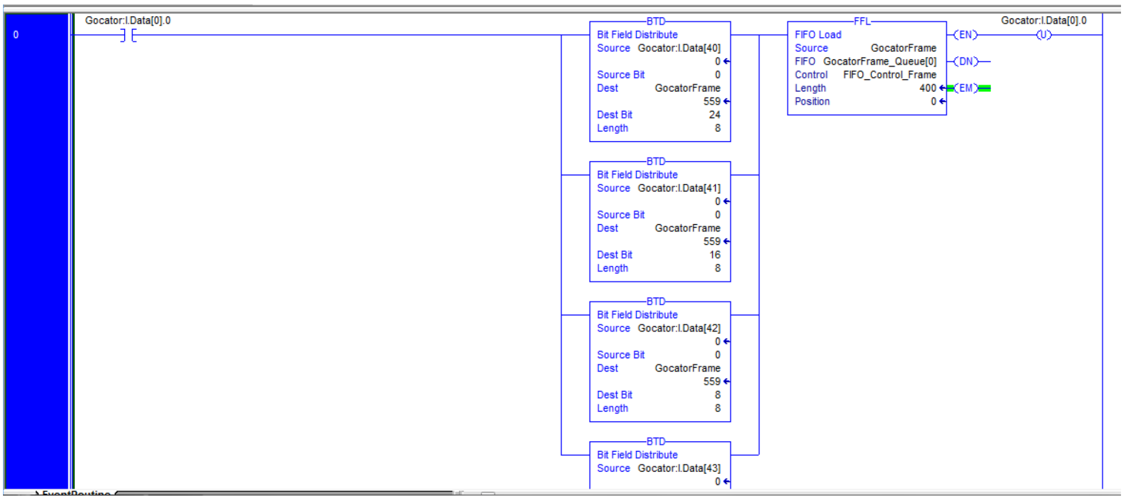
Name	Data Type
Measurement26	DINT
Measurement27	DINT
Measurement28	DINT
Measurement29	DINT
Measurement30	DINT
Measurement31	DINT
Measurement32	DINT
Measurement33	DINT
Measurement34	DINT
Measurement35	DINT
Measurement36	DINT
Measurement37	DINT
Measurement38	DINT
Measurement39	DINT
Measurement40	DINT
Measurement41	DINT
Measurement42	DINT
Measurement43	DINT
Measurement44	DINT
Measurement45	DINT
Measurement46	DINT
Measurement47	DINT
Measurement48	DINT
Measurement49	DINT
Measurement50	DINT
Measurement51	DINT
Measurement52	DINT
Measurement53	DINT
Measurement54	DINT
Measurement55	DINT
Measurement56	DINT
Measurement57	DINT
Measurement58	DINT
Measurement59	DINT
Measurement60	DINT
Measurement61	DINT
Measurement62	DINT
Measurement63	DINT

17 If you set the sensor to use change of state earlier ([Trigger Override] is set to [Force Change of State] in the Output panel), perform the following additional steps.

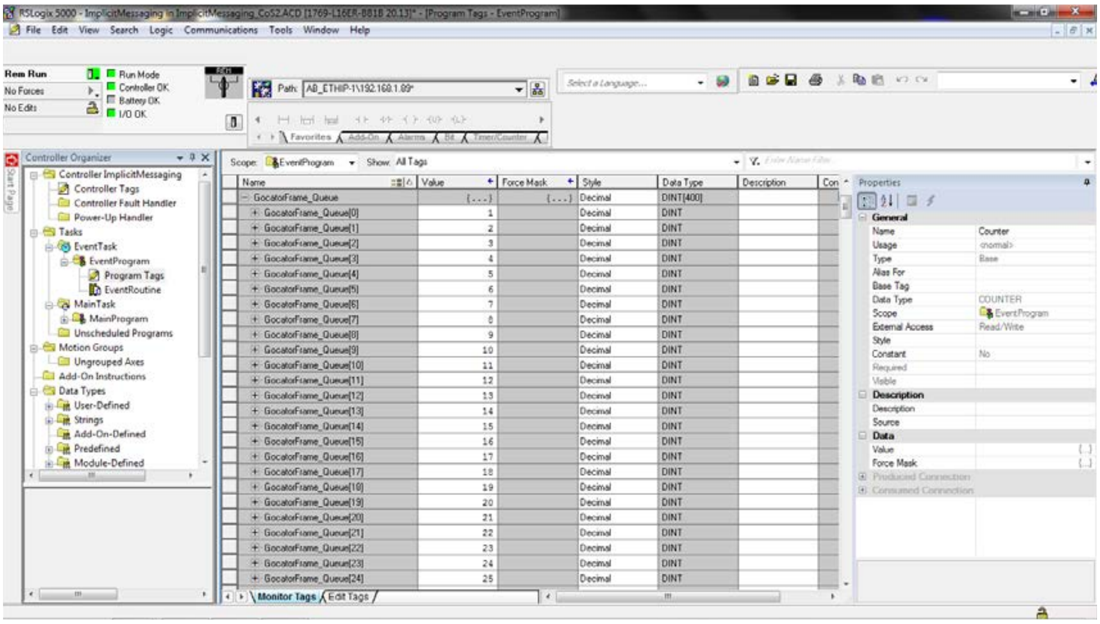
1 In the RSLogix 5000 programming tool, create a new task with a 0.5 millisecond period and a 1.0 millisecond watchdog, and then click [OK] at the upper right.
A major fault alarm is triggered if the task does not finish execution within the watchdog time limit.



» Ladder logic is written to monitor the SurfaceMeasure1008S's running state and store data into a FIFO (Ladder Element FFL) array of the same data type.



2 Confirm that frames are properly stored in the stored array, without any repetition or dropped frames. In this case, the SurfaceMeasure1008S frame count is stored in a user-defined array.



- Using the Implicit Messaging SurfaceMeasure1008S Command Assembly

The Output Message format (from PLC to SurfaceMeasure1008S) is used to control the sensor through implicit messaging. This message is sent continuously from the PLC to the SurfaceMeasure1008S at the user-requested Request Packet Interval (RPI) on the PLC side. The default SurfaceMeasure1008S RPI is 10ms.

In PLC programming, the standard practice is to use bits instead of sending a value representing that command, for example, start/stop bits. When using values, the PLC needs to add more code to convert it to bits and vice versa.

Since the SurfaceMeasure1008S does not allow parallel commands, a priority scheme is needed to handle multiple command bits being set at the same time. Only the bit with the highest priority will be accepted as the command.

The total command message size is 32 bytes.

For information on the command assembly structure, see "• Implicit Messaging Command Assembly" on page 830.

It's important to understand that because the SurfaceMeasure1008S is driven internally by its own clock, and because users can configure the SurfaceMeasure1008S for any frame rate—independently of the RPI request configured on the PLC—Cyclic implicit messaging can cause unnecessary data loss if the two clocks are not synchronized. Using Change of State implicit messaging instead can overcome this issue. For instructions on how to set up Change of State implicit messaging, see [Setting Up Change of State Implicit Messaging](#).

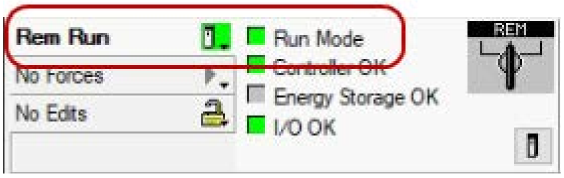
The data block used to send control messages to the SurfaceMeasure1008S should have been set properly up in Setting Up Implicit Messaging on the PLC on page 917. It will appear in the SurfaceMeasure1008S Module-Defined data types as shown below:

Name	Data Type
Command	SINT
Reserved_or_Job_File1	SINT
Reserved_or_Job_File2	SINT
Reserved_or_Job_File3	SINT
Reserved_or_Job_File4	SINT
Reserved_or_Job_File5	SINT
Reserved_or_Job_File6	SINT
Reserved_or_Job_File7	SINT
Reserved_or_Job_File8	SINT
Reserved_or_Job_File9	SINT
Reserved_or_Job_File10	SINT
Reserved_or_Job_File11	SINT
Reserved_or_Job_File12	SINT
Reserved_or_Job_File13	SINT
Reserved_or_Job_File14	SINT
Reserved_or_Job_File15	SINT
Reserved_or_Job_File16	SINT
Reserved_or_Job_File17	SINT
Reserved_or_Job_File18	SINT
Reserved_or_Job_File19	SINT
Reserved_or_Job_File20	SINT
Reserved_or_Job_File21	SINT
Reserved_or_Job_File22	SINT
Reserved_or_Job_File23	SINT
Reserved_or_Job_File24	SINT
Reserved_or_Job_File25	SINT
Reserved_or_Job_File26	SINT
Reserved_or_Job_File27	SINT
Reserved_or_Job_File28	SINT
Reserved_or_Job_File29	SINT
Reserved_or_Job_File30	SINT
Reserved_or_Job_File31	SINT

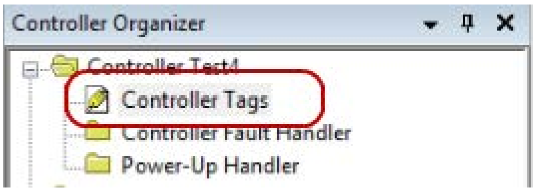
- **Starting a Sensor**

  To start a sensor, do the following:

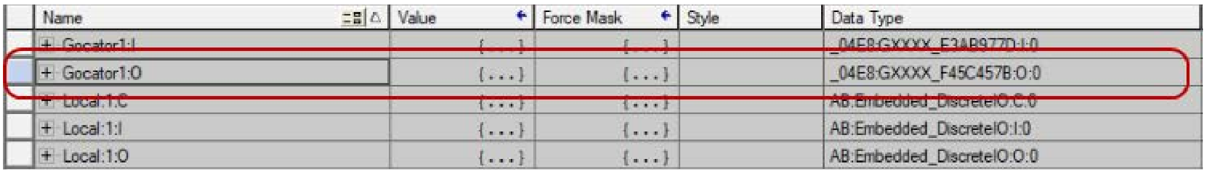
1 **Make sure that you have downloaded your PLC program to the controller and that your controller is in Run mode.**



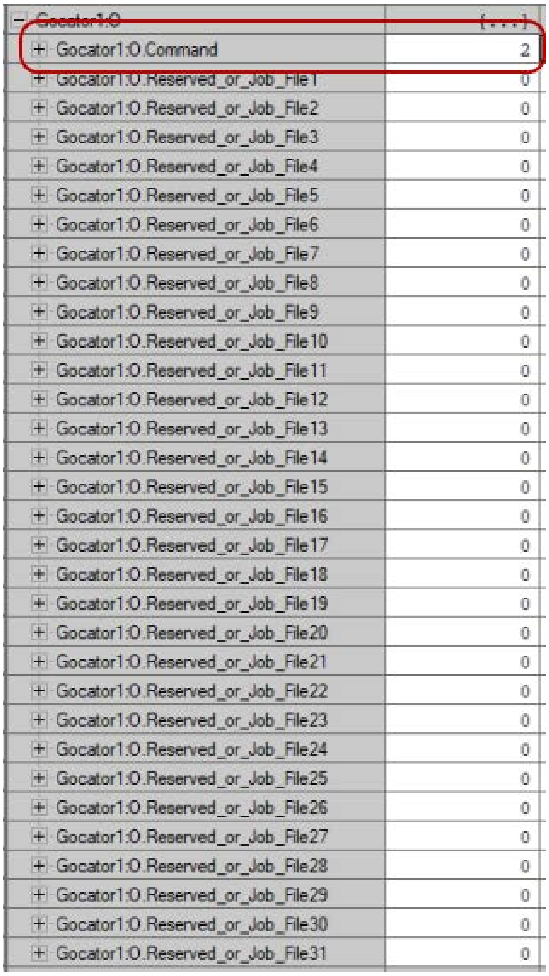
2 **In the Controller Organizer, double-click［Controller Tags］to show them in the main screen**



3 **Click your Output data block to expand**



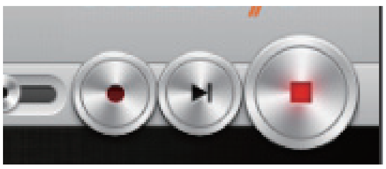
4 **Write the integer value 2 to the first byte named [Command].**



5 **Go to a web browser and type in the sensor IP address to the URL bar. This should load the web GUI**

6 **Verify that the sensor started.**

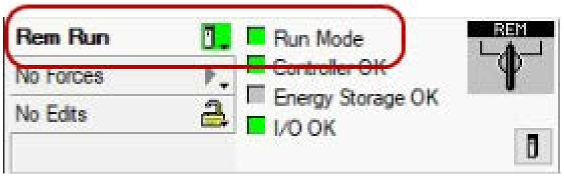
If the Run button is a red square, then the sensor was successfully started.



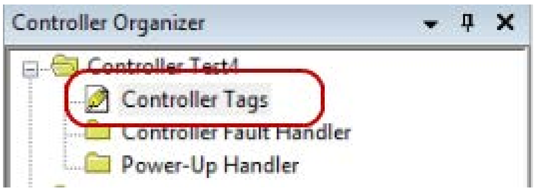
This process can be repeated to stop the sensor, clear alignment, start moving alignment, start stationary alignment, or issue a software trigger by typing the proper integer value into the Command byte of the Output assembly. For additional commands and control options, "• Implicit Messaging Command Assembly" on page 830, or refer to the provided sample Studio 5000 job file.

- **Loading a Sensor Job File**

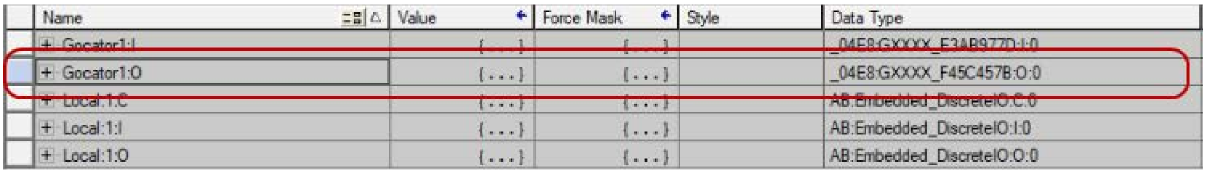
1 **Make sure that you have downloaded your PLC program to the controller and that your controller is in Run mode.**



2 **Double click［Controller Tags］to show them in the main screen**



3 **Click your Output data block to expand**



4 **If 1.job is the name of the job file to be loaded on the sensor and it is not currently running, type each of the five characters making up the filename into the first five characters of the Reserved bytes of the Command assembly.**

The ASCII character inputs here are case sensitive and the extension, .job, must be included. All non-jobname characters must be null or empty values. Changing the display option from Decimal (which is the default) to ASCII can make this easier.

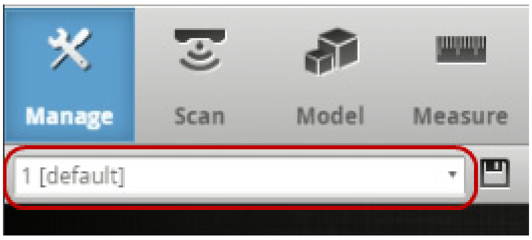
Gocator:O	{...}	{...}	
Gocator:O.Command	0		Decimal
Gocator:O.Reserved_or_Job_File1	'1'		ASCII
Gocator:O.Reserved_or_Job_File2	'.'		ASCII
Gocator:O.Reserved_or_Job_File3	'j'		ASCII
Gocator:O.Reserved_or_Job_File4	'o'		ASCII
Gocator:O.Reserved_or_Job_File5	'b'		ASCII
Gocator:O.Reserved_or_Job_File6	'$00'		ASCII
Gocator:O.Reserved_or_Job_File7	'$00'		ASCII
Gocator:O.Reserved_or_Job_File8	'$00'		ASCII
Gocator:O.Reserved_or_Job_File9	'$00'		ASCII
Gocator:O.Reserved_or_Job_File10	'$00'		ASCII
Gocator:O.Reserved_or_Job_File11	'$00'		ASCII
Gocator:O.Reserved_or_Job_File12	'$00'		ASCII
Gocator:O.Reserved_or_Job_File13	'$00'		ASCII
Gocator:O.Reserved_or_Job_File14	'$00'		ASCII
Gocator:O.Reserved_or_Job_File15	'$00'		ASCII
Gocator:O.Reserved_or_Job_File16	'$00'		ASCII
Gocator:O.Reserved_or_Job_File17	'$00'		ASCII
Gocator:O.Reserved_or_Job_File18	'$00'		ASCII
Gocator:O.Reserved_or_Job_File19	'$00'		ASCII
Gocator:O.Reserved_or_Job_File20	'$00'		ASCII
Gocator:O.Reserved_or_Job_File21	'$00'		ASCII
Gocator:O.Reserved_or_Job_File22	'$00'		ASCII
Gocator:O.Reserved_or_Job_File23	'$00'		ASCII
Gocator:O.Reserved_or_Job_File24	'$00'		ASCII
Gocator:O.Reserved_or_Job_File25	'$00'		ASCII
Gocator:O.Reserved_or_Job_File26	'$00'		ASCII
Gocator:O.Reserved_or_Job_File27	'$00'		ASCII
Gocator:O.Reserved_or_Job_File28	'$00'		ASCII
Gocator:O.Reserved_or_Job_File29	'$00'		ASCII
Gocator:O.Reserved_or_Job_File30	'$00'		ASCII
Gocator:O.Reserved_or_Job_File31	'$00'		ASCII

5 **Then type the integer value 64 into the [Command] byte to transmit the job name for loading.**

Gocator:O	{...}	{...}	
Gocator:O.Command	64		Decimal
Gocator:O.Reserved_or_Job_File1	'1'		ASCII
Gocator:O.Reserved_or_Job_File2	'.'		ASCII
Gocator:O.Reserved_or_Job_File3	'j'		ASCII
Gocator:O.Reserved_or_Job_File4	'o'		ASCII
Gocator:O.Reserved_or_Job_File5	'b'		ASCII
Gocator:O.Reserved_or_Job_File6	'$00'		ASCII
Gocator:O.Reserved_or_Job_File7	'$00'		ASCII

6 **Go to a web browser and type in the sensor IP address to the URL bar**

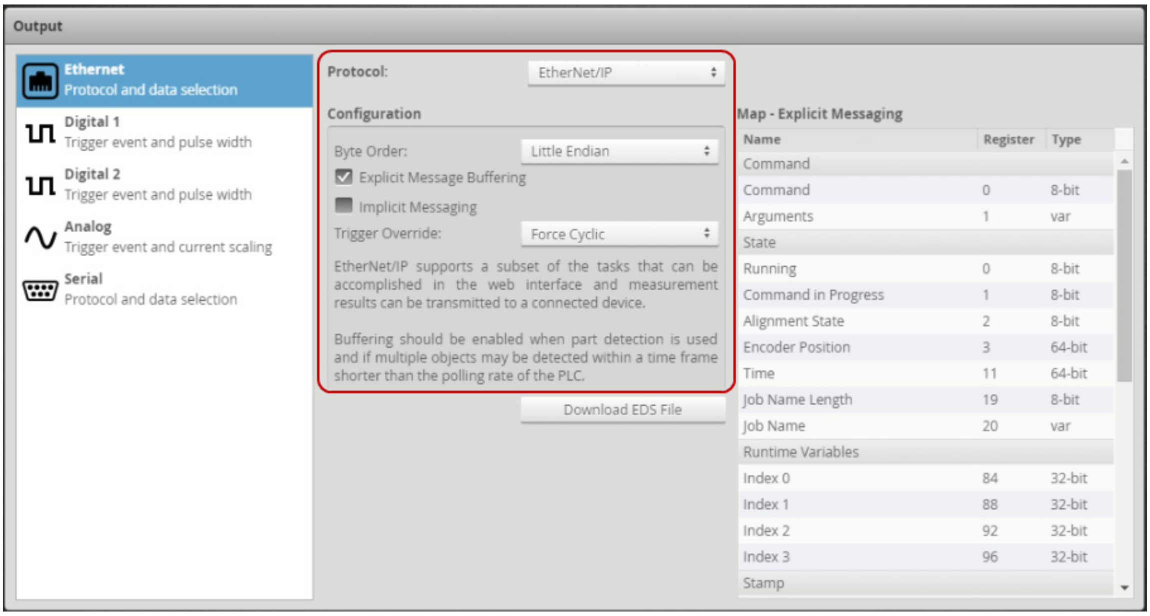
7 **Once the web GUI loads, verify that the job was loaded on the SurfaceMeasure1008S by looking at the job name box**



This process can be repeated to load runtime variables by typing the proper integer value into the Command byte of the Output assembly after preloading the runtime variable values into four successive bytes starting at byte 4 of the Reserved bytes. For additional commands and control options, 📖 "• Implicit Messaging Command Assembly" on page 830, or refer to the Mitutoyo web site.

● Setting Up Explicit Messaging on the SurfaceMeasure1008S

To output in EtherNet/IP explicit messaging mode on the sensor, you configure the sensor using the ［Protocol］ setting and the ［Configuration］ area on the ［Output］ page.



To configure the sensor for EtherNet/IP explicit messaging mode:

1 **On the ［Output］ page, in the ［Ethernet］ category, choose ［EtherNet/IP］ as the protocol.**

2 **Choose ［Little Endian］ from the ［Byte Order］ dropdown box.**

3 **Check the ［Explicit Message Buffering］ option.**

4 **Make sure that ［Implicit Messaging］ is unchecked.**

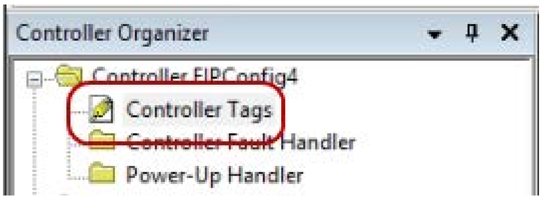
● Reading Single Attribute on the PLC (Explicit Messaging)

This section shows how to read the serial number from a SurfaceMeasure1008S sensor, that is, attribute 6. (For more on the Identity Object, see 📖 "●Identity Object (Class 0x01)" on page 824.)

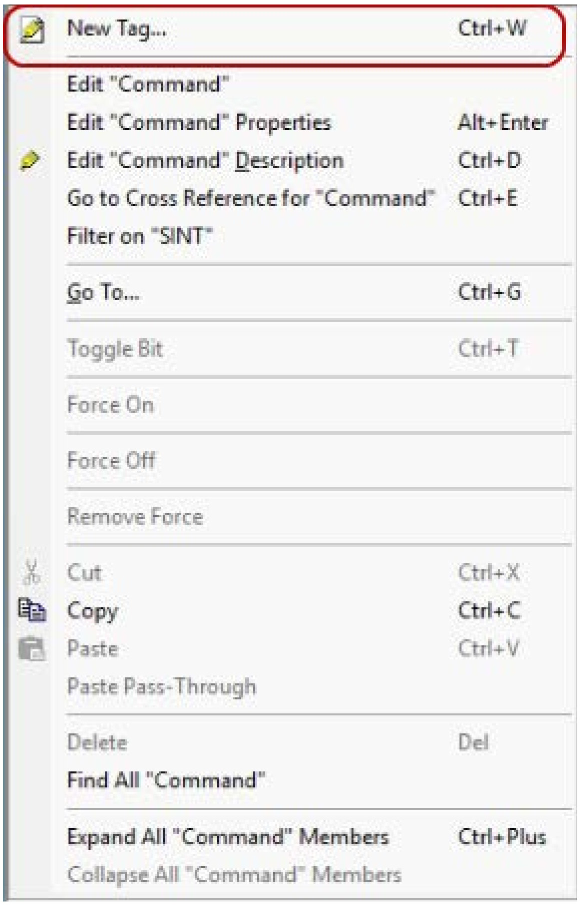
Before attempting to control and run the SurfaceMeasure1008S from the PLC, you should always verify the connection first by reading an attribute from the Identity Object, for example the sensor's serial number. Mitutoyo recommends following the steps described in this section before trying to control the sensor.

To read the sensor's serial number:

1 In Studio 5000, in the Controller Organizer, expand［Controller Tags］by double-clicking it.

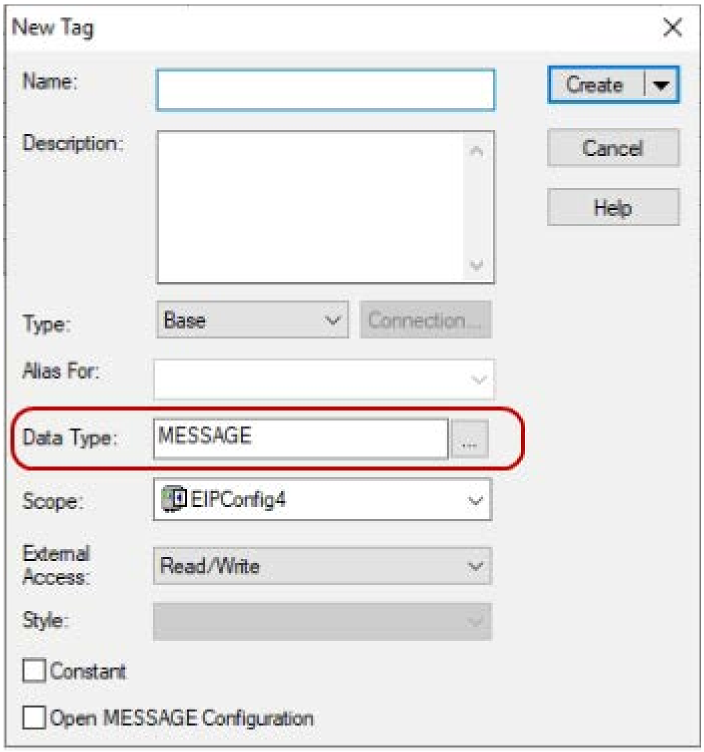


2 Right-click in the middle of the screen and choose［New Tag］from the context menu.

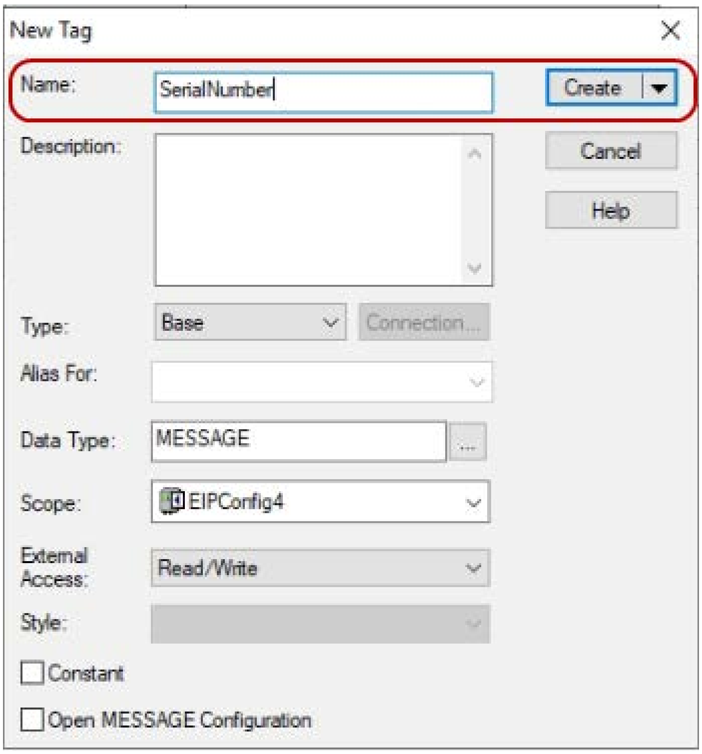


3 In the New Tag dialog, change the data type to MESSAGE.

This creates a block to store parameters for requesting data from the SurfaceMeasure1008S.



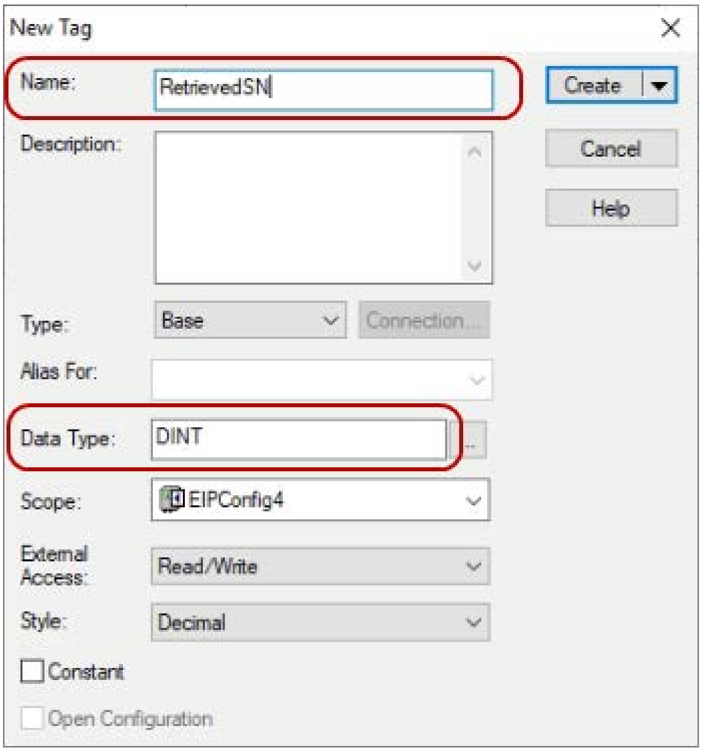
4 Name the tag and click［Create］to the right.



5 Right-click in the middle of the screen again and choose［New Tag］from the context menu.

6 Change the data type to DINT and name the tag.

This will create a tag to store the serial number in. The type must match the data type of the attribute you want to get. To determine the type of the attribute, see 📖 "●Identity Object (Class 0x01)" on page 824.

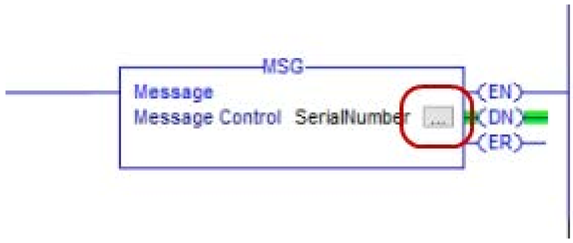


7 **In the ladder, navigate to the Input/Output function blocks and click MSG to add a Message function block.**

You may need to add a new rung to allow this.

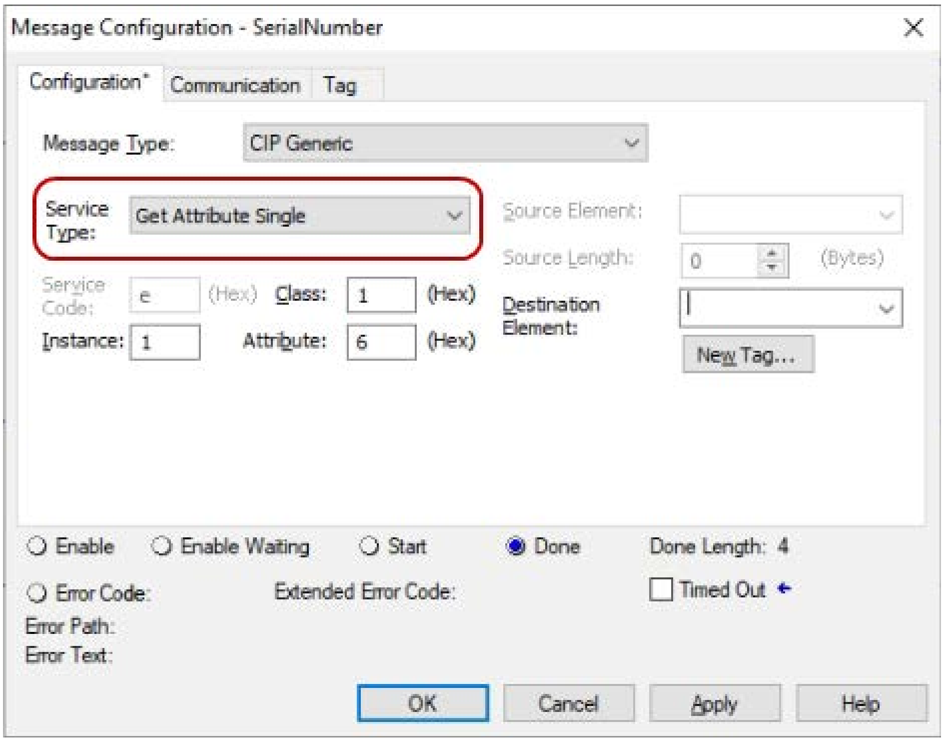
8 **Once the new MSG function block has been added, click the tag dropdown and select the MSG tag you created earlier.**

9 **Click the grey box to open the Configuration Dialog box.**



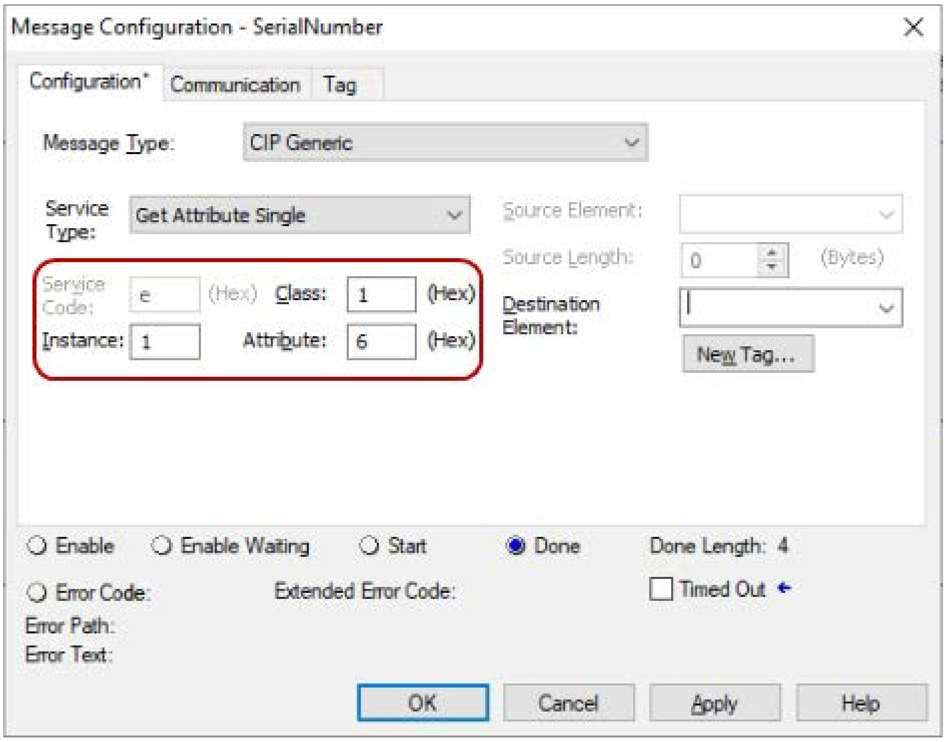
10 **Choose the［Get Attribute Single］function from the［Service Type］dropdown.**

This will auto-populate the Service Code hex character.

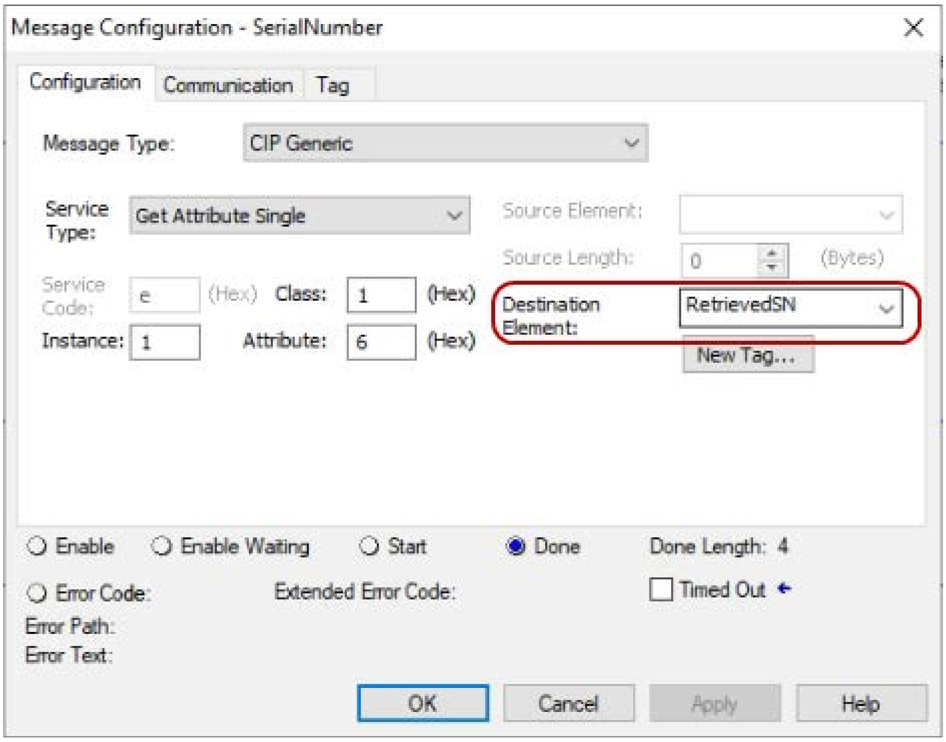


11 Type 1 in [Class], 1 in [Instance], and 6 in [Attribute].

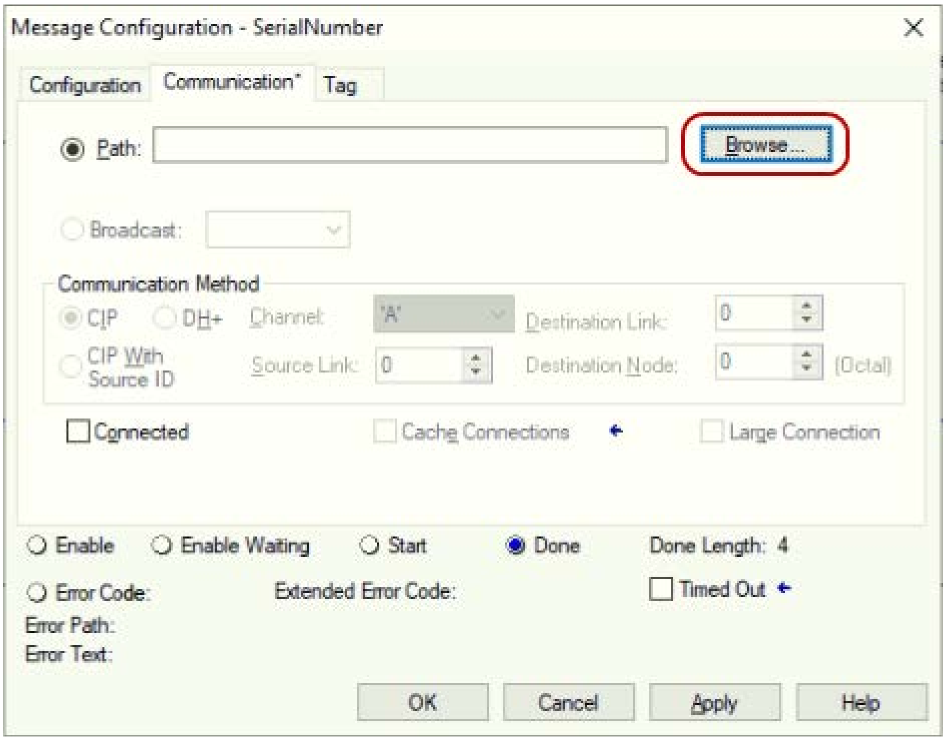
These settings indicate that the sensor's serial number will be retrieved.



12 Choose the DINT tag you created to store the serial number from the [Destination Element]dropdown.

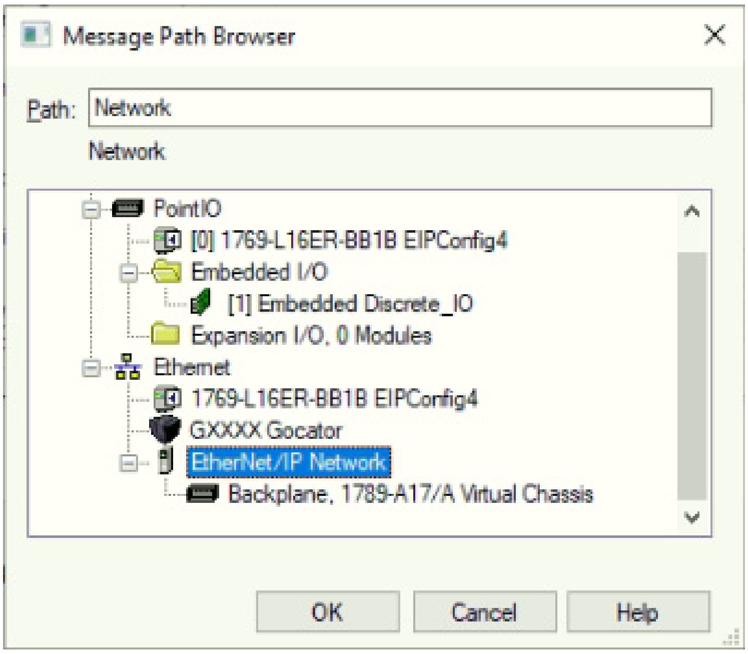


13 On the [Communication] tab, click [Browse].



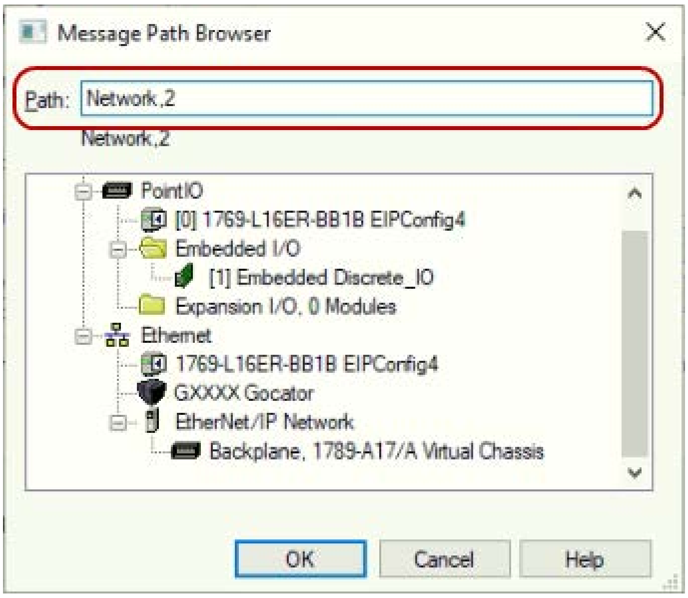
14 In the Message Path Browser dialog, choose the [EtherNet/IP Network] node.

This will route communication messages to the EtherNet/IP network.



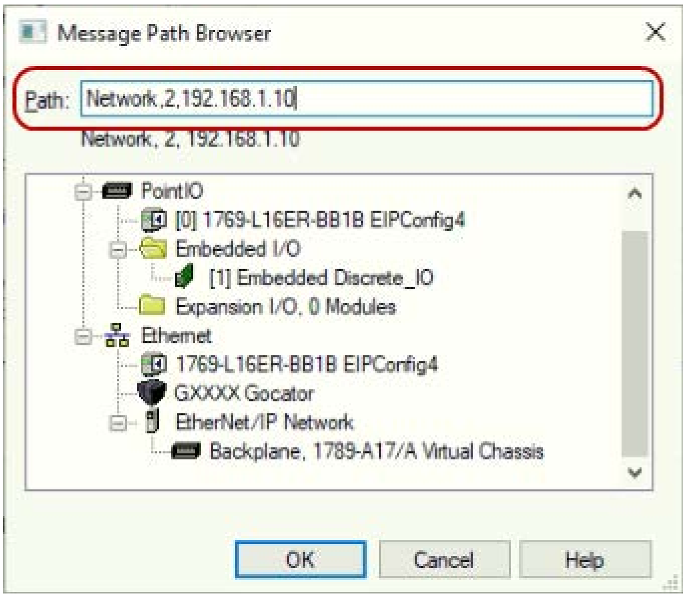
15 **In［Path］, type the Ethernet port on the PLC that is physically connected to the SurfaceMeasure1008S, after the name in the field.**

Here, the port “2” is added.



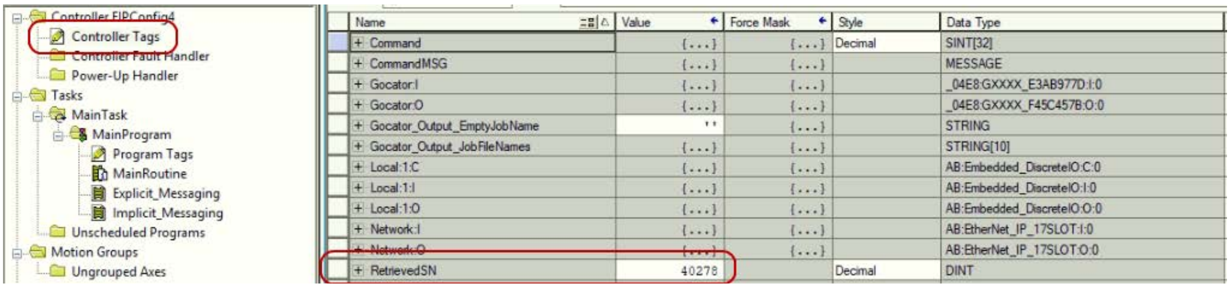
16 **In［Path］, type the IP address of the SurfaceMeasure1008S to complete the path.**

Double-check that the network, port, and IP address are separated by commas in the form “networkname,port,IPaddress”.



17 **Click［OK］to exit the Message Path Browser dialog, and click［OK］again to exit the Message Configuration dialog.**

18 In the Controller Organizer, verify that the serial number is updated in the RetrievedSN tag by going to the Controller Tags node.



To obtain a measurement result, use the procedure described above but change the messaging block class to 4, the instance to 801, and the attribute to 3. The data storage location for this attribute will have to be the proper type and length; for more information, see 📖 "• Sensor State Assembly" on page 827. You will now have to create ladder logic to copy the correct bits in the raw data stream into Controller Tags holding the individual results. This can be done with the Bit Field Distribute (BTD) block. For

- Setting Single Attribute to SurfaceMeasure1008S on the PLC (Explicit Messaging)

You use the Command assembly to do the following:

- Start a sensor
- Stop a sensor
- Align a sensor
- Clear sensor alignment
- Set a sensor's runtime variables
- Load a job on a sensor
- Trigger a sensor

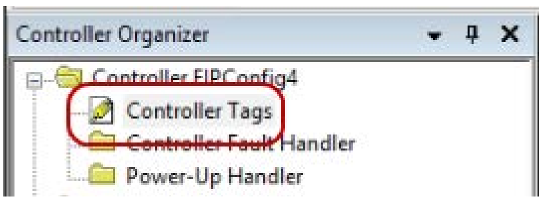
To see the information needed to properly configure the control byte, see 📖 "• Command Assembly" on page 825.

Tips

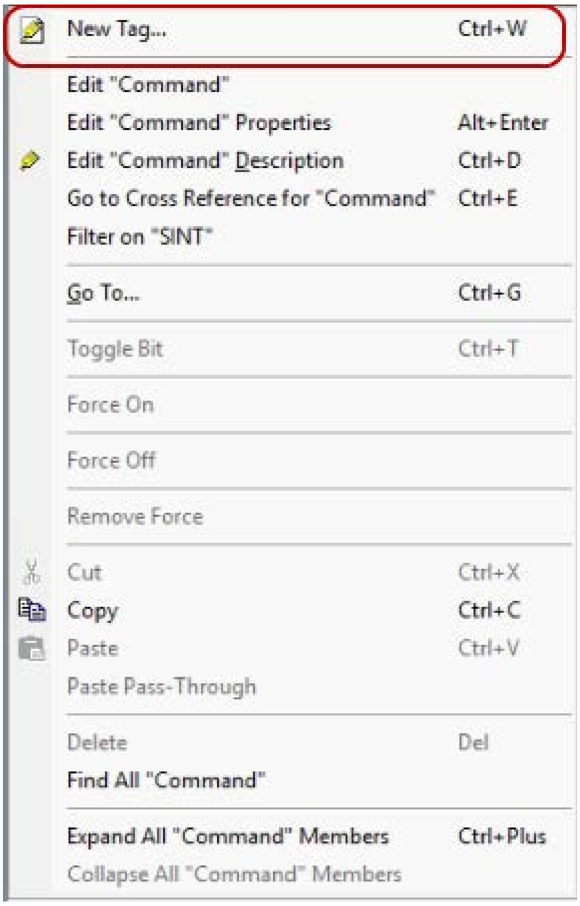
Mitutoyo recommends following the steps in 📖 "• To read the sensor's serial number:" on page 859 to verify the communication path and message block before attempting to control a sensor.

To set a single attribute to the sensor on the PLC, do the following:

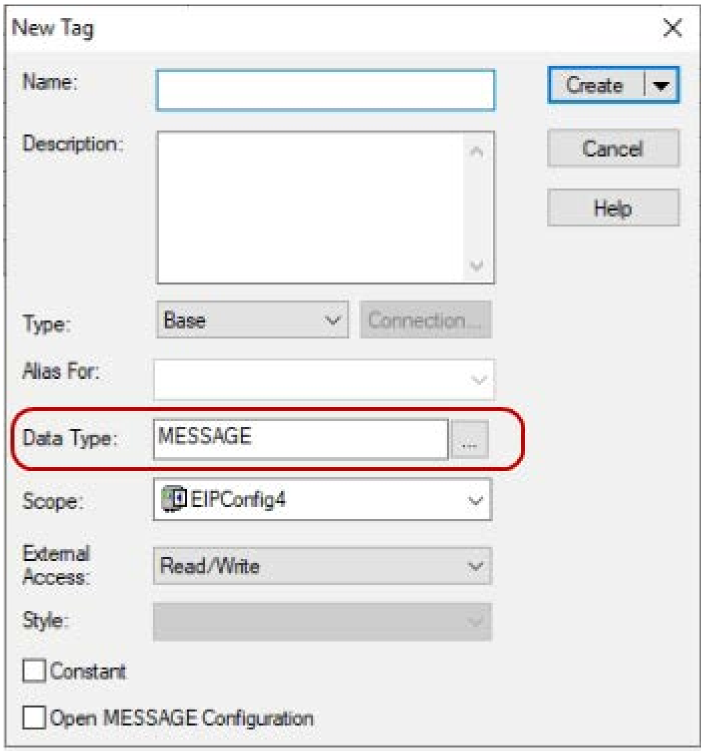
1 In Studio 5000, in the Controller Organizer, expand Controller Tags by double-clicking it.



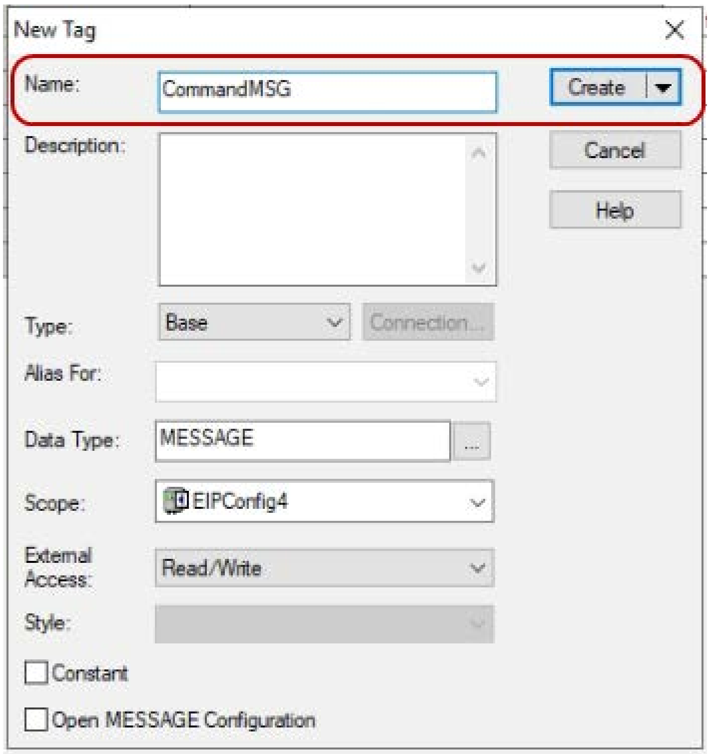
2 **Right-click in the middle of the screen and select［New Tag］from the context menu.**



3 **Change the data type to MESSAGE.**

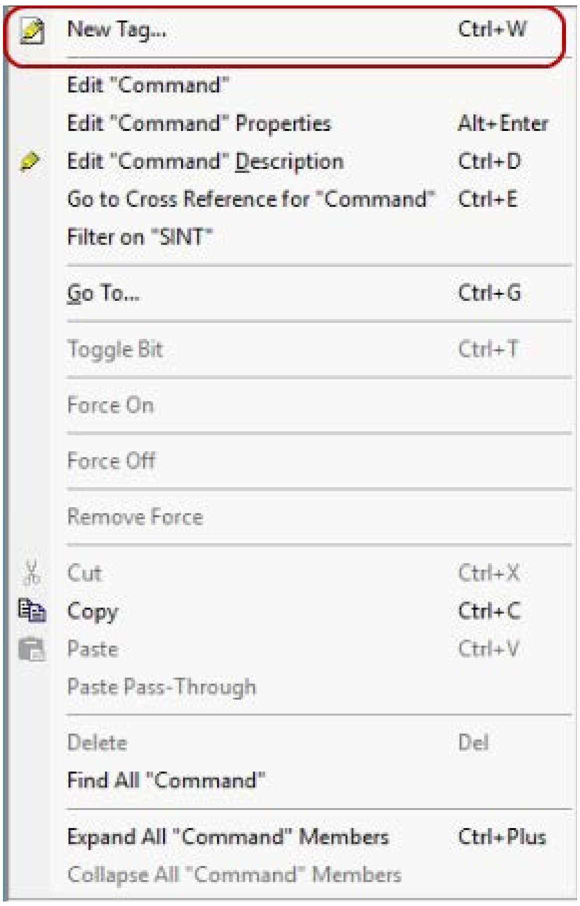


4 **Name the tag and click Create.**

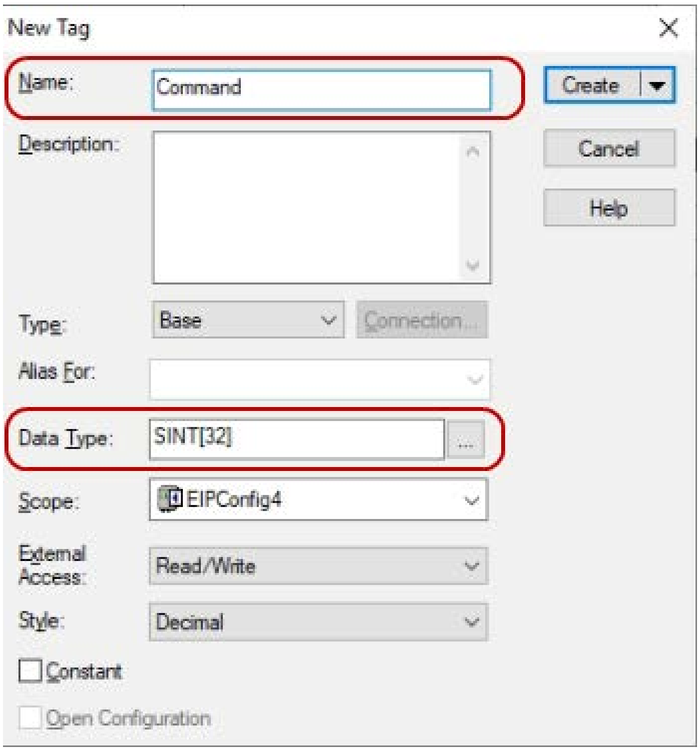


» This creates a block to store parameters for sending data to the SurfaceMeasure1008S.

5 **Right-click in the middle of the screen again and choose［New Tag］from the context menu.**

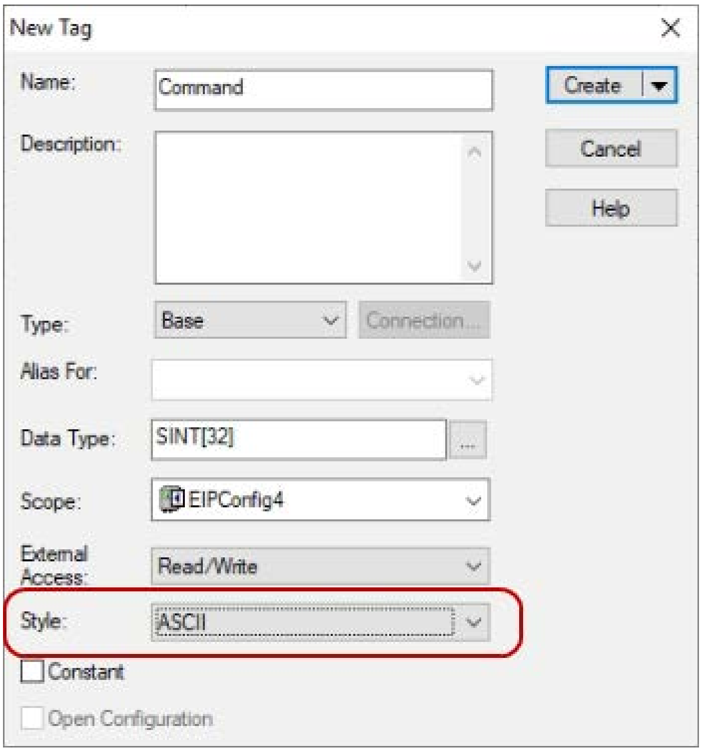


6 **Change the data type to SINT[32] and name the tag.**



7 **Set Style to one of the following:**

If you will be loading job files on the SurfaceMeasure1008S over the protocol, change [Style] from the default to [ASCII]. This will make editing the command assembly easier later.



If you will only be starting or stopping the sensor, leave [Style] at the default setting of [Decimal].

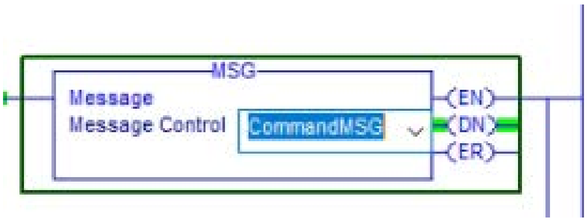
8 **Click［Create］.**

This creates a tag to store the command data before sending it.

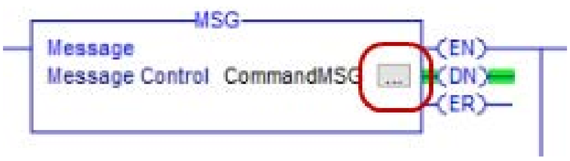
9 **In the ladder, navigate to the Input/Output function blocks and click MSG to add a Message function block.**

You may need to add a new rung to allow this.

10 **Once the new MSG function block has been added, click the tag dropdown and select the MSG tag you created earlier.**

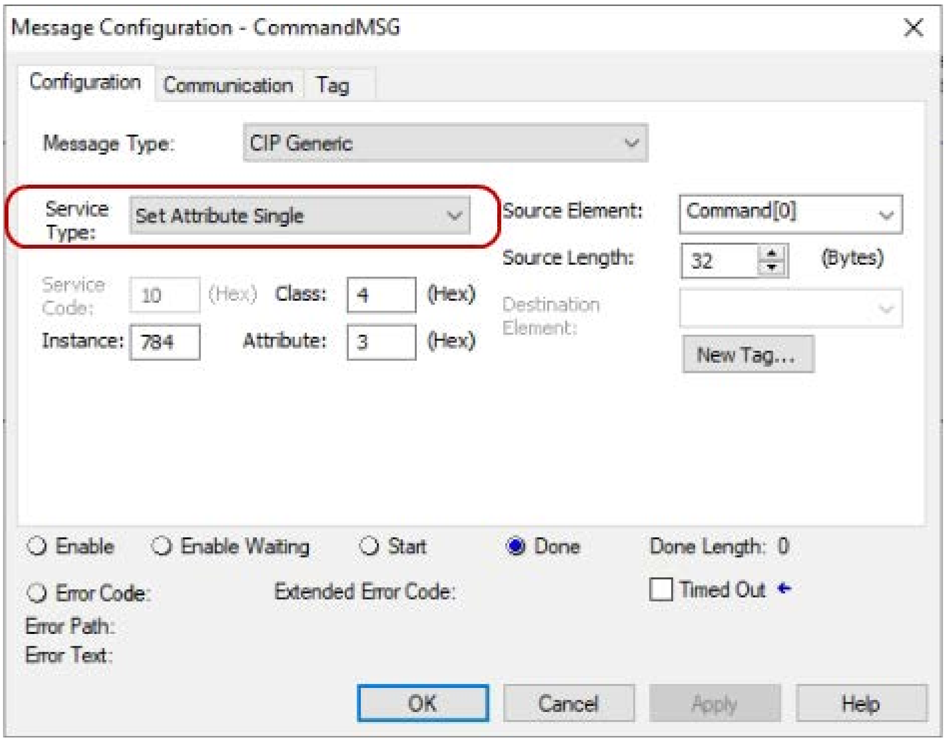


11 **Click the grey box to open the Configuration Dialog box.**

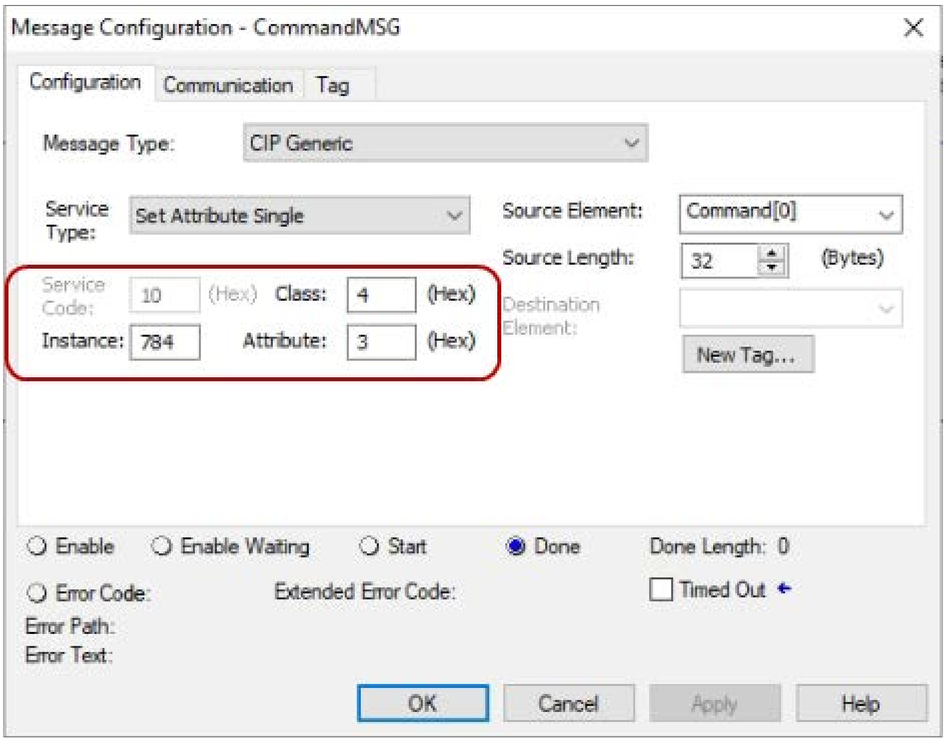


12 In the Message Configuration dialog, choose the Set Attribute Single function from the Service Type drop-down.

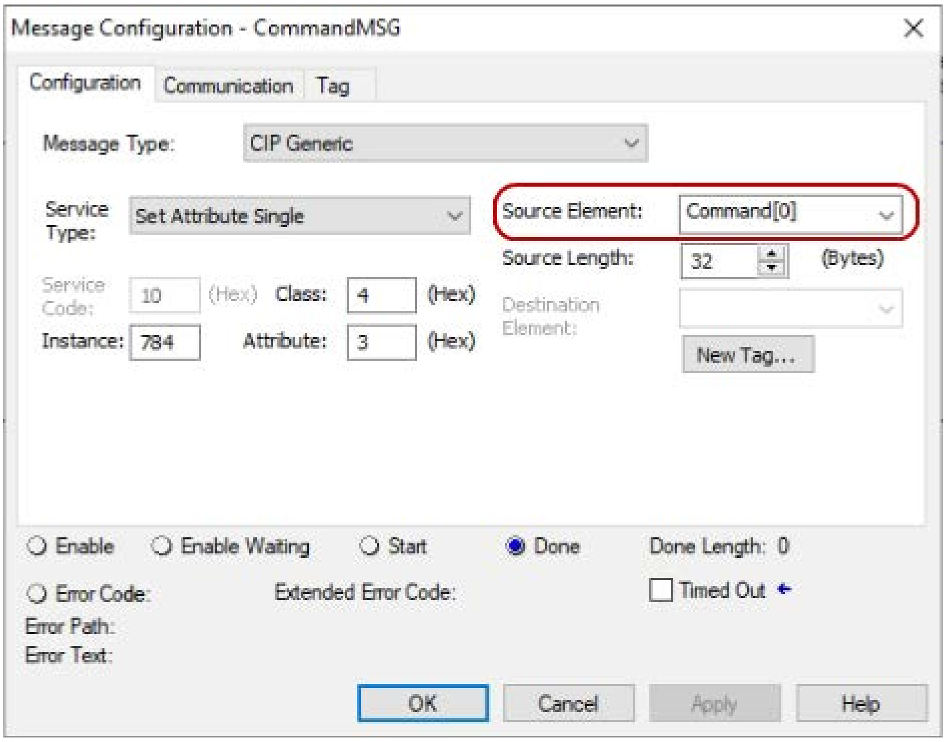
» This will auto populate the Service Code hex character.



13 Enter 4 for Class, 784 for Instance, and 3 for Attribute to set the sensor's command assembly.

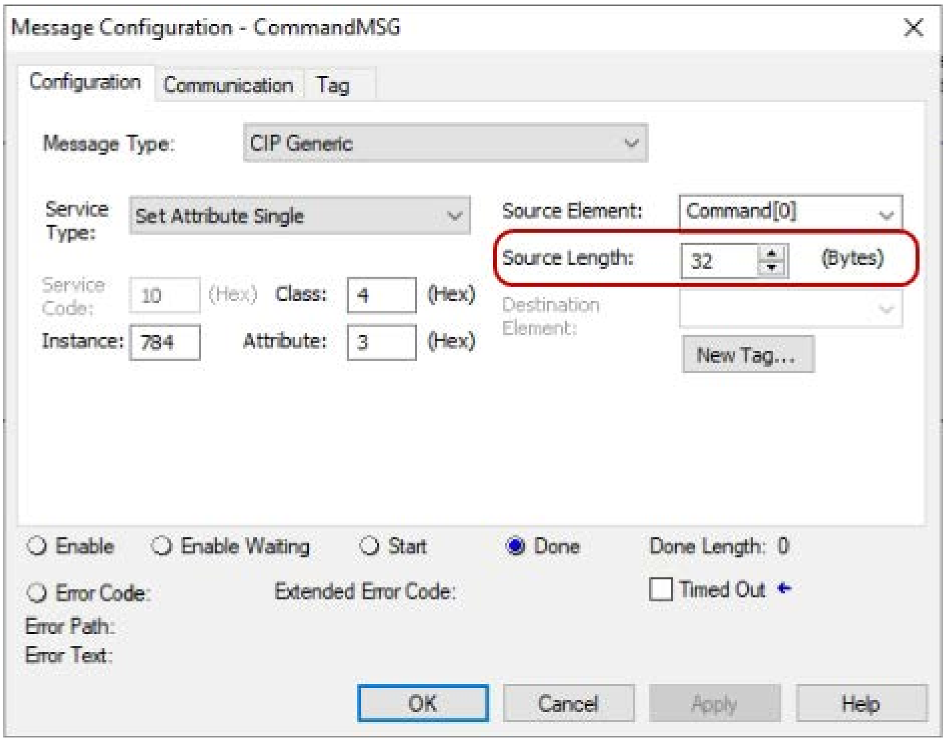


14 **Select the SINT[32] tag you created to store the command assembly from the [Source Element] dropdown**

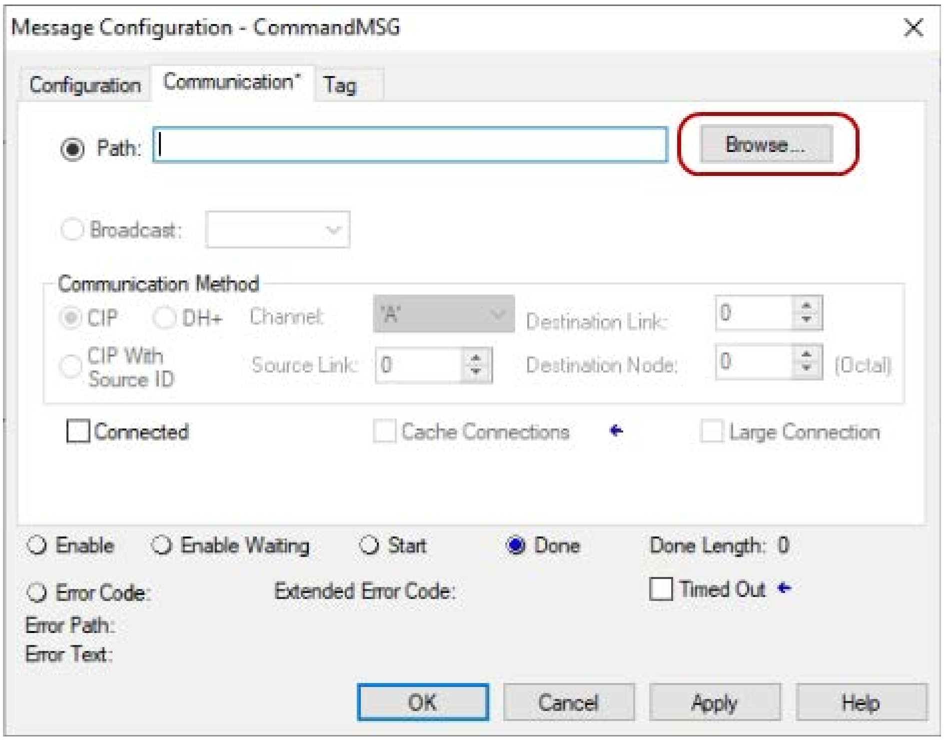


15 **Make sure that the length is set to 32 bytes so that the entire command assembly is transmitted.**

A partial transmission may result in an unexecuted command.

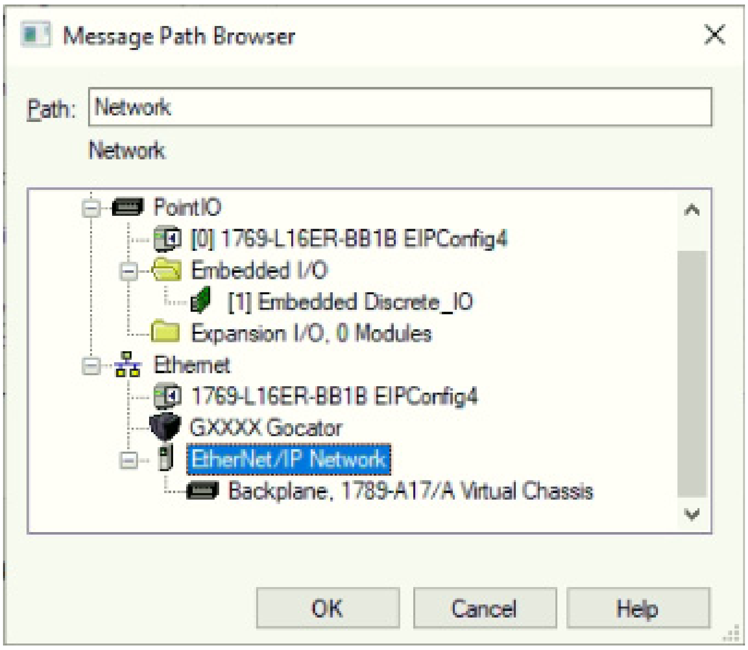


16 **On the [Communication] tab, click [Browse]**



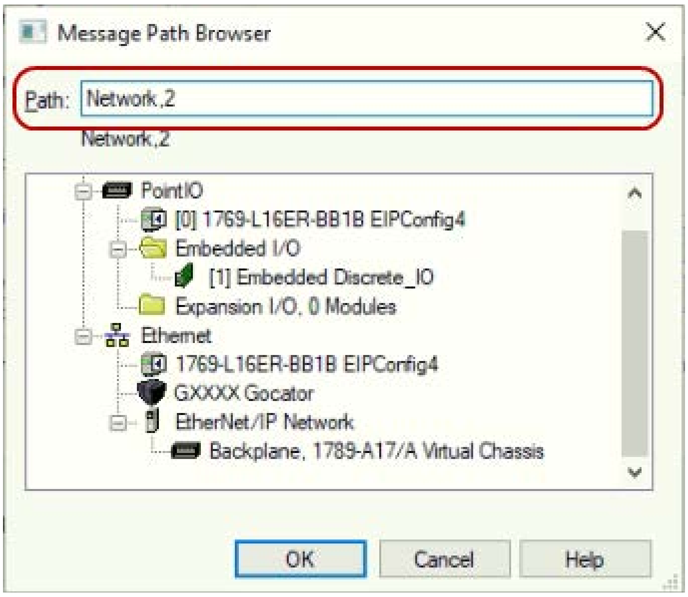
17 **Click the [EtherNet/IP Network] node.**

» This will route communication messages to the EtherNet/IP network.



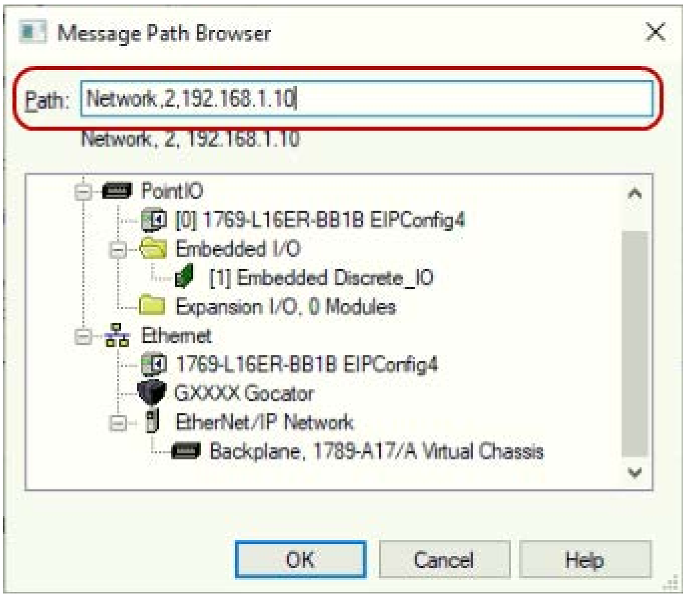
18 **Add the ethernet port that is physically connected to the SurfaceMeasure1008S.**

» This will add the specific port address to your communication path.



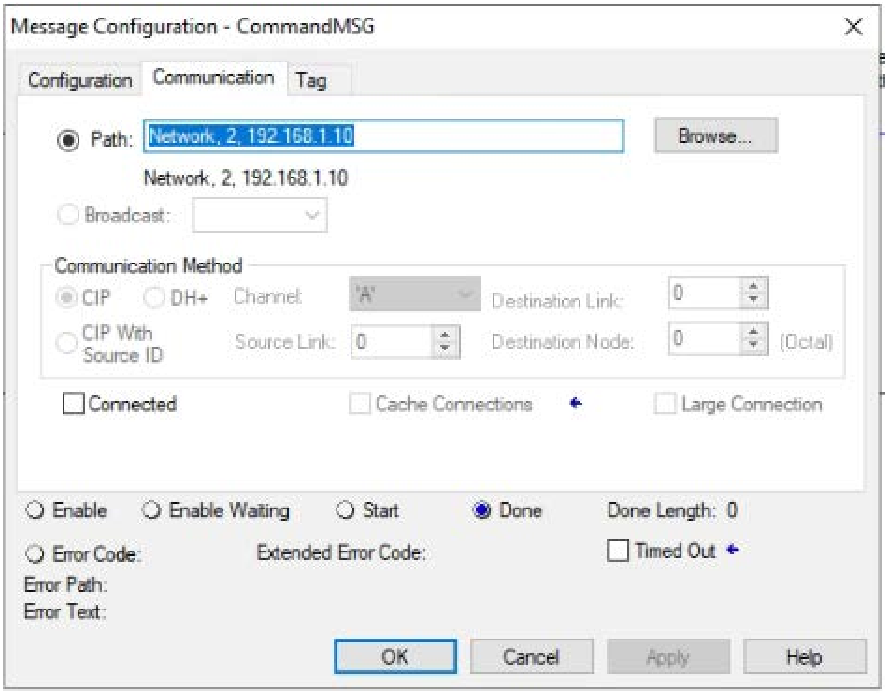
19 **Type the IP address of the SurfaceMeasure1008S to complete the path.**

It is important to double-check that the network, port, and IP address are separated by commas in the form “networkname,port,IPaddress”.



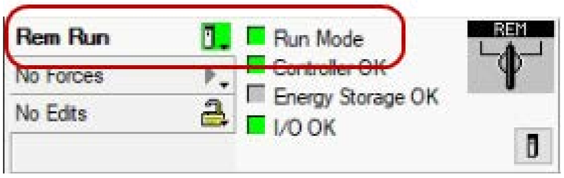
20 **Click［OK］.**

21 **Click［OK］to exit the Message Configuration dialog.**

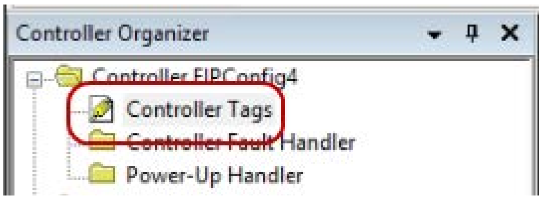


To start a sensor over explicit messaging, the Command assembly must be correctly modified for the integer-based command byte.

1 **Make sure that you have downloaded your PLC program to the controller and that your controller is in Run Mode.**



2 **Expand Controller Tags by double-clicking it.**



3 Expand the Command assembly tag.

Name	Value	Force Mask	Style	Data Type
Command	{...}	{...}	ASCII	SINT[32]
Command[0]	'$00'		ASCII	SINT
Command[1]	'$00'		ASCII	SINT
Command[2]	'$00'		ASCII	SINT
Command[3]	'$00'		ASCII	SINT
Command[4]	'$00'		ASCII	SINT
Command[5]	'$00'		ASCII	SINT
Command[6]	'$00'		ASCII	SINT
Command[7]	'$00'		ASCII	SINT
Command[8]	'$00'		ASCII	SINT
Command[9]	'$00'		ASCII	SINT
Command[10]	'$00'		ASCII	SINT
Command[11]	'$00'		ASCII	SINT
Command[12]	'$00'		ASCII	SINT
Command[13]	'$00'		ASCII	SINT
Command[14]	'$00'		ASCII	SINT
Command[15]	'$00'		ASCII	SINT
Command[16]	'$00'		ASCII	SINT
Command[17]	'$00'		ASCII	SINT
Command[18]	'$00'		ASCII	SINT
Command[19]	'$00'		ASCII	SINT
Command[20]	'$00'		ASCII	SINT
Command[21]	'$00'		ASCII	SINT
Command[22]	'$00'		ASCII	SINT
Command[23]	'$00'		ASCII	SINT
Command[24]	'$00'		ASCII	SINT
Command[25]	'$00'		ASCII	SINT
Command[26]	'$00'		ASCII	SINT
Command[27]	'$00'		ASCII	SINT
Command[28]	'$00'		ASCII	SINT
Command[29]	'$00'		ASCII	SINT
Command[30]	'$00'		ASCII	SINT
Command[31]	'$00'		ASCII	SINT

1 If you changed the formatting of the Command tag array to ASCII, then change the display of only the first byte, Command[0], back to Decimal as the control command are sent as integer-based values.

Command	{...}	{...}	ASCII	SINT[32]
Command[0]	0		Decimal	SINT
Command[1]	'$00'		ASCII	SINT
Command[2]	'$00'		ASCII	SINT

4 Type the number 1 into the value field of Command[0].

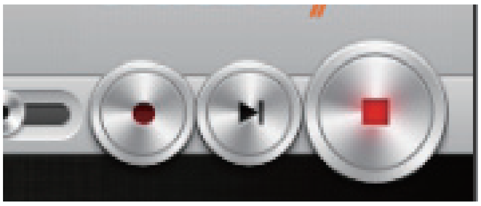
Command	{...}	{...}	ASCII	SINT[32]
Command[0]	1		Decimal	SINT
Command[1]	'$00'		ASCII	SINT
Command[2]	'$00'		ASCII	SINT
Command[3]	'$00'		ASCII	SINT
Command[4]	'$00'		ASCII	SINT

5 Go to a web browser and type in the sensor IP address to the URL bar.

» This should load the web GUI.

6 **Verify that the sensor started.**

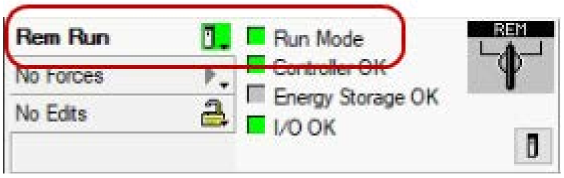
If the Run button is a red square, then the sensor was successfully started.



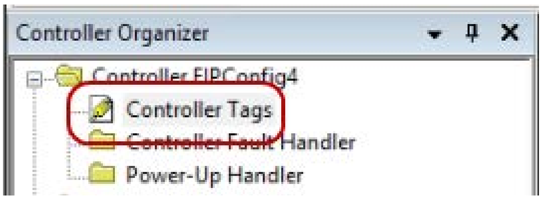
Your ladder logic should only be able to edit the Command assembly 1 time. Since Explicit Message Buffering is checked from the SurfaceMeasure1008S setup, multiple message transfers from improper ladder logic will end up buffering on the SurfaceMeasure1008S side of the network. The only way to easily clear the messaging buffer is to power cycle the sensor.

- **Loading a Sensor Job File**

1 **Make sure that you have downloaded your PLC program to the controller and that your controller is in Run Mode**



2 **Expand［Controller Tags］by double-clicking it**



3 Expand the Command assembly tag

Name	Value	Force Mask	Style	Data Type
Command	{...}	{...}	ASCII	SINT[32]
Command[0]	'$00'		ASCII	SINT
Command[1]	'$00'		ASCII	SINT
Command[2]	'$00'		ASCII	SINT
Command[3]	'$00'		ASCII	SINT
Command[4]	'$00'		ASCII	SINT
Command[5]	'$00'		ASCII	SINT
Command[6]	'$00'		ASCII	SINT
Command[7]	'$00'		ASCII	SINT
Command[8]	'$00'		ASCII	SINT
Command[9]	'$00'		ASCII	SINT
Command[10]	'$00'		ASCII	SINT
Command[11]	'$00'		ASCII	SINT
Command[12]	'$00'		ASCII	SINT
Command[13]	'$00'		ASCII	SINT
Command[14]	'$00'		ASCII	SINT
Command[15]	'$00'		ASCII	SINT
Command[16]	'$00'		ASCII	SINT
Command[17]	'$00'		ASCII	SINT
Command[18]	'$00'		ASCII	SINT
Command[19]	'$00'		ASCII	SINT
Command[20]	'$00'		ASCII	SINT
Command[21]	'$00'		ASCII	SINT
Command[22]	'$00'		ASCII	SINT
Command[23]	'$00'		ASCII	SINT
Command[24]	'$00'		ASCII	SINT
Command[25]	'$00'		ASCII	SINT
Command[26]	'$00'		ASCII	SINT
Command[27]	'$00'		ASCII	SINT
Command[28]	'$00'		ASCII	SINT
Command[29]	'$00'		ASCII	SINT
Command[30]	'$00'		ASCII	SINT
Command[31]	'$00'		ASCII	SINT

1 If you changed the formatting of the Command tag array to ASCII, then change the display of only the first byte, Command[0], back to Decimal as the control command are sent as integer-based values.

Command	{...}	{...}	ASCII	SINT[32]
Command[0]	0		Decimal	SINT
Command[1]	'$00'		ASCII	SINT
Command[2]	'$00'		ASCII	SINT

4 **If 1.job is the job file to be loaded on the sensor and it is not currently running, type each of the five characters making up the filename into Command[1] through Command[5] of the Command assembly.**

The ASCII character inputs here are case sensitive and the extension, .job, must be included. All non-jobname characters must be null or empty values. If the style was changed to ASCII as the default during the tag creation, this will be done already, and the alphanumeric characters can be directly typed into the value column of the bytes.

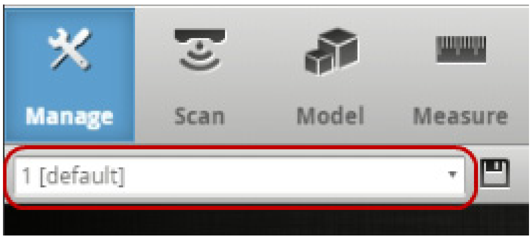
Name	Value	Force Mask	Style	Data Type
Command	{...}	{...}	ASCII	SINT[32]
Command[0]	0		Decimal	SINT
Command[1]	'1'		ASCII	SINT
Command[2]	'.'		ASCII	SINT
Command[3]	'j'		ASCII	SINT
Command[4]	'o'		ASCII	SINT
Command[5]	'b'		ASCII	SINT
Command[6]	'$00'		ASCII	SINT
Command[7]	'$00'		ASCII	SINT
Command[8]	'$00'		ASCII	SINT
Command[9]	'$00'		ASCII	SINT
Command[10]	'$00'		ASCII	SINT
Command[11]	'$00'		ASCII	SINT
Command[12]	'$00'		ASCII	SINT
Command[13]	'$00'		ASCII	SINT
Command[14]	'$00'		ASCII	SINT
Command[15]	'$00'		ASCII	SINT
Command[16]	'$00'		ASCII	SINT
Command[17]	'$00'		ASCII	SINT
Command[18]	'$00'		ASCII	SINT
Command[19]	'$00'		ASCII	SINT
Command[20]	'$00'		ASCII	SINT
Command[21]	'$00'		ASCII	SINT
Command[22]	'$00'		ASCII	SINT
Command[23]	'$00'		ASCII	SINT
Command[24]	'$00'		ASCII	SINT
Command[25]	'$00'		ASCII	SINT
Command[26]	'$00'		ASCII	SINT
Command[27]	'$00'		ASCII	SINT
Command[28]	'$00'		ASCII	SINT
Command[29]	'$00'		ASCII	SINT
Command[30]	'$00'		ASCII	SINT
Command[31]	'$00'		ASCII	SINT

5 **Type the integer value 64 into the Command byte to transmit the job name for loading.**

Name	Value	Force Mask	Style
Command	{...}	{...}	ASCII
Command[0]	64		Decimal
Command[1]	'1'		ASCII
Command[2]	'.'		ASCII
Command[3]	'j'		ASCII
Command[4]	'o'		ASCII
Command[5]	'b'		ASCII
Command[6]	'$00'		ASCII
Command[7]	'$00'		ASCII
Command[8]	'$00'		ASCII

6 **Go to a web browser and type in the sensor IP address to the URL bar.**

7 **Once the web GUI loads, verify that the job was loaded on the SurfaceMeasure1008S by looking at the job name box.**



■ Yaskawa Instructions

This section describes how to set up network communications over the Ethernet/IP industrial communication protocol with Yaskawa Motoman robot controllers that are Ethernet/IP-capable. The SurfaceMeasure1008S supports two different messaging methods: implicit messaging via UDP and explicit messaging via TCP.

Implicit messaging has advantages and disadvantages. Implicit messaging uses UDP and is faster than explicit messaging and is ideal for time-critical applications. Since implicit messaging is layered on top of UDP, it is connectionless and data delivery is not guaranteed. For this reason, implicit messaging is only suitable for applications where occasional data loss is acceptable. Two different connection types are available for implicit communication: a Monitor Data connection or a Monitor Data and Control Data connection.

Not all Yaskawa Motoman robot controllers can communicate over Ethernet/IP to/from a SurfaceMeasure1008S sensor. At this time, it is known that the YRC1000-micro robot controller does not have enough on-board memory for the input assembly, so this guide is intended for YRC1000 controllers and up.

Explicit messaging is more suitable for deterministic and verified communication transfer where no losses are desired. It is not possible to use the EDS file for automatic configuration of implicit or explicit messaging on Motoman controllers.

For these reasons, it is recommended in most application to utilize a closed ethernet subnet (i.e. network switch, robot controller, SurfaceMeasure1008S(s), and setup PC only) to minimize losses and collisions and cyclical implicit messaging over the Ethernet/IP protocol unless a specific control command such as job loading and/or transfer verification is required.

● Software and Hardware Setup

The following software and hardware were used during development.

Requirements	Details
SurfaceMeasure1008S Firmware	5.3 SR1 and higher
Other	Yaskawa Motoman YRC1000 Robot Controller D-Link Unmanaged Industrial Gigabit Ethernet Switch DGS-108

Yaskawa YRC 1000 Controller with Teach Pendant

Tips

The Ethernet/IP function card must be enabled on the robot controller at the factory. Please make sure that you purchase a robot controller that has had this function enabled.

Tips

Successful connections have been verified for a standalone SurfaceMeasure1008S sensor to a robot controller and a GoMax accelerated sensor to a robot controller. The GoAccelerator utility running on a PC connections have not yet been verified.

- Byte Order Options

SurfaceMeasure1008S supports outputting in either Big Endian or Little-Endian byte ordering options.

Big Endian Byte Order: The most significant byte (the "big end") of the data is placed at the byte with the lowest address. The rest of the data is placed in order of decreasing significance in the next three bytes of memory (for 32-bit values).

Little Endian Byte Order: The least significant byte (the "little end") of the data is placed at the byte with the lowest address. The rest of the data is placed in order of increasing significance in the next three bytes in memory (for 32-bit values).

This selection will depend on the default endianness of the controlling device. Motoman controllers default to Little Endian addressing formats, but this should be verified before communication may proceed.

- Memory Limitation

When using Ethernet/IP Implicit Messaging, the SurfaceMeasure1008S will consume 3008 input bits and 256 output bits, otherwise known as points in the Motoman manual. The YRC1000 only allows for 4040 Input points and 4040 Output points noted below as Transmission I/O points. The following table provides the YRC1000 board specifications (copied directly from Yaskawa Motoman YRC1000 Options - EthernetIP Options Instructions Manual, 178651-1CD, Rev 3).

Items	Specifications
Interface to external devices	EtherNet/IP
Transmission I/O points (max.)	Input: 4040 points/Output: 4040 points
Processing capacity (max. number of packets)	3000 packets/sec
Connection type	Star (Connection by HUB)
Communication speed	10 Mbps/100 Mbps (Detected automatically during startup)
Communication media	Use category 5 or higher shielded Ethernet cables.

The table below shows that the only three controllers that can communicate with 1 SurfaceMeasure1008S sensor are the YRC1000, DX100, and DX200 due to memory limitations on the controller.

Controller Model	Available Inputs (pts)	Available Outputs (pts)
YRC1000	4040	4040
YRC1000micro	1008	1008
DX200	4040	4040
DX100 with EtherNet/IP Option Board	4040	4040
NX100 with Applicon IO Board	1016	1016
FS100/L with 263IF-01 EIP module	976	976

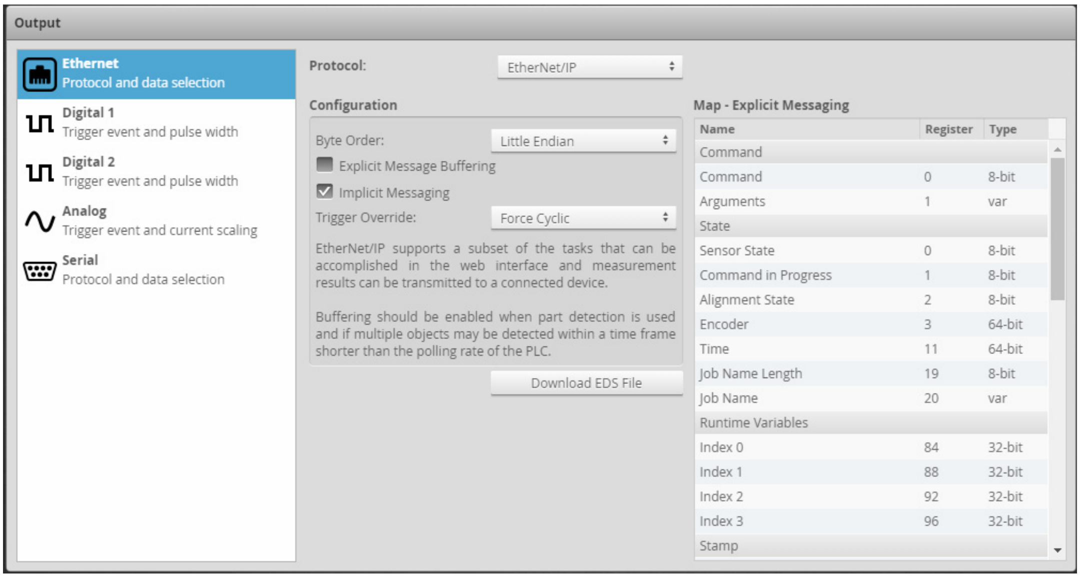
Whichever controller is selected that has an acceptable amount of available memory, the Ethernet/IP function option must be purchased along with the controller from Yaskawa, and enabled at the factory.

- Implicit Messaging

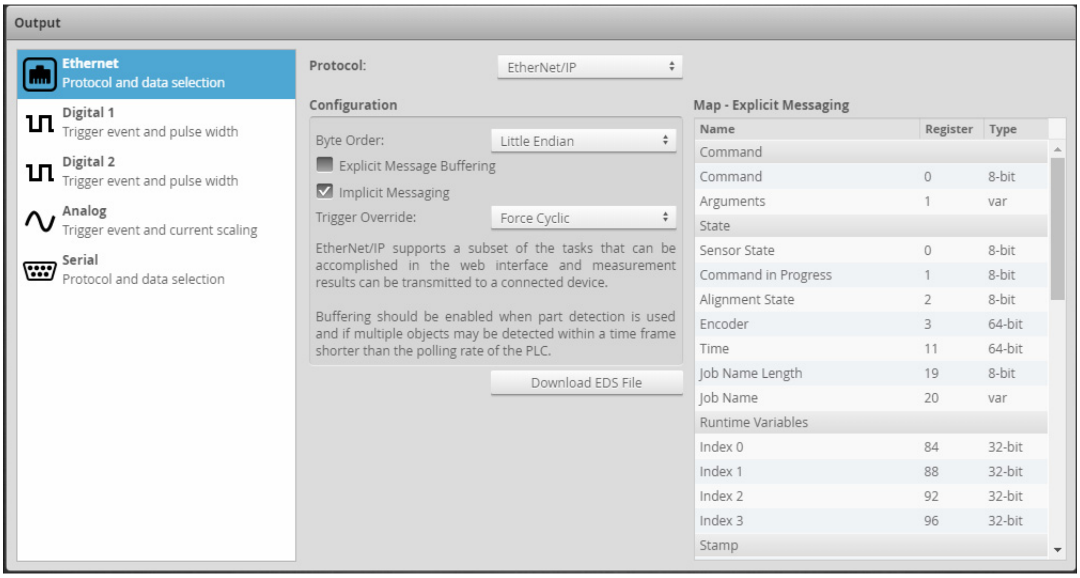
General Sensor Output Page Configuration

To configure the sensor to output in Ethernet/IP Implicit Messaging mode, do the following:

1 On the［Output］page, in the［Ethernet］category, choose EtherNet/IP as the protocol.

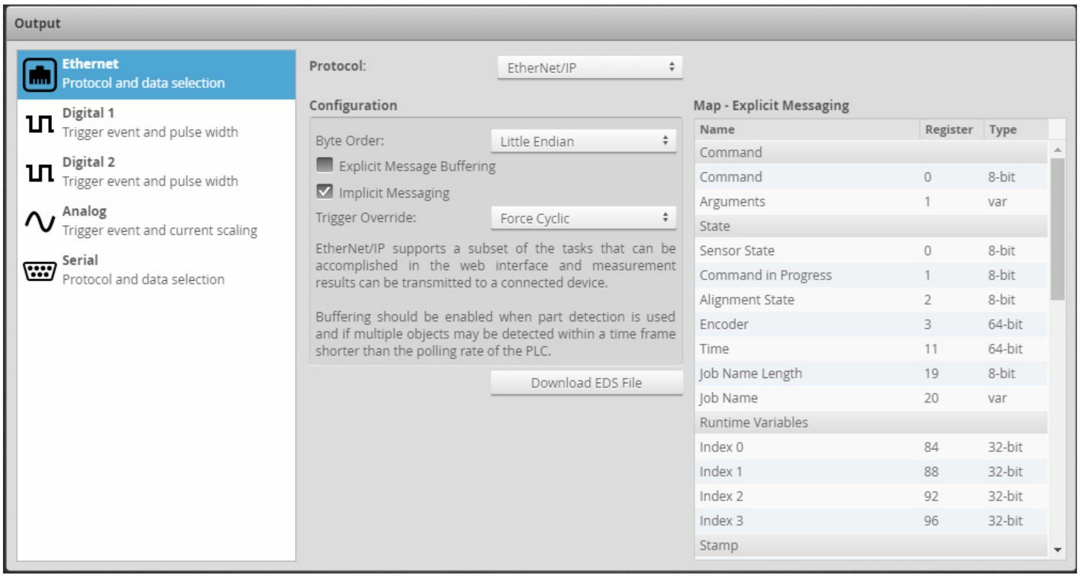


2 Select Little Endian from the Byte Order dropdown box.



3 Check the Implicit Messaging option.

1 Be sure that [Explicit Message Buffering] is unchecked.

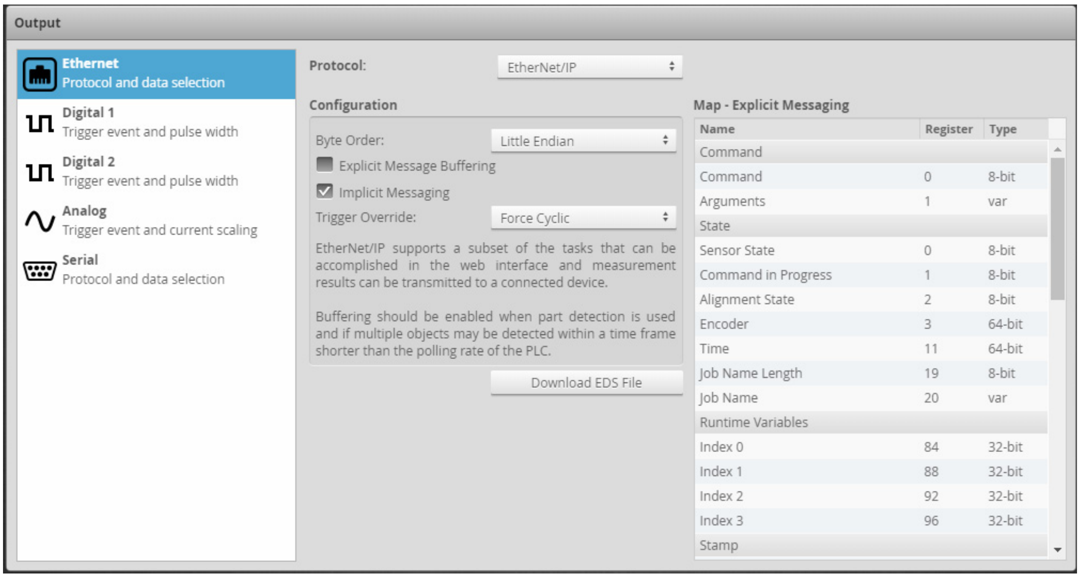


Setting Up Cyclic Implicit Messaging

To set up cyclic implicit messaging, do the following:

Sensor Setup

1 Select [Force Cyclic] from the [Trigger Override] dropdown.



Install EDS File - NOT SUPPORTED

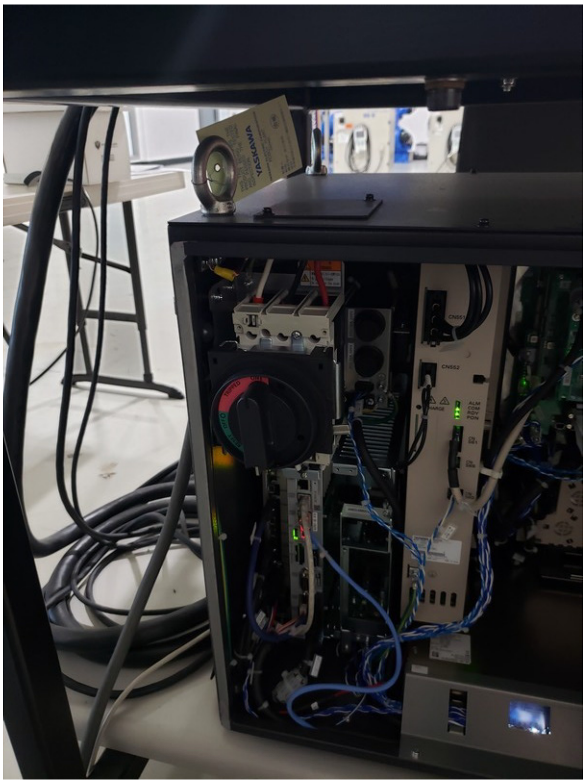
Motoman controllers do not support native import of adapter device EDS files. They must be set up manually. Proceed to next section.

Add SurfaceMeasure1008S IO Device to Robot Controller as Adapter

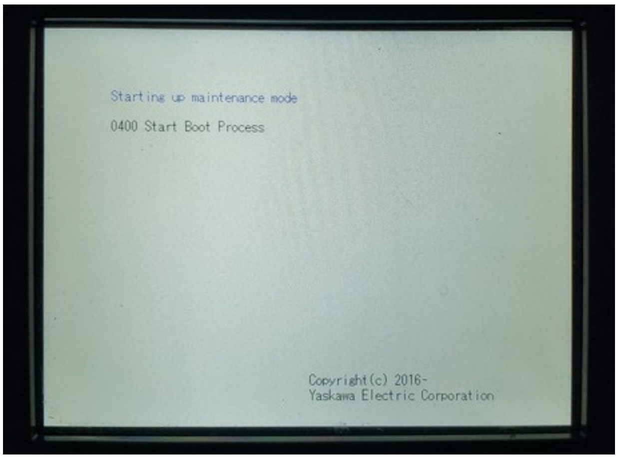
This section details how to add the SurfaceMeasure1008S as an adapter device that the robot controller will scan for in its role as the Ethernet/IP Scanner.

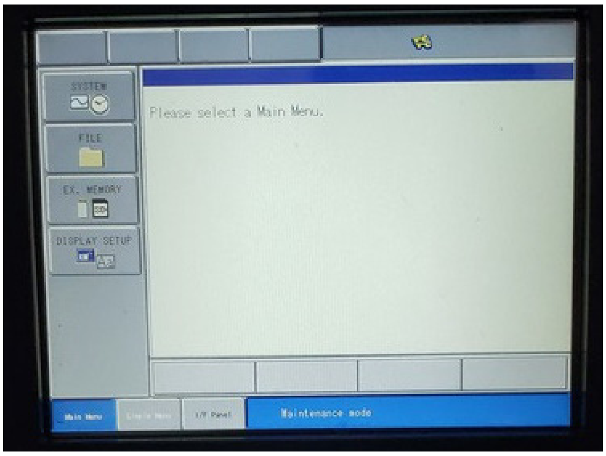
Configure LAN Interface on Controller

1 **Turn on the robot controller in Maintenance Mode by holding down the Menu button and turning the power switch to the ON position.**

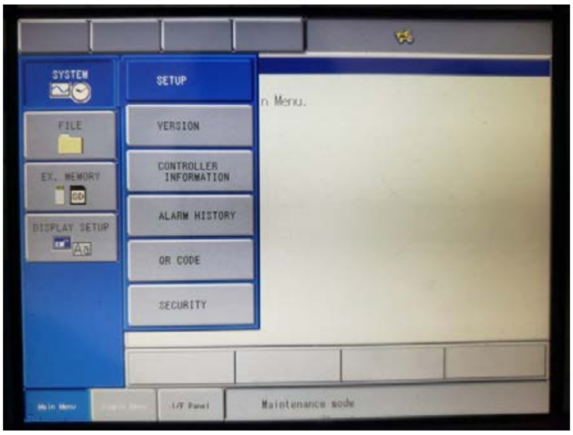


You will see the Teach Pendant launch in Maintenance Mode.

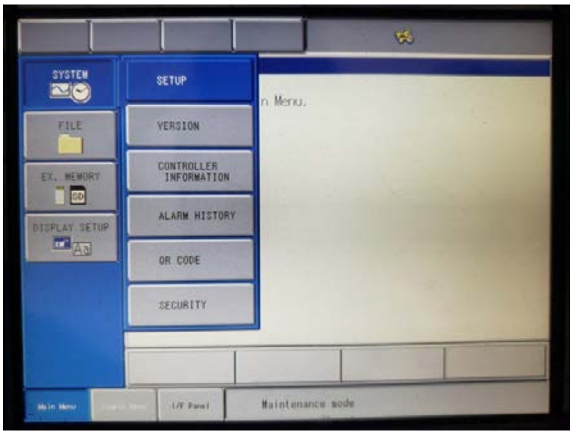




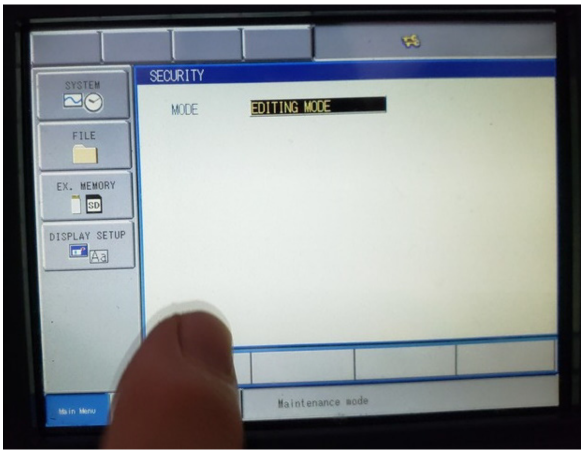
2 **Click the System Menu.**



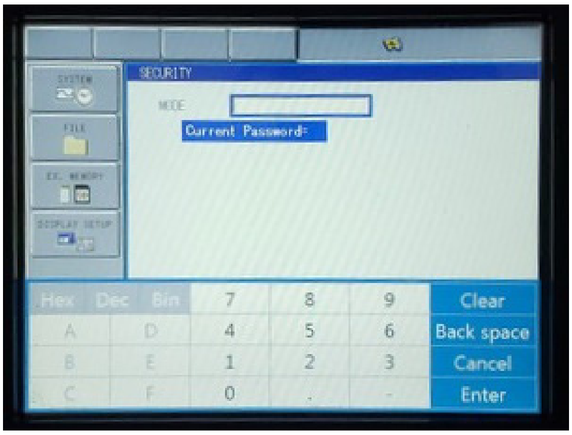
3 **Click the Security sub-menu.**



4 **Select Safety Mode from the Mode dropdown box.**

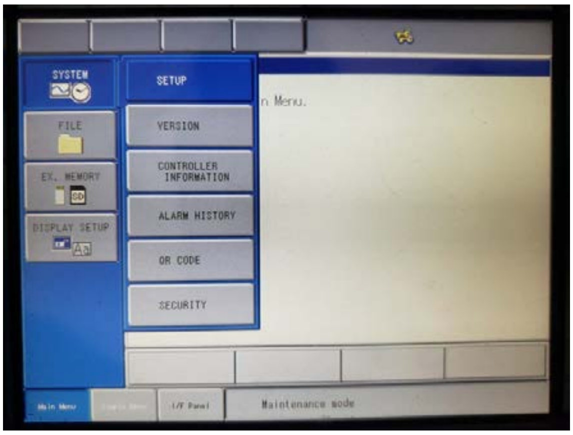


5 When prompted for the Security password, enter 5 until the entire password buffer is full.

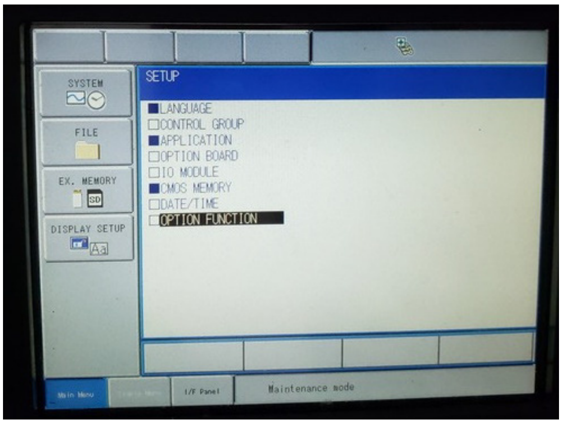


6 Press Enter to accept changes.

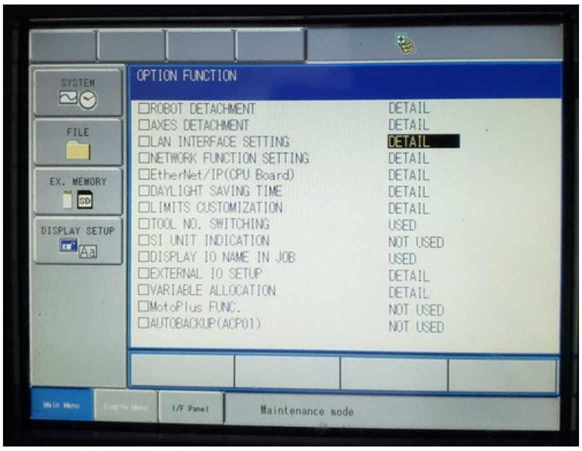
7 **After returning to the System menu, click the Setup sub-menu.**



8 **Highlight and select the Option Function from the Setup list. Press Enter.**

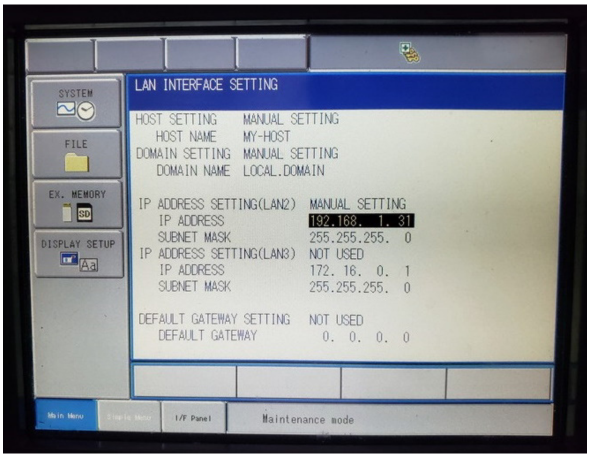


9 **On the Option Function menu, highlight the word "Detail" next to LAN Interface Setting and press Enter.**



10 **Modify the LAN2 settings to those shown below.**

LAN1 should be used for teach pendant communication in most cases, so do not modify that interface. The default IP address of a SurfaceMeasure1008S is 192.168.1.10, and the default sensor subnet mask is 255.255.255.0. Therefore, the LAN2 interface must be set to an available static IP address on this subnet.

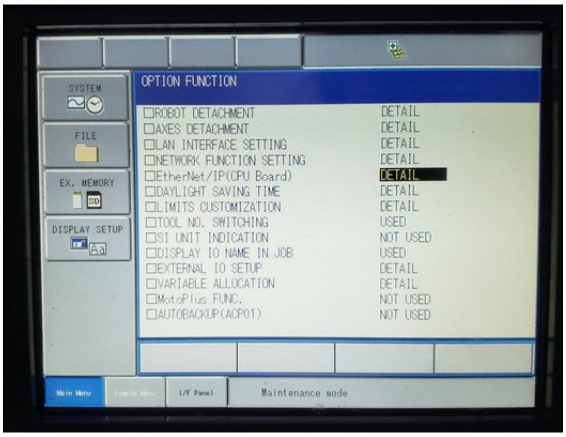


- IP Address Setting: Manual Setting
- IP Address: 192.168.1.X
- Subnet Mask: 255.255.255.0

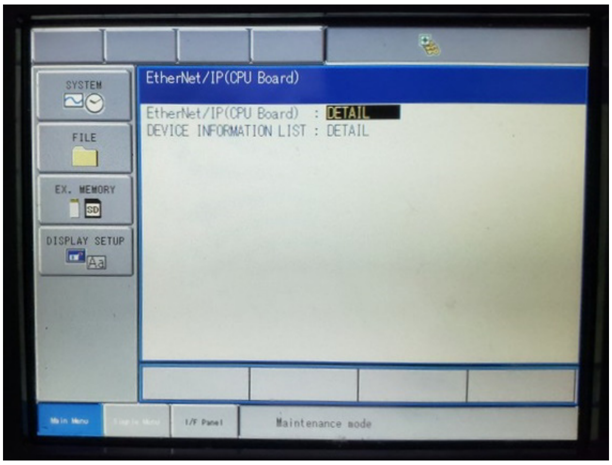
11 **Press Enter to accept these changes and return to the Option Function menu.**

- Add SurfaceMeasure1008S as Generic Adapter Device in Controller Device Information List

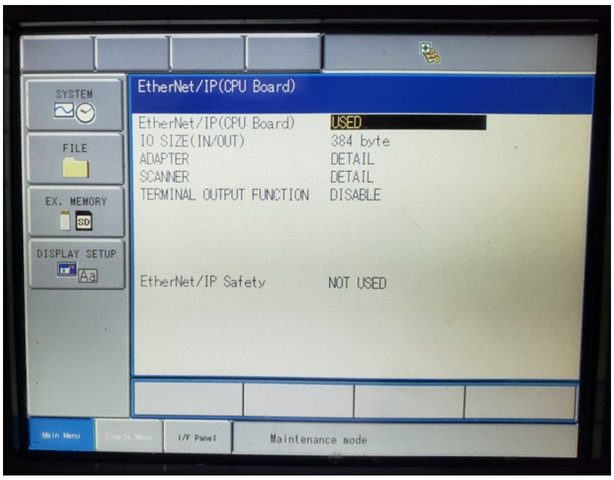
1 **On the Option Function menu, highlight the word "Detail" next to Ethernet/IP CPU Board and press Enter.**



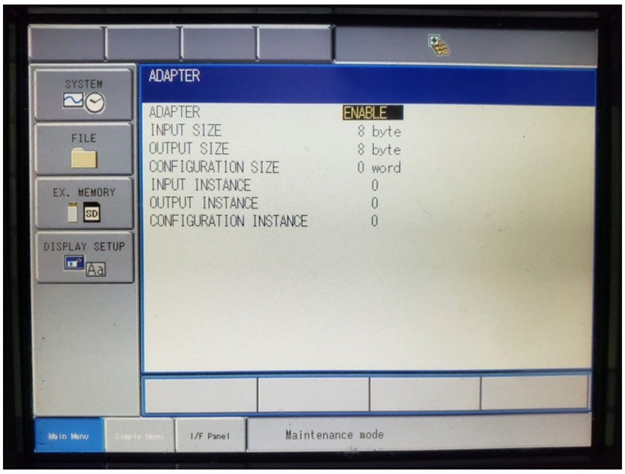
2 **On the Ethernet/IP CPU Board menu, highlight the word "Detail" next to Ethernet/IP CPU Board and press Enter**



3 **On the Ethernet/IP CPU Board sub-menu, highlight the word "Detail" next to Adapter and press Enter**



4 **On the Adapter menu, select Enable from the first dropdown. This will enable the robot controller's ability to serve as an Ethernet/IP Adapter**



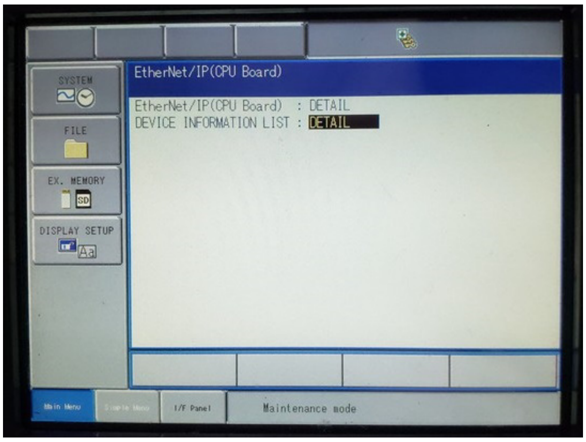
5 **Set up the Adapter menu as follows**

- Input Size: 8 byte
- Output Size: 8 byte
- Configuration Size: 0 word
- Input Instance: 0
- Output Instance: 0
- Configuration Instance: 0

These values will serve as placeholders in case a PLC is used later for additional communications if desired.

6 **Press Enter to return to the Ethernet/IP CPU Board menu**

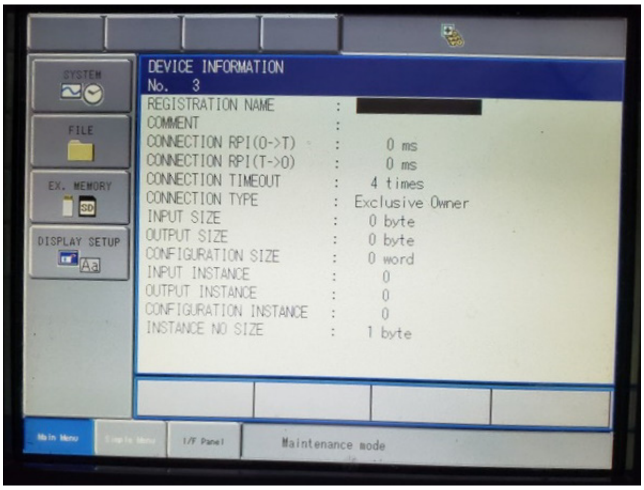
1 On the Ethernet/IP CPU Board menu, highlight the word "Detail" next to DEVICE INFORMATION LIST and press Enter.

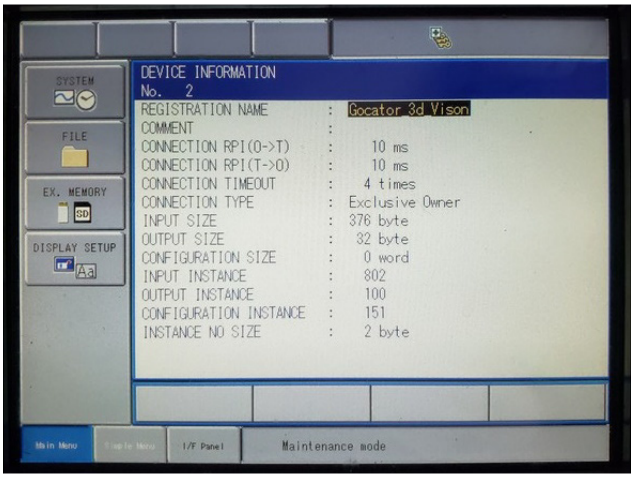


7 **Add a new device with the following parameters**

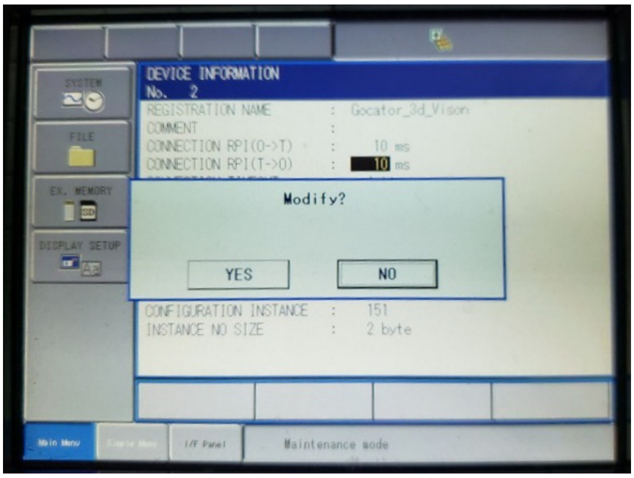
- Registration Name: choose a specific name
- Connection RPI (O->T): 10ms
- Connection RPI (T->O): 10ms
- Connection Timeout: 4 times (but this can be selected for any multiple of 4)
- Connection Type: Exclusive Owner
- Input Size: 376 bytes

- Output Size: 32 bytes
- Configuration Size: 0 word
- Input Instance: 802
- Output Instance: 100
- Configuration Instance: 151
- Instance Number Size: 2 bytes (size of the memory location required to store the three instance values noted earlier)



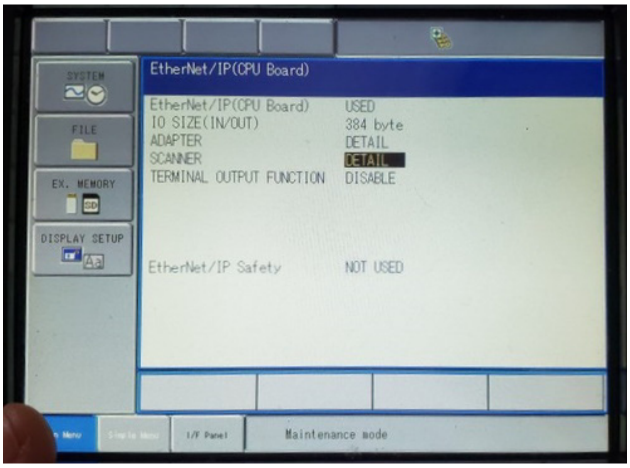


8 **Press Enter, and you will be prompted to approve the modifications. Click Yes.**

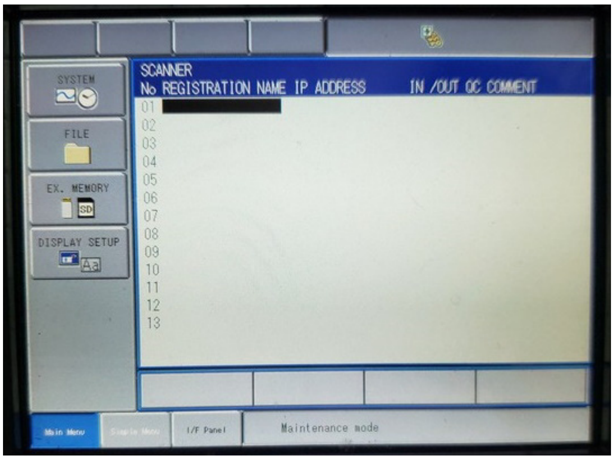


- Add SurfaceMeasure1008S as Specific Adapter Device in Controller Scanner List

1 **Return to the Ethernet/IP CPU Board menu, highlight the word "Detail" next to Scanner and press Enter.**

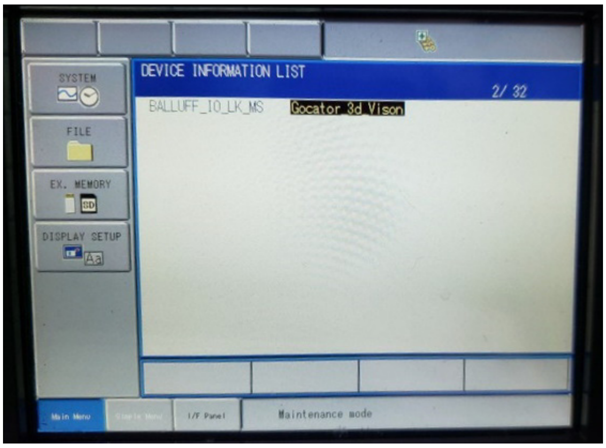


2 **Highlight the first free slot in the Scanner device list and press Enter. There really shouldn't be any other devices added as Adapters here since the SurfaceMeasure1008S consumes most of the available memory for the YRC1000 controller. Please consult your available memory limitations prior to installing a SurfaceMeasure1008S directly with the controller.**

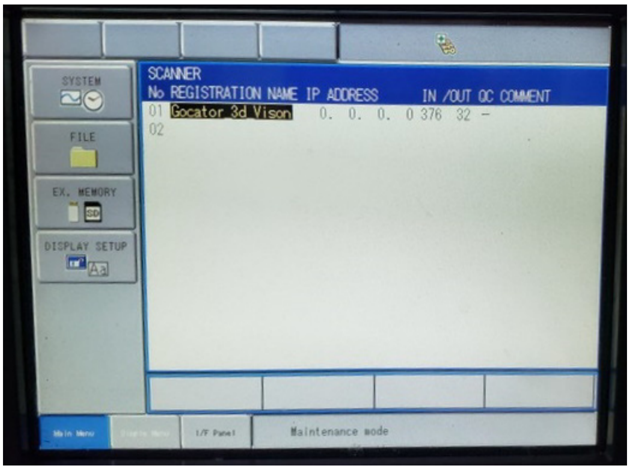


3 **Select Modify from the Dropdown**

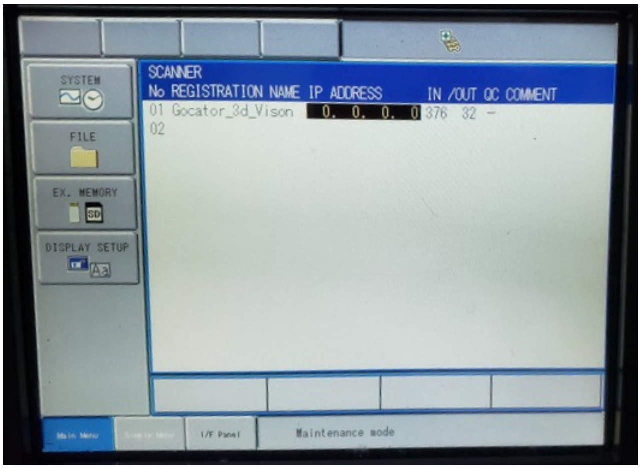
4 **Select the SurfaceMeasure1008S device you added earlier from the DEVICE INFORMATION LIST.**



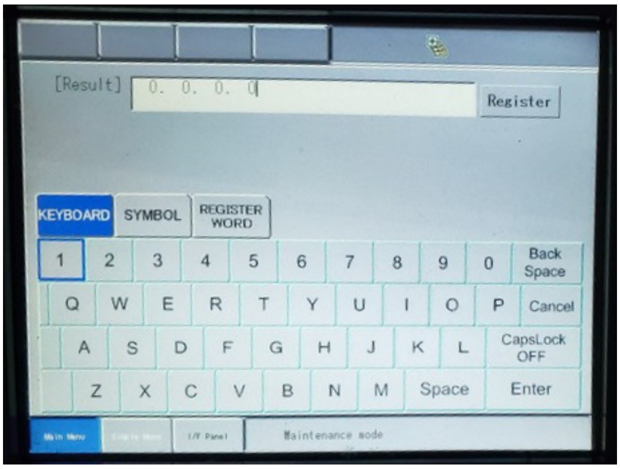
5 **The SurfaceMeasure1008S will be added in the slot you had selected.**

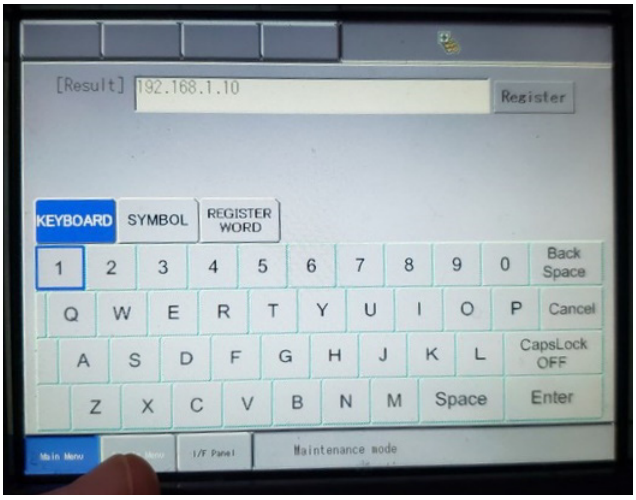


6 **Highlight the IP address position and press Enter.**



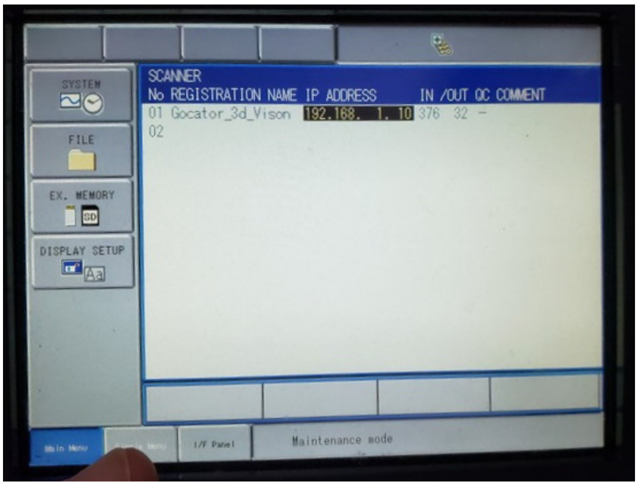
7 **Enter the IP address of the SurfaceMeasure1008S. The factory default is 192.168.1.10.**





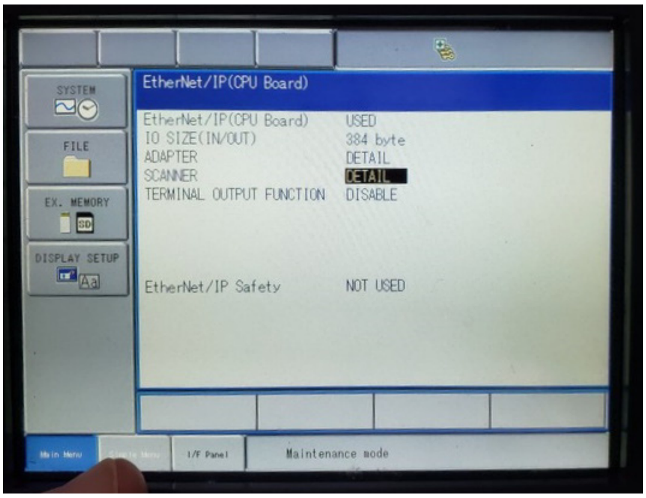
8 **Press Enter and accept changes.**

» The modified IP address will now be shown in the scanner list.

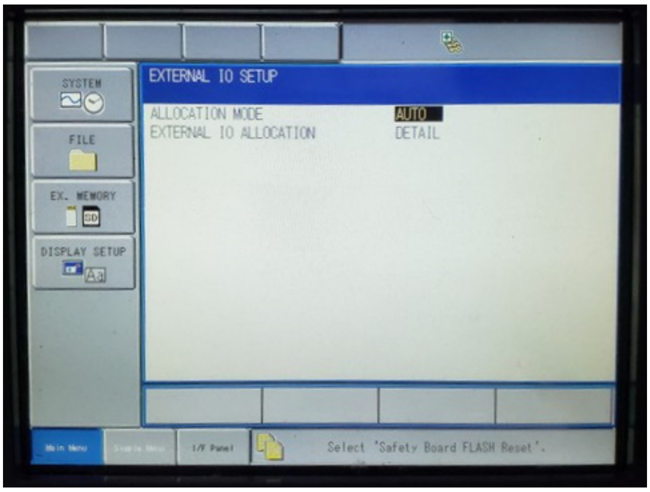


- Verify IO Auto Allocation of Specific SurfaceMeasure1008S Device

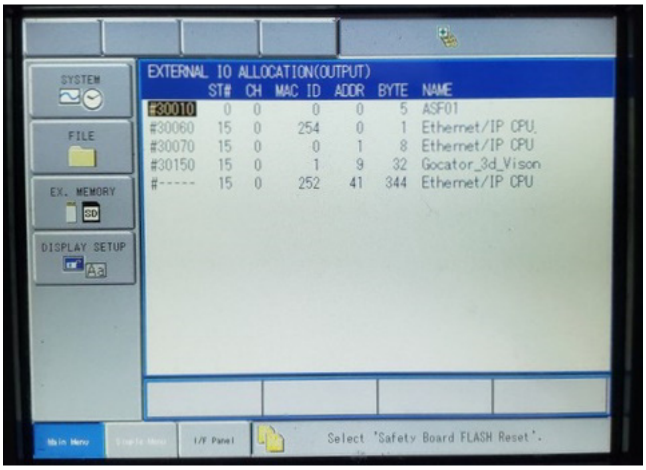
1 **Return to the Ethernet/IP CPU Board menu and accept IO module changes.**



2 **Verify that the External IO Setup Allocation mode is set to Auto.**



3 **Double-check the memory blocks for SurfaceMeasure1008S inputs and outputs are continuous and note their locations. The memory will be listed by the device name in the right-hand column. The byte allocation should match what was entered earlier in the DEVICE INFORMATION LIST.**

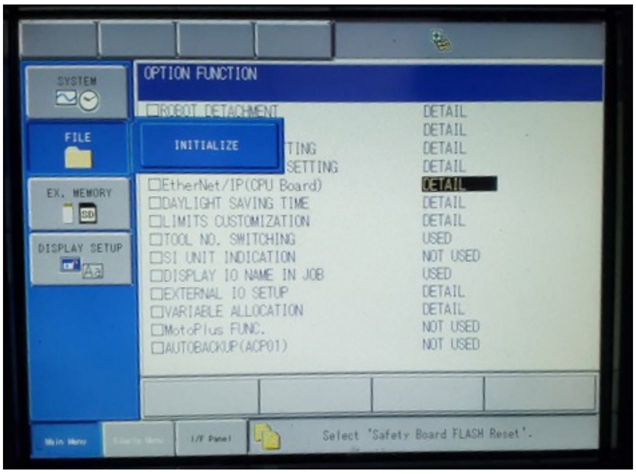


4 **Accept the changes when prompted by clicking Yes.**

Reset Safety Board Flash Memory to Save Changes

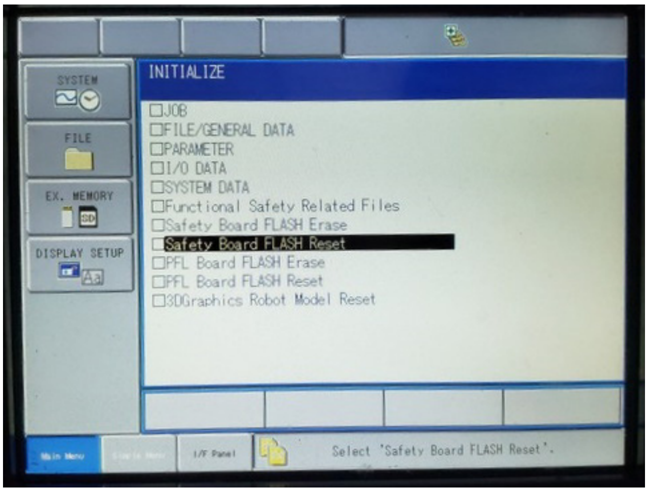
1 **Return to the Option Function menu.**

2 **Select the File menu.**

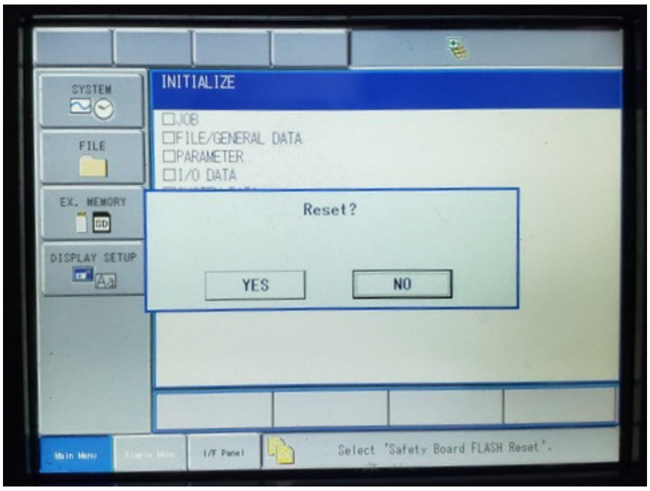


3 **Select Initialize**

4 **From the Initialize menu, highlight and select the Safety Board FLASH Reset option.**

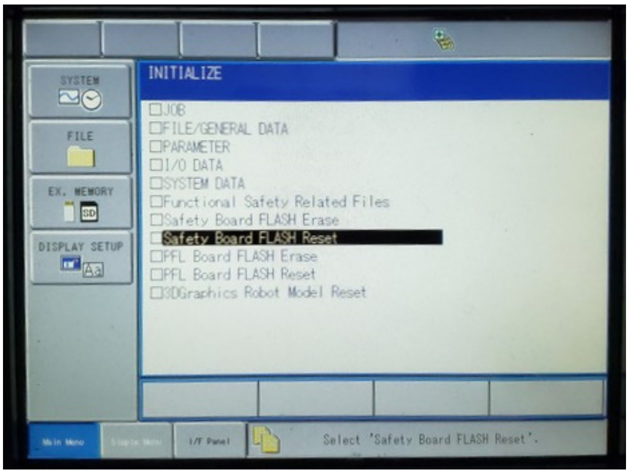


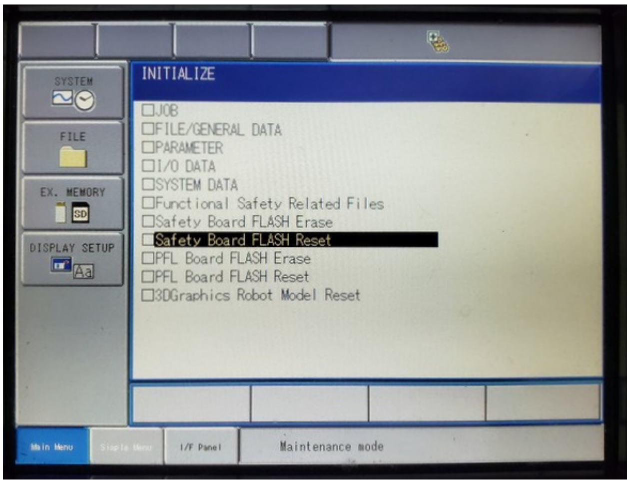
5 **When prompted, accept changes by clicking Yes.**



6 **Wait a few seconds and the flash will be reset.**

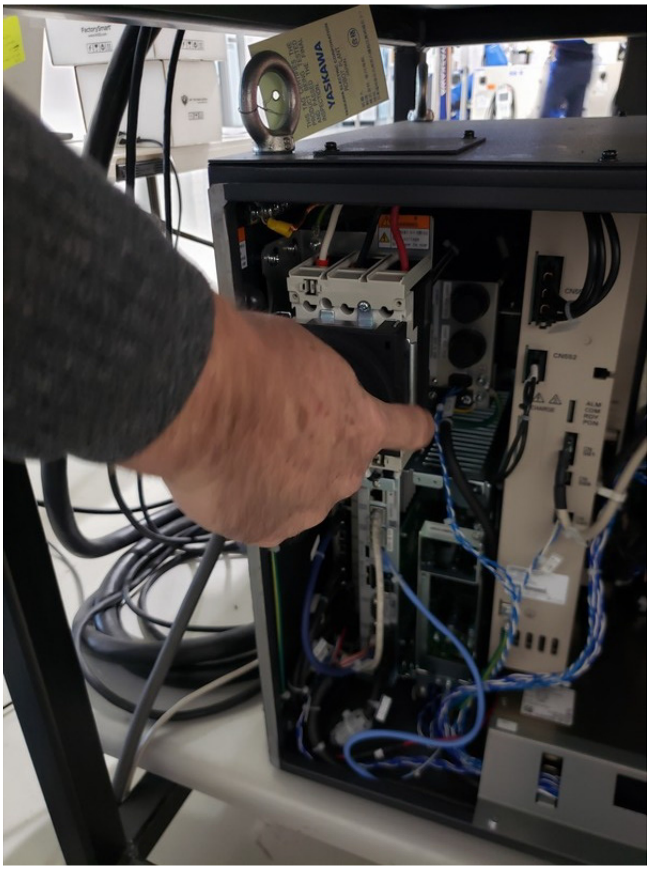
» This will be indicated when the message at the bottom of the screen changes from "Select Safety Board FLASH Reset" to "Maintenance Mode".

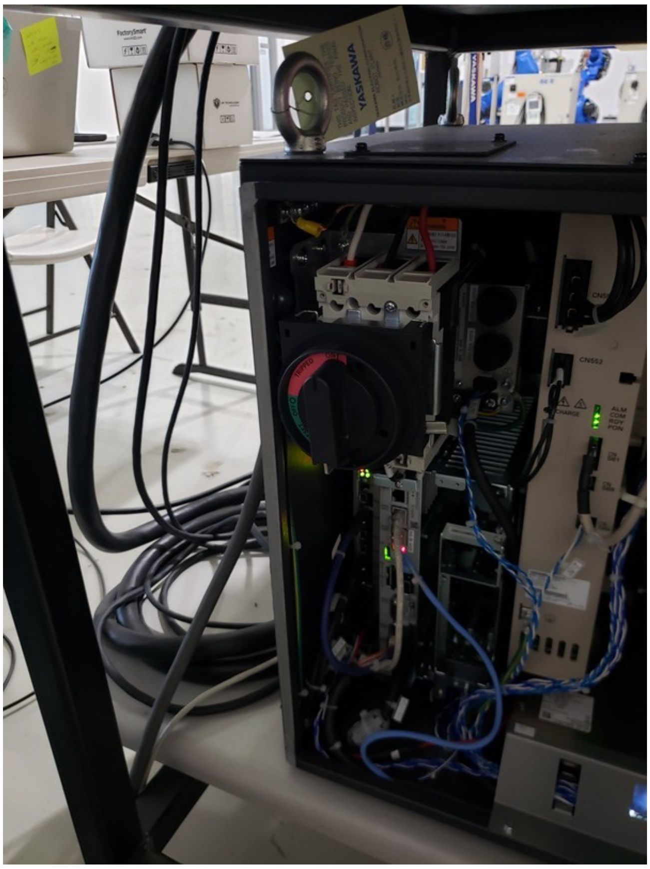




All the changes made have been saved and written to retentive memory.

7 **Power cycle the controller to power up in run mode instead of Maintenance Mode by turning the power switch 90 degrees to the right, waiting until the lights in the controller all turn off, and then turning the power switch 90 degrees to the top again.**


YASKAWA


YASKAWA

Verify Connection with Controller Ping Utility

You can verify the network connection between the robot controller and the SurfaceMeasure1008S sensor using the ping utility on the controller side.

1 **Turn on the robot controller in Run or regular operation mode.**

2 **Enter the System Info menu.**

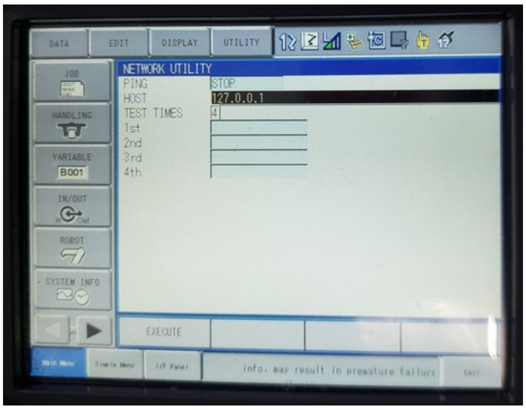
3 **Click Security.**

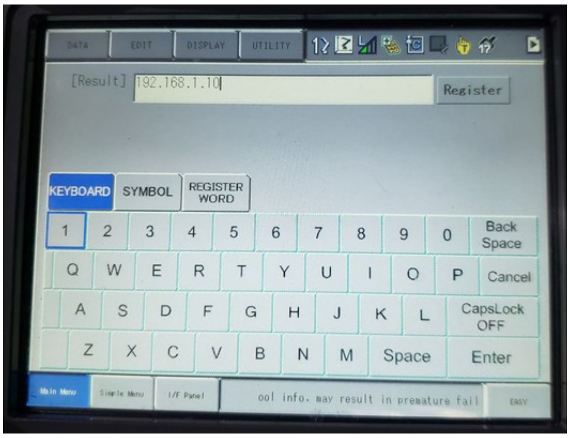
4 **Select Editing Mode from the Mode dropdown box.**

5 **When prompted for the Security password, enter 5 until the entire password text box is full, and press Enter.**

6 **Select Network Utility from the System Info menu.**

7 **In the Network Utility, enter the IP address of SurfaceMeasure1008S.**

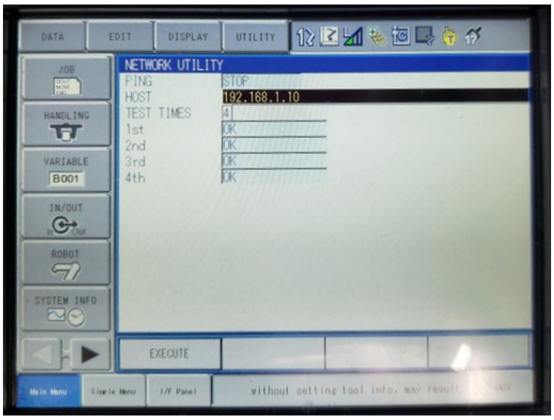




8 **Highlight the Execute button and press Enter.**

» A certain number of PING attempts will bel executed to see if the network will allow any communication at all between the SurfaceMeasure1008S sensor and the robot controller.

Ideally, you will receive all OK return messages.

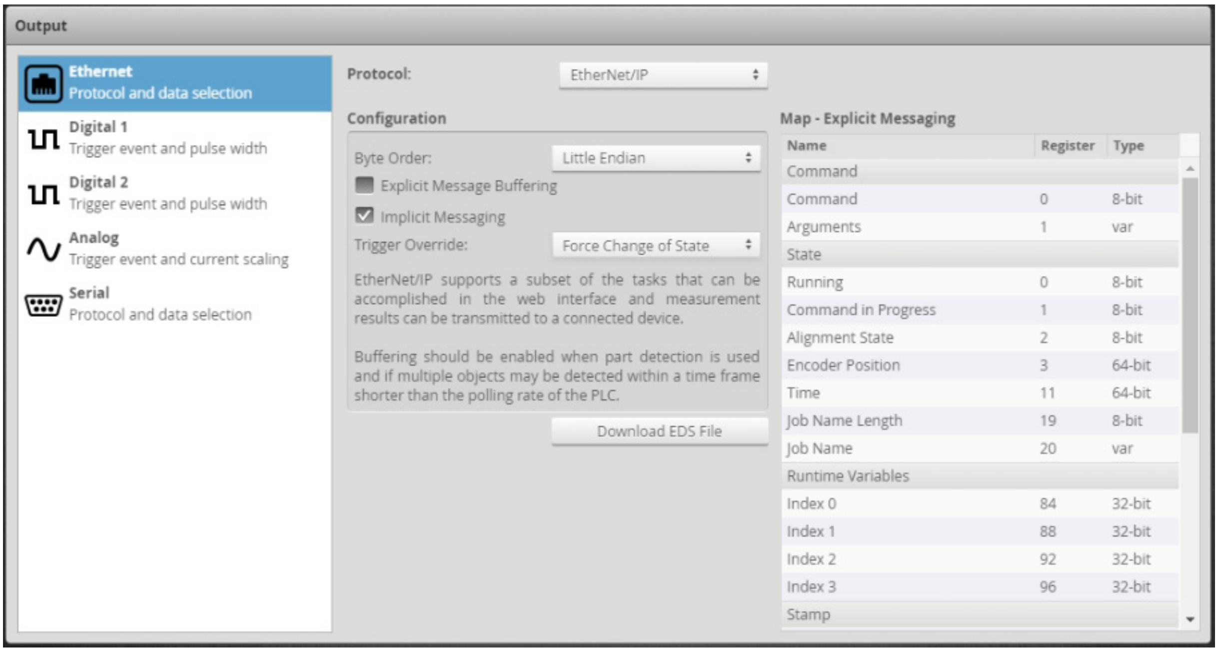


- ## Setting Up Change of State Implicit Messaging

To set up the robot controller to communicate with a SurfaceMeasure1008S using Change of State implicit messaging, an event task must be created in the controller to rapidly check whether the sensor is running; if the frame count increases, data is copied to an array. The event task period must allow the event task to be executed at a higher rate than SurfaceMeasure1008S frame rate.

- Sensor Setup

1 In SurfaceMeasure1008S, set Trigger Override to Force Change of State.



- Robot Controller Setup

*********THIS SECTION HAS NOT BEEN UPDATED FOR YASKAWA CONTROLLER SETUP**********

Using the Implicit Messaging SurfaceMeasure1008S Command Assembly

The Output Message format (from robot controller to SurfaceMeasure1008S) is used to control the sensor through implicit messaging, where this message is sent from the controller to the SurfaceMeasure1008S continuously at the user-requested Request Packet Interval (RPI) on the controller side. The default SurfaceMeasure1008S RPI is 10ms.

In logic programming, the standard practice is to use bits instead of sending a value representing that command, for example, start/stop bits. When using values such as integers, the controller needs to add more code to convert it to bits and vice versa.

Since the SurfaceMeasure1008S does not allow parallel commands, a priority scheme is needed to handle multiple command bits being set at the same time. Only the bit with the highest priority will be accepted as the command.

The total command message size is 32 bytes. For information on the command assembly structure, see "• Implicit Messaging Command Assembly" on page 830.

It's important to understand that because the SurfaceMeasure1008S is driven internally by its own clock, and because users can configure the SurfaceMeasure1008S for any frame rate-independently of the RPI request configured on the controller-Cyclic implicit messaging can cause unnecessary data loss if the two clocks are not synchronized. Using Change of State implicit messaging instead can overcome this issue. For instructions on how to set up Change of State implicit messaging, see "• Setting Up Change of State Implicit Messaging" on page 906

Starting a Sensor

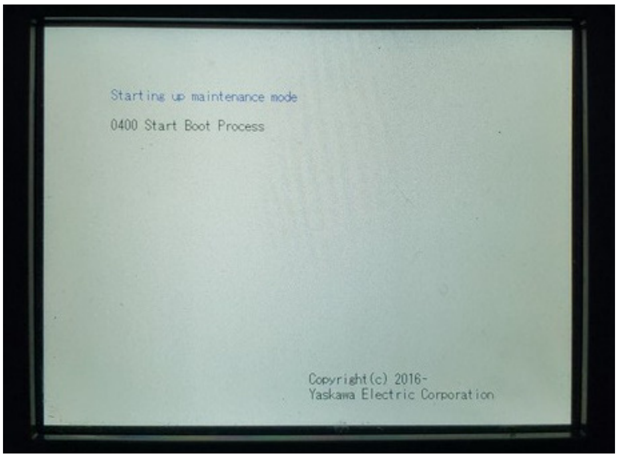
Starting the sensor using the output assembly from the robot controller can be tested very simply at the bit-level.

1 In Run mode, select the IN/OUT menu.

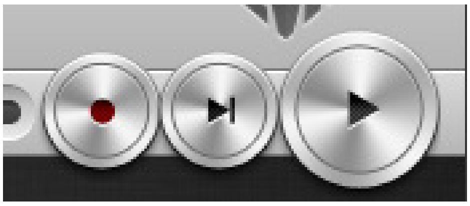
2 Select the External Input button.

Notice in the External Inputs that the 0th bit of 0th byte is value 0 indicating that the sensor is not running.

3 **Go to a web browser and type in the sensor IP address to the URL bar. This should load the sensor web GUI.**

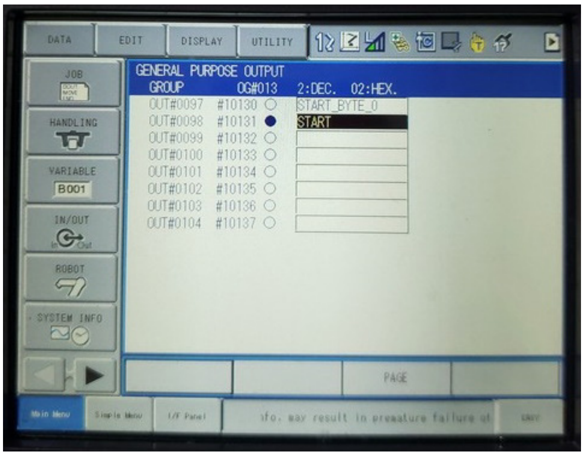


Notice in the web browser that the sensor is not currently started.



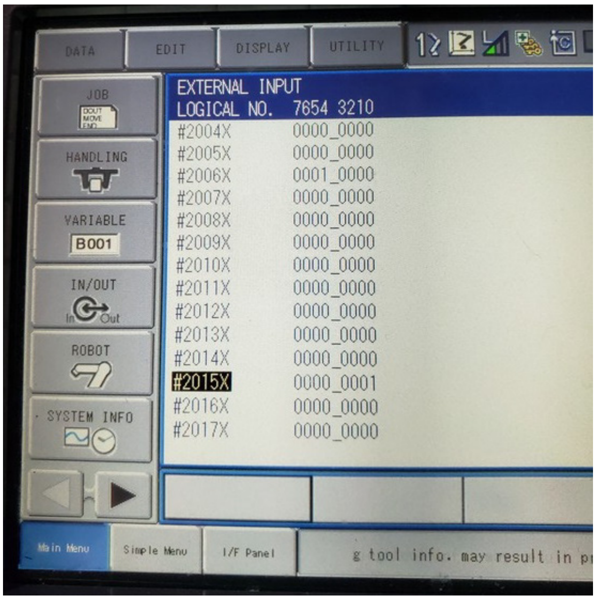
4 **Return to the In/Out menu and select General Purpose Outputs menu.**

5 **Toggle the 1st bit of the 0th byte of the SurfaceMeasure1008S Output Assembly from bit value 0 to bit value 1 (i.e. the Command byte will equal uint value 2 with the other 7 bits OFF) to transmit a Start sensor command.**

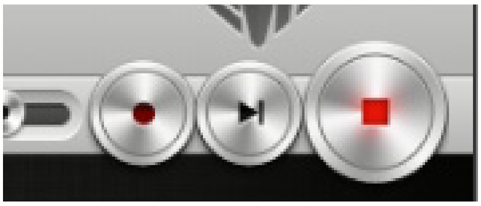


6 **Verify that the sensor started in the External Inputs menu.**

» The 0th bit of the 0th byte should change from 0 to 1.



7 **Verify that the sensor started in the sensor web GUI. If the Run button is a red square, then the sensor was successfully started.**



This process can be repeated to stop the sensor, clear alignment, start moving alignment, start stationary alignment, or issue a software trigger by typing the proper integer value into the Command byte of the Output assembly. For additional commands and control options, please refer to the manual section for the Output Assembly or the sample Studio 5000 job file.

Loading a Sensor Job File

1 **Load the sample controller program provided in the** [Appendix A - Load Job on Sensor Sample Text Code]() **or similar code**

Executing this code will attempt to load onto the SurfaceMeasure1008S a job titled "1.job"

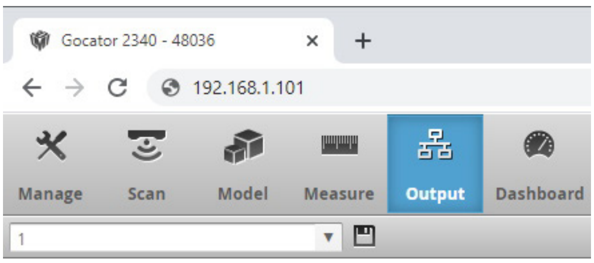
It is important to remember that the values that indicate the name of the job on the sensor must be entered as the DEC equivalent of the ASCII code. In the sample 1.job is entered as shown below:

ASCII	DEC
1	49
.	46
j	106
o	111
b	98
remaining	0

It is very important to clear the job-to-load positions once you have loaded the job you need to ensure that no errors occur during the next job load.

» If the job load is successful, the name that was entered as ASCII characters converted to DEC values will be shown in the web GUI in the loaded job box.

You may have to refresh the web GUI if it was already loaded to see the change after the program was executed.



- Explicit Messaging

*********THIS SECTION HAS NOT BEEN UPDATED FOR YASKAWA CONTROLLER SETUP**********

- Load Job on Sensor Sample Text Code

Paste this text into a .JBI file, and you will be able to load it into the robot controller. This sample shows the text file for loading a SurfaceMeasure1008S job titled "1.job" without the quotations.

```
/JOB
//NAME 1
//POS
///NPOS 0,0,0,0,0,0
//INST
///DATE 2020/02/07 12:27
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OG#(14) 49
DOUT OG#(15) 46
DOUT OG#(16) 106
DOUT OG#(17) 111
DOUT OG#(18) 98
DOUT OG#(19) 0
DOUT OG#(20) 0
DOUT OG#(21) 0
DOUT OG#(22) 0
DOUT OG#(23) 0
DOUT OG#(24) 0
DOUT OG#(25) 0
DOUT OG#(26) 0
DOUT OG#(27) 0
DOUT OG#(28) 0
DOUT OG#(29) 0
DOUT OG#(30) 0
DOUT OG#(31) 0
DOUT OG#(32) 0
DOUT OG#(33) 0
DOUT OG#(34) 0
DOUT OG#(35) 0
DOUT OG#(36) 0
DOUT OG#(37) 0
DOUT OG#(38) 0
DOUT OG#(39) 0
```

```
DOUT OG#(40) 0
DOUT OG#(41) 0
DOUT OG#(42) 0
DOUT OG#(43) 0
DOUT OG#(44) 0
DOUT OG#(13) 64
PAUSE
PAUSE
DOUT OG#(13) 0
DOUT OG#(14) 0
DOUT OG#(15) 0
DOUT OG#(16) 0
DOUT OG#(17) 0
DOUT OG#(18) 0
DOUT OG#(19) 0
DOUT OG#(20) 0
DOUT OG#(21) 0
DOUT OG#(22) 0
DOUT OG#(23) 0
DOUT OG#(24) 0
DOUT OG#(25) 0
DOUT OG#(26) 0
DOUT OG#(27) 0
DOUT OG#(28) 0
DOUT OG#(29) 0
DOUT OG#(30) 0
DOUT OG#(31) 0
DOUT OG#(32) 0
DOUT OG#(33) 0
DOUT OG#(34) 0
DOUT OG#(35) 0
DOUT OG#(36) 0
DOUT OG#(37) 0
DOUT OG#(38) 0
DOUT OG#(39) 0
DOUT OG#(40) 0
DOUT OG#(41) 0
DOUT OG#(42) 0
DOUT OG#(43) 0
DOUT OG#(44) 0
DOUT OG#(13) 0
END
```

10.1.4 PROFINET Protocol

PROFINET is an Industrial Ethernet network protocol that allows controllers such as PLCs to communicate with sensors. Sensors are PROFINET IO devices with Conformance Class A.

Tips
The emulator and accelerator (software and GoMax) do not support the PROFINET protocol.

This section describes the PROFINET modules that let a controller do the following:

- Switch jobs.
- Align and run sensors.
- Receive sensor states, stamps, and measurement results.
- Set and retrieve runtime variables.

To use the PROFINET protocol, it must be enabled and configured in the active job. For information on configuring the protocol using the Web interface, see 📖 "4.8.2 Ethernet Output" on page 327.

■ Control Module

The client sends the Control module to the sensor. The length of the Control module is 256 bytes. Unused space is for future expansion.

Control Module Elements

Byte Index	Type	Description
0	Command Register	Takes a 8-bit command as given in the table below.
1-64	Command Parameters. (Job filename in the case of command 5)	For command 5, these registers contains the null terminated job file name. The ".job" extension is optional.

Command Definitions

Value	Name	Description
0	Stop running	Stop the sensor. If already stopped, do nothing
1	Start Running	Start the sensor. If already running, do nothing
2	Stationary Alignment	Start the stationary alignment process. State register 301 will be set to 1 (busy) until the alignment process is complete, then back to zero.
3	Moving Alignment	Start the moving alignment process. State register 301 will be set to 1 (busy) until the alignment process is complete, then back to zero.
4	Clear Alignment	Clear the alignment
5	Load Job	Set bytes 1 - 64 for the null terminated file name, one file name character per 8-bit register, including the null terminator character. The ".job" extension is optional. If the extension is missing, it is automatically appended to the file name.
6	Set Runtime Variables	The runtime variables are expected to be sent in the Runtime Variables module. The runtime variables are not included as part of the Control module.

Value	Name	Description
7	Software trigger	Software trigger the sensor to capture one frame. The sensor must already be running, in trigger mode “Software”. Otherwise, software trigger has no effect.

Runtime Variables Module

The length of the Runtime Variables module is 16 bytes. The client sends the variables to the sensor in big endian format.

Byte Index	Name	Data Type	Description
0-3	Runtime Variable 0	32s	Stores the intended value of the Runtime Variable at index 0.
4-7	Runtime Variable 1	32s	Stores the intended value of the Runtime Variable at index 1.
8-11	Runtime Variable 2	32s	Stores the intended value of the Runtime Variable at index 2.
12-15	Runtime Variable 3	32s	Stores the intended value of the Runtime Variable at index 3.

State Module

The length of the State module is 116 bytes. The sensor sends the module to the client. The runtime variables are received from the sensor in big endian format. The extra unused space is for future expansion.

Byte Index	Name	Data Type	Description
0	Sensor state		0= stopped, 1 = running
1	Command in progress		1 when the sensor is busy performing the last command, 0 when done. Bytes 2, 19->83 below are only valid when there is no command in progress
2	Alignment State		0 - not calibrated, 1 calibrated (valid when byte 1 = 0)
3-10	Encoder Position	64s	Encoder position
11-18	Time	64s	Timestamp
19	Current Job filename length	8u	Number of characters in the current job filename. (eg. 11 for “current.job”) (valid when byte 1 = 0)
20-83	Current job filename		Name of currently loaded job, including extension. Each byte contains a single character. Max 64 bytes. (valid when byte 1 = 0)
84-87	Runtime Variable 0	32s	Runtime variable value at index 0
…	…		
96-99	Runtime Variable 3	32s	Runtime variable value at index 3

■ Stamp Module

The length of the Stamp module is 45 bytes. The sensor sends the module to the client. The extra unused space is for future expansion.

Byte Index	Name	Data Type	Description
0-1	Inputs	16u	Digital input state of the last frame.
2-9	zPosition	64u	Encoder position at time of last index pulse of the last frame.
10-13	Exposure	32u	Laser exposure in μs of the last frame.
14-17	Temperature	32u	Sensor temperature in degrees celsius * 100 (centidegrees) of the last frame.
18-25	Encoder Position	64u	Encoder position of the last frame when the image data was scanned/taken.
26-33	Time	64u	Time stamp in microseconds of the last frame.
34-41	Frame Count	64u	The frame number of the last frame.

■ Measurements Module

The length of the Measurement module is 800 bytes. The sensor sends the module to the client. The measurements and decisions are sent in big endian format only. Each measurement plus decision takes 5 bytes so this module can hold a maximum of 800/5 = 160 measurements + decisions.

Byte Index	Name	Data Type	Description
0-3	Measurement 0	32s	measurement value (0x80000000 if invalid)
4	Decision 0	8u	Measurement decision is a bit mask where: Bit 0: 1 – Pass, 0 – Fail Bits [1-7]: 0 – Measurement value OK 1 – Invalid Value 2 – Invalid Anchor
5-8	Measurement 1		
9	Decision 1		
...	...		
795-798	Measurement 159		
799	Decision 159		

Tips

The byte mapping of each measurement/decision pair depends on its ID as specified in the measurement interface. Each measurement will begin at byte (0 + 5*ID). For example, a measurement with ID set to 4 can be read from bytes 20 (high byte) to 23 (low byte) and the decision at 24.

10.1.5 ASCII Protocol

This section describes the ASCII protocol.

The ASCII protocol is available over either serial output or Ethernet output. Over serial output, communication is asynchronous (measurement results are automatically sent on the Data channel when the sensor is in the running state and results become available). Over Ethernet, communication can be asynchronous or can use polling. For more information on polling commands, see 📖 "■Polling Operation Commands (Ethernet Only)" on page 918.

The protocol communicates using ASCII strings. The output result format from the sensor is user-configurable.

To use the ASCII protocol, it must be enabled and configured in the active job.

For information on configuring the protocol with the Web interface (when using the protocol over Ethernet), see 📖 "4.8.2 Ethernet Output" on page 327.

For information on configuring the protocol with the Web interface (when using the protocol over Serial), see 📖 "4.8.4 Serial Output" on page 335.

■ Connection Settings

● Ethernet Communication

With Ethernet ASCII output, you can set the connection port numbers of the three channels used for communication (Control, Data, and Health):

Ethernet Ports for ASCII

Name	Description	Default Port
Control	To send commands to control the sensor.	8190
Data	To retrieve measurement output.	8190
Health	To retrieve specific health indicator values.	8190

Channels can share the same port or operate on individual ports. The following port numbers are reserved for sensor internal use: 2016, 2017, 2018, and 2019. Each port can accept multiple connections, up to a total of 16 connections for all ports.

● Serial Communication

Over serial, ASCII communication uses the following connection settings:

Serial Connection Settings for ASCII

Parameter	Value
Start Bits	1
Stop Bits	1
Parity	None
Data Bits	8
Baud Rate (b/s)	115200
Format	ASCII
Delimiter	CR

Up to 16 users can connect to the sensor for ASCII interfacing at a time. Any additional connections will remove the oldest connected user.

■ Polling Operation Commands (Ethernet Only)

Measurement results are automatically sent on the Data channel when the sensor is in the running state and results become available. The result is sent on all connected data channels. A client can:

- Switch to a different job.
- Trigger, run, and align sensors.
- Receive sensor states, health indicators, stamps, and measurement results

A sensor sends Control, Data, and Health messages over separate channels. The Control channel is used for commands such as starting and stopping the sensor, loading jobs, and performing alignment (see 📖 "●Command Channel" on page 919).

The Data channel is used to receive and poll for measurement results. When the sensor receives a Result command, it will send the latest measurement results on the same data channel that the request is received on. See 📖 "●Data Channel" on page 924 for more information.

The Health channel is used to receive health indicators (see 📖 "●Health Channel" on page 926).

● Command and Reply Format

Commands are sent from the client to the sensor. Command strings are not case sensitive. The command format is:

<COMMAND><DELIMITER><PARAMETER><TERMINATION>

If a command has more than one parameter, each parameter is separated by the delimiter. Similarly, the reply has the following format:

<STATUS><DELIMITER><OPTIONAL RESULTS><DELIMITER>

The status can either be "OK" or "ERROR". The optional results can be relevant data for the command if successful, or a text based error message if the operation failed. If there is more than one data item, each item is separated by the delimiter.

The delimiter and termination characters are configured in the Special Character settings.

Special Characters

The ASCII Protocol has three special characters.

Special Characters

Special Character	Explanation
Delimiter	Separates input arguments in commands and replies, or data items in results. Default value is ",".
Terminator	Terminates both commands and result output. Default value is "%r%n".
Invalid	Represents invalid measurement results. Default value is "INVALID"

The values of the special characters are defined in the Special Character settings. In addition to normal ASCII characters, the special characters can also contain the following format values.

Format values for Special Characters

Format Value	Explanation
%t	Tab
%n	New line
%r	Carriage return
%%	Percentage (%) symbol

Command Channel

The following sections list the actions available on the command channel.

Optional parameters are shown in italic. The placeholder for data is surrounded by brackets (<>). In the examples, the delimiter is set to ','.

- **Start**

The Start command starts the sensor system (causes it to enter the Running state). This command is only valid when the system is in the Ready state. If a start target is specified, the sensor starts at the target time or encoder (depending on the trigger mode).

Formats

Message	Format
Command	Start,*start target* The start target (optional) is the time or encoder position at which the sensor will be started. The time and encoder target value should be set by adding a delay to the time or encoder position returned by the Stamp command. The delay should be set such that it covers the command response time of the Start command.
Reply	OK or ERROR, <Error Message>

Examples:

Command: Start

Reply: OK

Command: Start,1000000

Reply: OK

Command: Start

Reply: ERROR, Could not start the sensor

- **Stop**

  The stop command stops the sensor system (causes it to enter the Ready state). This command is valid when the system is in the Ready or Running state.

Formats

Message	Format
Command	Stop
Reply	OK or ERROR, <Error Message>

Examples:

Command: Stop

Reply: OK

- **Trigger**

  The Trigger command triggers a single frame capture. This command is only valid if the sensor is configured in the Software trigger mode and the sensor is in the Running state.

Formats

Message	Format
Command	Trigger
Reply	OK or ERROR, <Error Message>

Examples:

Command: Trigger

Reply: OK

- **LoadJob**

  The LoadJob command switches the active sensor configuration.

Formats

Message	Format
Command	LoadJob,job file name If the job file name is not specified, the command returns the current job name. An error message is generated if no job is loaded. ".job" is appended if the filename does not have an extension.
Reply	OK or ERROR, <Error Message>

Examples:

Command: LoadJob,test.job

Reply: OK,test.job loaded successfully

Command: LoadJob

Reply: OK,test.job

Command: LoadJob,wrongname.job

Reply: ERROR, failed to load wrongname.job

- **Stamp**

The Stamp command retrieves the current time, encoder, and/or the last frame count.

Formats

Message	Format
Command	Stamp,time,encoder,frame If no parameters are given, time, encoder, and frame will be returned. There could be more than one selection.
Reply	If no arguments are specified: OK, time, <time value>, encoder, <encoder position>, frame, <frame count> ERROR, <Error Message> If arguments are specified, only the selected stamps will be returned.

Examples:

Command: Stamp

Reply: OK,Time,9226989840,Encoder,0,Frame,6

Command: Stamp,frame

Reply: OK,6

- **Clear Alignment**

The Clear Alignment command clears the alignment record generated by the alignment process.

Formats

Message	Format
Command	ClearAlignment
Reply	OK or ERROR, <Error Message>

Examples:

Command: ClearAlignment

Reply: OK

- **Moving Alignment**

  The Moving Alignment command performs an alignment based on the settings in the sensor's live job file. A reply to the command is sent when the alignment has completed or failed. The command is timed out if there has been no progress after one minute.

Formats

Message	Format
Command	MovingAlignment
Reply	If no arguments are specified OK or ERROR, <Error Message>

Examples:

Command: MovingAlignment

Reply: OK

Command: MovingAlignment

Reply: ERROR, ALIGNMENT FAILED

- **Stationary Alignment**

  The Stationary Alignment command performs an alignment based on the settings in the sensor's live job file. A reply to the command is sent when the alignment has completed or failed. The command is timed out if there has been no progress after one minute.

Formats

Message	Format
Command	StationaryAlignment
Reply	If no arguments are specified OK or ERROR, <Error Message>

Examples:

Command: StationaryAlignment

Reply: OK

Command: StationaryAlignment

Reply: ERROR,ALIGNMENT FAILED

- **Set Runtime Variables**

  The Set Runtime Variables command sets the runtime variables, using the specified index, length, and data. Values are integers.

Formats

Message	Format
Command	setvars,index,length,data Where data is the delimited integer values to be set.
Reply	OK or ERROR

Examples:

Command: setvars,0,4,1,2,3,4

Reply: OK

- **Get Runtime Variables**

  The Get Runtime Variables command gets the runtime variables, using the specified index and length.

Formats

Message	Format
Command	setvars,index,length
Reply	OK,data Where data is the delimited data for the passed length.

Examples:

Command: getvars,0,4

Reply: OK,1,2,3,4

Data Channel

The following sections list the actions available on the data channel.

Optional parameters are shown in italic. The placeholder for data is surrounded by brackets (<>). In the examples, the delimiter is set to ','.

- **Result**

The Result command retrieves measurement values and decisions.

Formats

Message	Format
Command	Result,measurement ID,measurement ID...
Reply	If no arguments are specified, the custom format data string is used. OK, <custom data string> ERROR, <Error Message> If arguments are specified, OK, <data string in standard format> ERROR, <Error Message>

Examples:

Standard data string for measurements ID 0 and 1:

Command: Result,0,1

Reply: OK,M00,00,V151290,D0,M01,01,V18520,D0

Standard formatted measurement data with a non-existent measurement of ID 2:

Command: Result,2

Reply: ERROR,Specified measurement ID not found. Please verify your input

Custom formatted data string (%time, %value[0], %decision[0]):

Command: Result

Reply: OK,1420266101,151290,0

- **Value**

The Value command retrieves measurement values.

Formats

Message	Format
Command	Value,measurement ID,measurement ID...
Reply	If no arguments are specified, the custom format data string is used. OK, <custom data string> ERROR, <Error Message> If arguments are specified, OK, <data string in standard format, except that the decisions are not sent> ERROR, <Error Message>

Examples:

Standard data string for measurements ID 0 and 1:

Command: Value,0,1

Reply: OK,M00,00,V151290,M01,01,V18520

Standard formatted measurement data with a non-existent measurement of ID 2:

Command: Value,2

Reply: ERROR,Specified measurement ID not found. Please verify your input

Custom formatted data string (%time, %value[0]):

Command: Value

Reply: OK, 1420266101, 151290

- **Decision**

  The Decision command retrieves measurement decisions.

Formats

Message	Format
Command	Decision,measurement ID,measurement ID...
Reply	If no arguments are specified, the custom format data string is used. OK, <custom data string> ERROR, <Error Message> If arguments are specified, OK, <data string in standard format, except that the values are not sent> ERROR, <Error Message>

Examples:

Standard data string for measurements ID 0 and 1:

Command: Decision,0,1

Reply: OK,M00,00,D0,M01,01,D0

Standard formatted measurement data with a non-existent measurement of ID 2:

Command: Decision,2

Reply: ERROR,Specified measurement ID not found. Please verify your input

Custom formatted data string (%time, %decision[0]):

Command: Decision

Reply: OK,1420266101, 0

● Health Channel

The following sections list the actions available on the health channel.

Optional parameters are shown in italic. The placeholder for data is surrounded by brackets (<>). In the examples, the delimiter is set to ','.

- **Health**

The Health command retrieves health indicators. See "●Health Results" on page 811 for details on health indicators.

Formats

Message	Format
Command	Health,health indicator ID.Optional health indicator instance ... More than one health indicator can be specified. Note that the health indicator instance is optionally attached to the indicator ID with a '.'. If the health indicator instance field is used the delimiter cannot be set to '.'.
Reply	OK, <health indicator of first ID>, <health indicator of second ID> ERROR, <Error Message>

Examples:

Command: health,2002,2017

Reply: OK,46,1674

Command: Health

Reply: ERROR,Insufficient parameters.

■ Standard Result Format

A sensor can send measurement results either in the standard format or in a custom format. In the standard format, you select in the web interface which measurement values and decisions to send. For each measurement the following message is transmitted:

M	tn	,	in	,	V	vn	,	D	d1	CR

Field	Shorthand	Length	Description
Measurement-Start	M	1	Start of measurement frame.
Type	tn	n	Hexadecimal value that identifies the type of measurement. The measurement type is the same as defined elsewhere (see "●Data Results" on page 798).
Id	in	n	Decimal value that represents the unique identifier of the measurement.
ValueStart	V	1	Start of measurement value.
Value	vn	n	Measurement value, in decimal. The unit of the value is measurement-specific.
DecisionStart	D	1	Start of measurement decision.

Field	Shorthand	Length	Description
Decision	d1	1	Measurement decision, a bit mask where: Bit 0: 1 – Pass 0 – Fail Bits 1-7: 0 – Measurement value OK 1 – Invalid value 2 - Invalid anchor

■ Custom Result Format

In the custom format, you enter a format string with place holders to create a custom message. The default format string is "%time, %value[0], %decision[0]".

Result Placeholders

Format Value	Name	Explanation
%time	Time	Timestamp in microseconds of the last frame.
%encoder	Encoder Position	Encoder position of the last frame when the image data was scanned/taken.
%frame	Frame Index	Frame number of the last frame.
%value[Measurement ID]	Value	Measurement value of the specified measurement ID. The ID must correspond to an existing measurement. The value output will be displayed as an integer in micrometers.
%decision[Measurement ID]	Decision	Measurement decision, where the selected measurement ID must correspond to an existing measurement. Measurement decision is a bit mask where: Bit 0: 1 – Pass 0 – Fail Bits 1-7: 0 – Measurement value OK 1 – Invalid value 2 - Invalid anchor

C language printf-style formatting is also supported: for example, %sprintf[%09d, %value[0]]. This allows fixed length formatting for easier input parsing in PLC and robot controller logic.

10.2 GenICam GenTL Driver

GenICam is an industry standard for controlling and acquiring data from an imaging device. SurfaceMeasure1008S sensors support GenICam through a GenTL Producer driver.

The included GenTL driver allows GenICam-compliant third-party software applications such as Halcon and Common Vision Blox to acquire and process 3D data and intensity generated from the sensor.

The following sensor scan modes are supported:

- Video
- Profile (with [Uniform Spacing] disabled). In this mode, the raw profiles are resampled and accumulated into a surface.
- Surface (with [Uniform Spacing] enabled)

For more information on scan modes and uniform spacing, see 📖 "4.4.2 Scan Modes" on page 116.

Tips

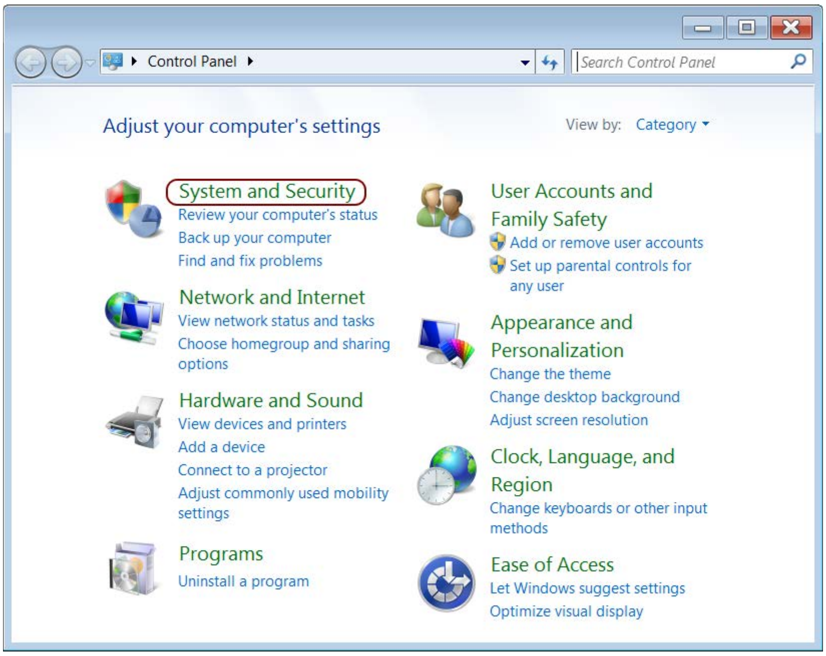
To use these third-party software applications, you must configure a system variable so the software can access the GenTL driver. For instructions, see To configure system variables to use the driver in Windows 10, below.

To get the utilities package containing the driver (14405-x.x.xx.x_SOFTWARE_Utilities_SM1008S.zip), go to https://www2.mitutoyo.co.jp/eng/contact/products/sm1008s/, choose your product from the Product Downloads section, and download it from the Download Center.

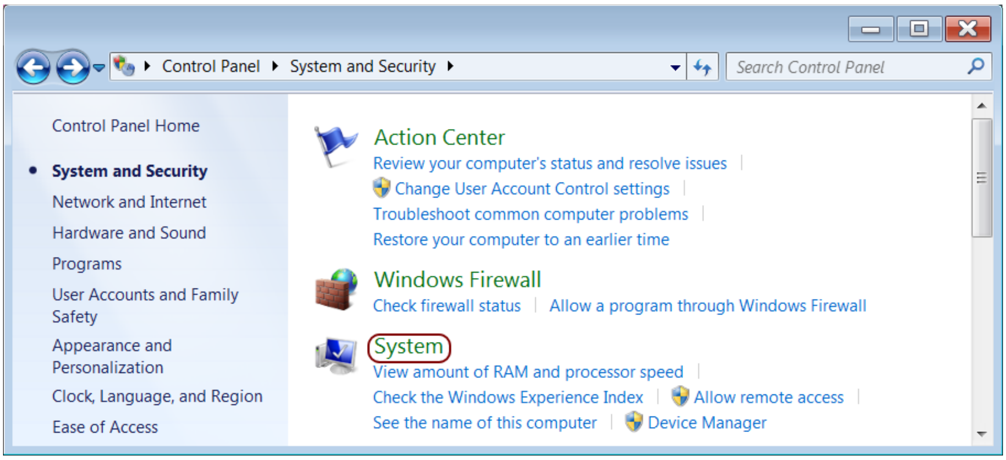
After downloading the package and unzipping the file to a location you will remember, you will find the driver in the GenTL\x86 or GenTL\x64 subfolder under Integration > GenTL (you can move the GenTL folder to a more convenient location).

To configure system variables to use the driver in Windows 10:

1 From the Start menu, open the ［Control］ panel and then click ［System and Security］.

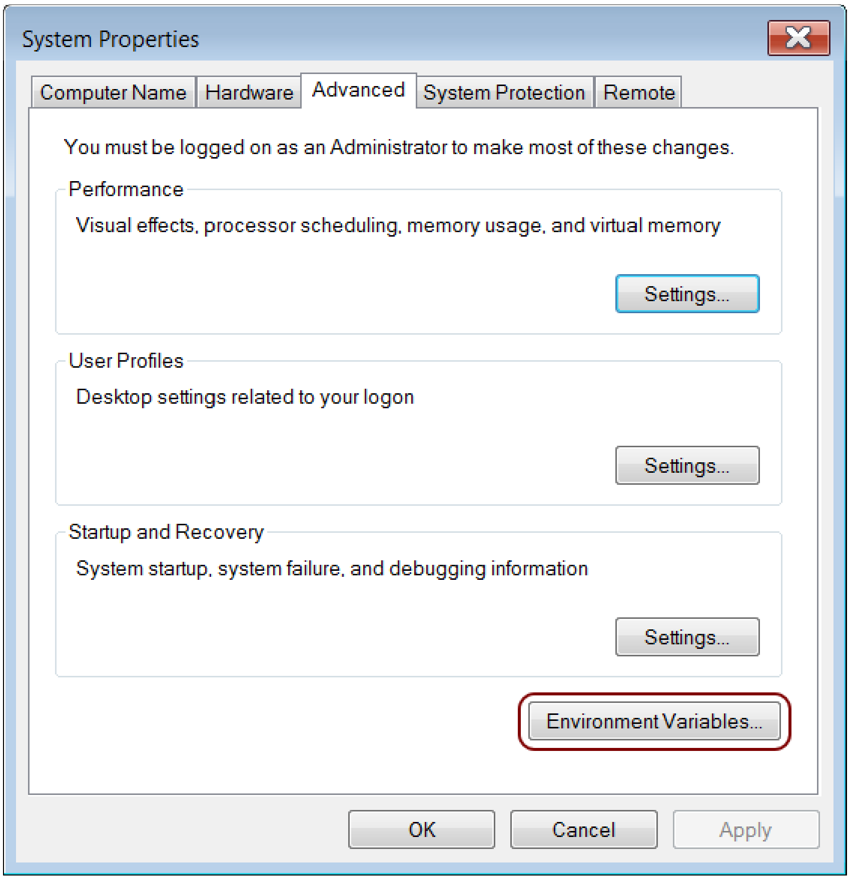


1 Click ［System］.

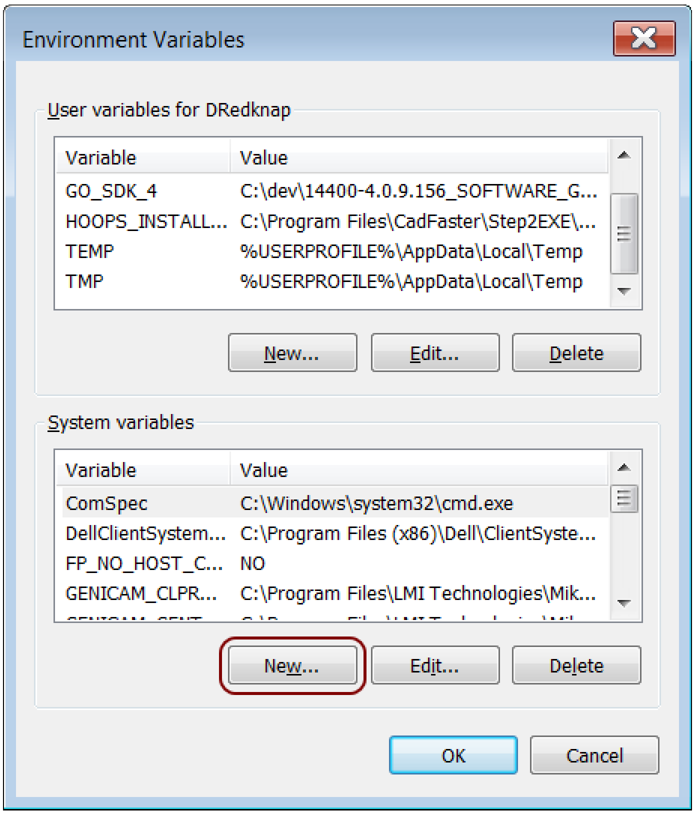


2 Click ［Advanced System Settings］.

2 **In the [System Properties] dialog, on the [Advanced] tab, click [Environment Variables]...**

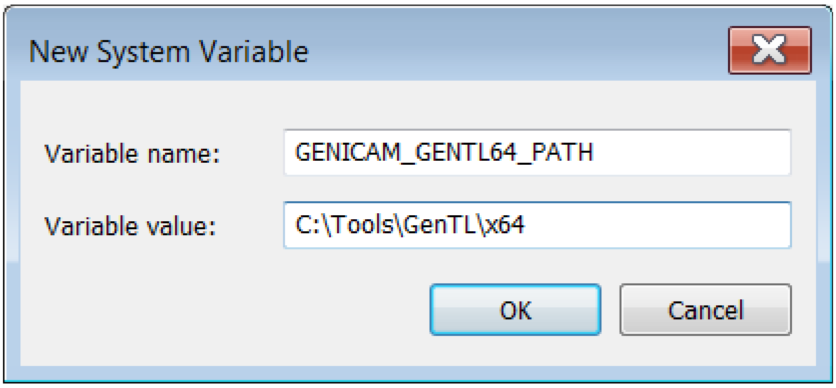


3 **In the [Environment Variables] dialog, under the [System variables] list, click [New].**



4 In the [New System Variable] dialog, enter the following information, depending on your system:

	Variable name	Variable value
32-bit system	GENICAM_GENTL32_PATH	The full path to the GenTL\x86 folder.
64-bit system	GENICAM_GENTL64_PATH	The full path to the GenTL\x64 folder.



5 Click OK in the dialogs until they are all closed.

To work with the GenTL driver, the sensor must operate with the appropriate output enabled in the [Ethernet] panel in the [Output] page. Check [Acquire Intensity] in the [Scan Mode] panel on the [Scan] page and enable intensity output in the [Ethernet] panel if intensity data is required.

The GenTL driver packs the output, intensity, and stamps (e.g., time stamp, encoder index, etc.) into either a 16-bit RGB image or a 16-bit grey scale image. You can select the format in the Go2GenTL.xml setting file.

The width and height of the 16-bit RGB or grey scale image is calculated from the maximum number of columns and rows needed to accommodate the sensor's field of view and the maximum part length.

10.2.1 16-bit RGB Image

When the 16-bit RGB format is used, the height map, intensity, and stamps are stored in the red, green, and blue channel respectively.

Channel	Details
Red	Height map information. The width and height of the image represent the dimensions in the X and Y axis. Together with the pixel value, each red pixel presents a 3D point in the real-world coordinates. The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz): X = X offset + Px * X resolution Y = Y offset + Py * Y resolution Z = Z offset + Pz * Z resolution Refer to the blue channel on how to retrieve the offset and resolution values. If Pz is 0 if the data is invalid. The Z offset is fixed to -32768 * Z resolution. Z is zero if Pz is 32768.
Green	Intensity information. Same as the red channel, the width and height of the image represent the dimension in the X and the Y axis. Together with the pixel value, each blue pixel represents an intensity value in the real-world coordinates. The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz): X = X offset + Px * X resolution Y = Y offset + Py * Y resolution Z = 16-bit intensity value The intensity value is 0 if the intensity image is not available. SurfaceMeasure1008S outputs 8-bit intensity values. The values stored in the 16-bit RGB image is multiplied by 256. To obtain the original values, divide the intensity values by 256. Refer to the blue channel on how to retrieve the offset and resolution values.
Blue	Stamp information. Stamps are 64-bit auxiliary information related to the height map and intensity content. The next table explains how the stamps are packed into the blue pixel channel See 📖 "●Data Results" on page 798 for an explanation of the stamp information.

The following table shows how the stamp information is packed into the blue channel. A stamp is a 64-bit value packed into four consecutive 16-bit blue pixels, with the first byte position storing the most significant byte.

Stamp Information from GenTL driver

Stamp Index	Blue Pixel Position	Details
0	0..3	Version
1	4..7	Frame Count
2	8..11	Timestamp (μs)
3	12..15	Encoder value (ticks)
4	16..19	Encoder index (ticks) This is the encoder value when the last index is triggered
5	20..23	Digital input states
6	24..27	X offset (nm)
7	28..31	X resolution(nm)
8	32..35	Y offset (nm)
9	36..39	Y resolution (nm)
10	40..43	Z offset (nm)
11	44..47	Z resolution (nm)
12	48..51	Height map Width (in pixels)
13	52..55	Height map length (in pixels)
14	56..59	Specify if the intensity is enabled

10.2.2 16-bit Grey Scale Image

When the 16-bit grey scale format is used, the height map, intensity, and stamps are stored sequentially in the grey scale image.

The last row of the image contains the stamp information.

Rows	Details
0 .. (max part height - 1)	Height map information. The width and height of the image represent the dimensions in the X and Y axis. Together with the pixel value, each pixel presents a 3D point in the real-world coordinates. The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz): X = X offset + Px * X resolution Y = Y offset + Py * Y resolution Z = Z offset + Pz * Z resolution Refer to the blue channel on how to retrieve the offset and resolution values. If Pz is 0 if the data is invalid. The Z offset is fixed to -32768 * Z Resolution. Z is zero if Pz is 32768.

Rows	Details
(max part height) .. 2* (max part height) If intensity is enabled	Intensity information. The width and height of the image represent the dimension in the X and the Y axis. Together with the pixel value, each blue pixel represents an intensity value in the real-world coordinates. The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz): The following formula assumes Py is relative to the first row of the intensity information, not the first row of the whole 16-bit grey scale image. X = X offset + Px * X resolution Y = Y offset + Py * Y resolution Z = 16-bit intensity value This intensity value is 0 if the intensity image is not available. SurfaceMeasure1008S outputs 8-bit intensity values. The values stored in the 16-bit Grey scale image is multiplied by 256. To obtain the original values, divide the intensity values by 256. Refer to the stamps on how to retrieve the offset and resolution values.
The last row of the 16-bit grey scale image	Stamp information. Stamps are 64-bit auxiliary information related to the height map and intensity content. The next table explains how the stamps are packed into the blue pixel channel See "●Data Results" on page 798 for an explanation of the stamp information.

The following table shows how the stamp information is packed into the last row. A stamp is a 64-bit value packed into four consecutive 16-bit pixels, with the first byte position storing the most significant byte.

Stamp Information from GenTL driver

Stamp Index	Column Position	Details
0	0..3	Version
1	4..7	Frame Count
2	8..11	Timestamp (μs)
3	12..15	Encoder value (ticks)
4	16..19	Encoder index (ticks) This is the encoder value when the last index is triggered
5	20..23	Digital input states
6	24..27	X offset (nm)
7	28..31	X resolution(nm)
8	32..35	Y offset (nm)
9	36..39	Y resolution (nm)
10	40..43	Z offset (nm)
11	44..47	Z resolution (nm)
12	48..51	Height map Width (in pixels)
13	52..55	Height map length (in pixels)
14	56..59	Specify if intensity is enabled or not

10.2.3 Registers

GenTL registers are multiples of 32 bits. The registers are used to control the operation of the GenTL driver, send commands to the sensors, or to report the current sensor information.

Register Map Overview

Register Address	Name	Read/Write	Length (bytes)	Description
260	WidthReg	RO	4	Specify the width of the returned images. The part height map is truncated if it is wider than the specified width.
264	HeightReg	RO	4	Specify the height of the returned images (i.e., length of the part). The part height map is truncated if it is longer than the specified length.
292	Resample-Mode	RO	4	Enable the resampling logic in the GenTL driver 0 – Disable resampling 1 – Enable resampling When resampling is enabled, the GenTL driver will resample the height map so that the pixel spacing is the same in the X and Y axis.
296	EncoderValue0	RO	4	Report the current encoder value (least significant 32-bit). The current encoder value is latched from the sensor when this register is read.
300	EncoderValue1	RO	4	Report the current encoder value (most significant 32-bit). The encoder value is latched when EncoderValue0 register is read. User should read EncoderValue0 before reading EncoderValue1.
304	Configuration File	RW	16	Read the name of sensor live configuration file or switch (write) the sensor configuration file. The configuration name is NULL terminated and includes the extension ".job". Writing to this register causes the sensor to switch to the specified configuration.
320	Transformation X offset	RO	4	Return the sensor transformation X offset
324	Transformation Z offset	RO	4	Return the sensor transformation Z offset
328	Transformation Angle	RO	4	Return the sensor transformation angle
332	Transformation Orientation	RO	4	Return the sensor transformation orientation
336	Clearance distance	RO	4	Return the sensor clearance distance

10.2.4 XML Settings File

The settings file, Go2GenTL.xml, resides in the same directory as the SurfaceMeasure1008S GenTL driver. Users can set the resample mode and output format by changing the setting in this file.

Element	Type	Description
ResampleMode	32u	Settings to disable or enable resampling mode: 0 – Disable 1 – Enable When resampling mode is enabled, the GenTL driver will resample the height map so that the pixel spacing is the same in the X and Y axis. The default value is 1.
DataFormat	32u	Settings to choose 16-bit RGB or 16-bit grey scale image output: 0 – 16-bit RGB Image 1 – 16-bit grey scale Image The default value is 0.

10.2.5 Interfacing with Halcon

Halcon is a comprehensive software package for machine vision applications with an integrated development environment. A sensor can use the included GenTL driver to stream 3D point clouds and intensity data into Halcon in real-time.

> **Tips**
> The current GenTL driver does not support scanning in profile mode.

For information on setting up the GenTL driver, see "10.2 GenICam GenTL Driver" on page 928.

This section describes how to configure Halcon to acquire data from the 4.x firmware. You should be familiar with the sensor's Surface mode. Before continuing, make sure Halcon is installed.

Requirements

Sensor	Laser profile sensor
Firmware	Firmware 4.0.9.136 or later
Halcon	Version 10.0 or later

■ Setting Up Halcon

Before using Halcon with a sensor, you must set up Halcon.

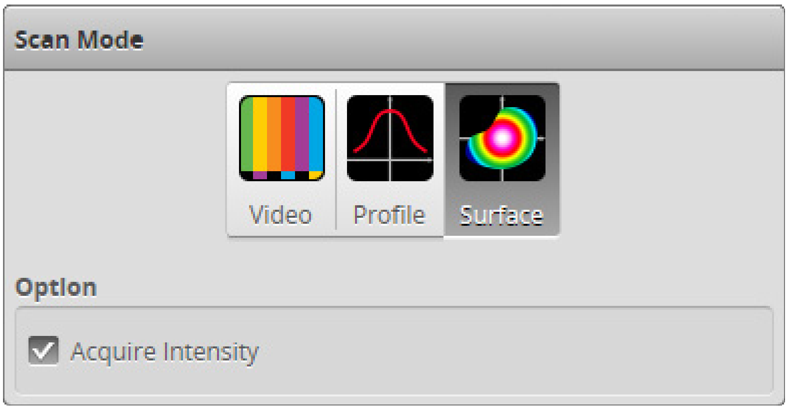
To set up Halcon:

1 Connect a sensor to the PC running Halcon.

You will need a Master hub to connect the sensor to the PC. For more information, see "2.4 Installation" on page 27 and "2.5 Network Setup" on page 42.

2 **Click the [Scan] page icon.**

3 **On the [Scan] page, click the [Surface] icon to switch to Surface mode.**

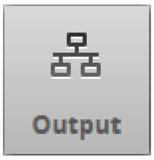


4 **(Optional) If you need intensity data, check the [Acquire Intensity] option.**

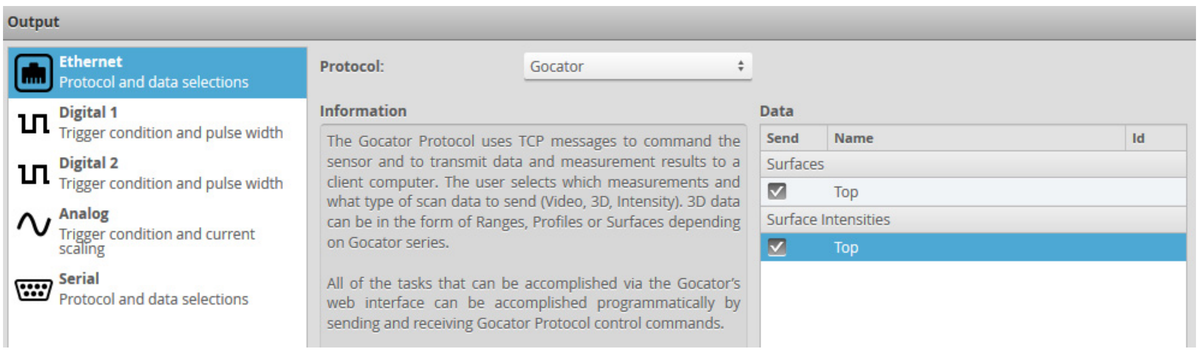
5 **Configure the sensor to produce the desired surface data.**

For more information on configuring sensors, see "4.4 Scan Setup" on page 114 and "4.6 Models" on page 209.

6 **Click the [Output] page icon.**



7 **On the [Output] page, enable the required surface under [Data] and choose SurfaceMeasure1008S in [Protocol].**



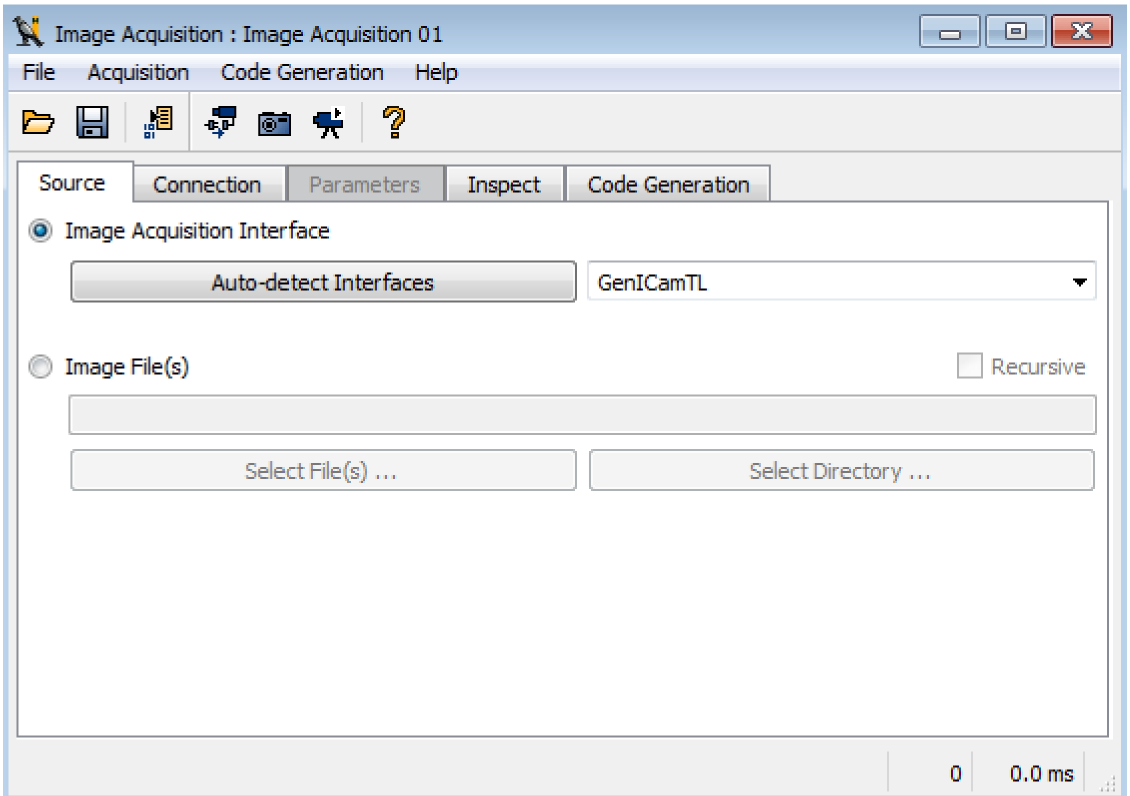
For more information on configuring Ethernet output, see "4.8.2 Ethernet Output" on page 327.

8 **Make sure the sensor is running.**

9 **On the PC, launch Halcon.**

10 **In Halcon, in the [Assistants] menu, click [Open New Image Acquisition].**

11 **In the dialog that opens, in the [Source] tab, check the [Image Acquisition Interface] option and choose GenICamTL in the drop-down.**

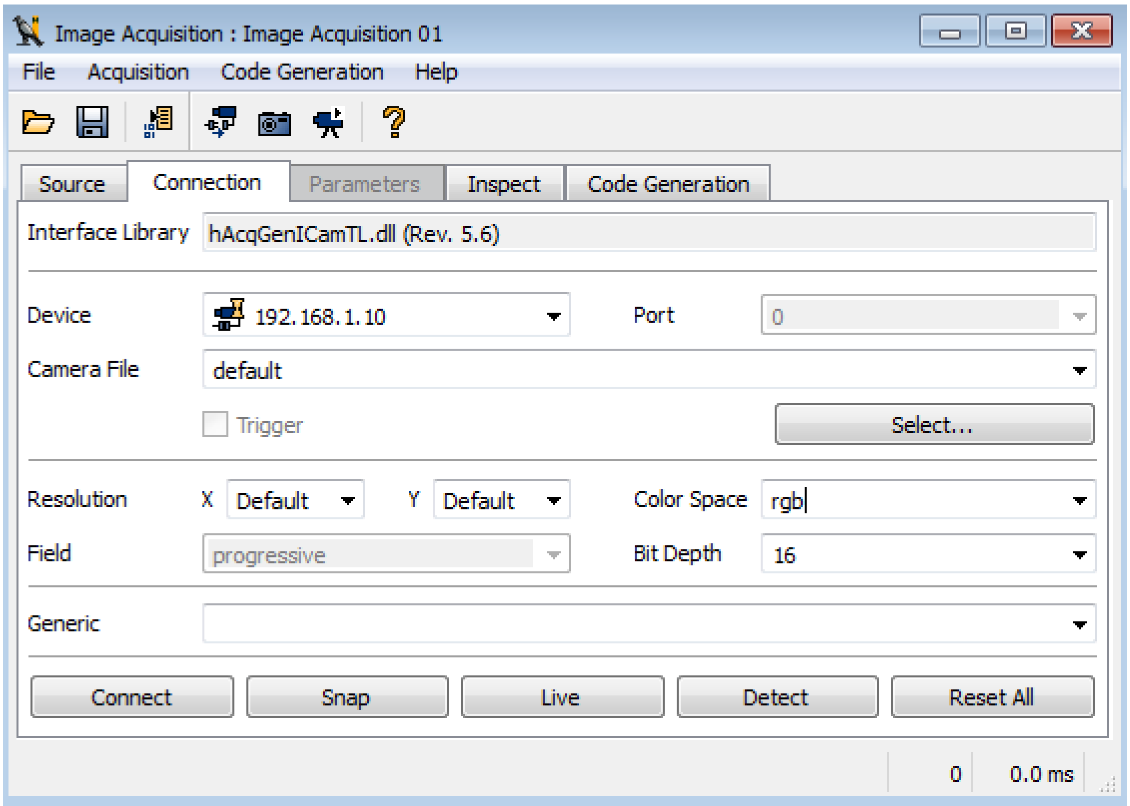


Tips

The driver uses the SurfaceMeasure1008S protocol discovery messages to search for available SurfaceMeasure1008S sensors. Discovery messages can be blocked by a PC’s firewall. You should therefore turn off the firewall and try again if the sensor can't be detected.

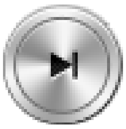
12 Switch to the [Connection] tab.

If Halcon detects a sensor, the sensor's IP will be listed next to [Device].

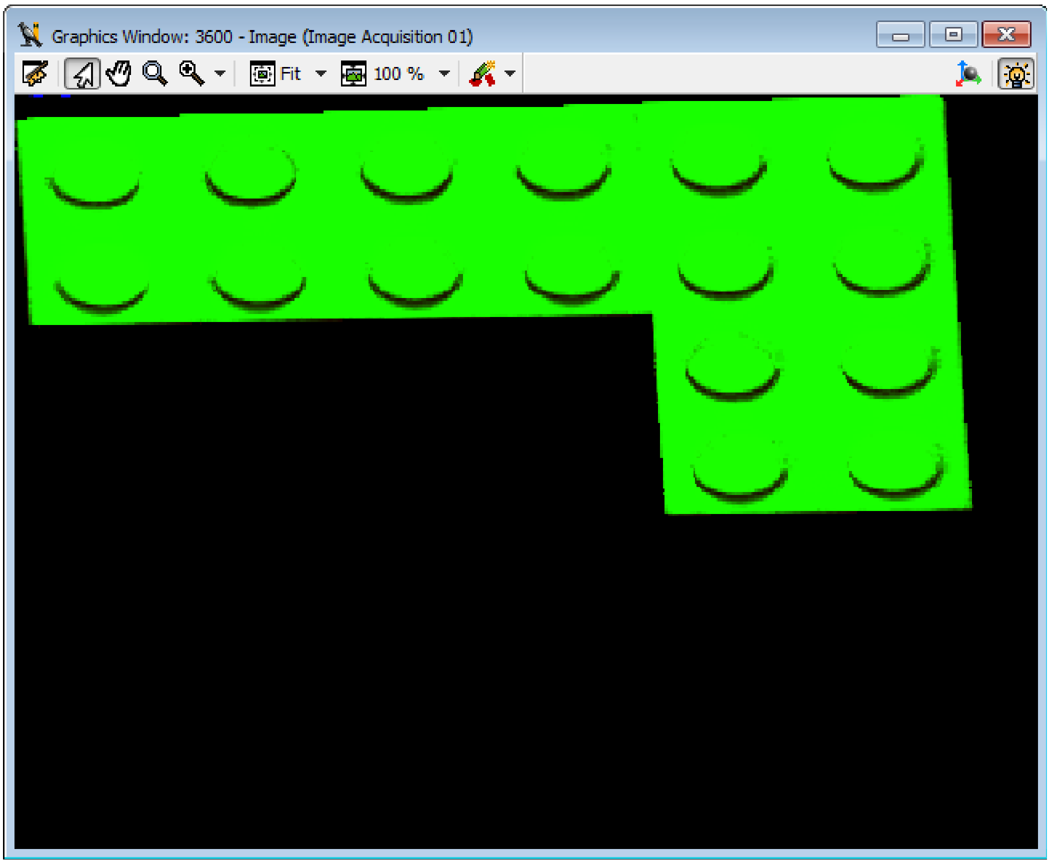


13 In the [Connection] tab, set [Color Space] to RGB and [Bit Depth] to 16.

14 In the sensor's web interface, click the Snapshot button to trigger the output of a surface.



» The output displays in the Halcon [Graphics Window].



Halcon is now configured for use with the sensor.

Halcon Procedures

The Halcon example code contains internal procedures that you can use to decompose the RGB image and to control registers that the GenTL driver opens.

You can import the procedures into your own code by selecting File > Insert Program > Insert Procedures and then choosing the example code Continuous_Acq.hdev under the Examples/Halcon directory.

The following section describes each of these procedures.

Halcon Procedures

Procedures	Description
Go2GenTL_Parse-Data	The GenTL driver packs the height map, intensity and stamp information into a 16-bit RGB image. The function is used to extract data from the RGB image. For details on how the information is packed in the data, see the sections under "10.2 GenICam GenTL Driver" on page 928. The function accepts the image acquired from grab_image_async, and returns the height map, intensity and stamps. Parameters (Input) [Image]: RGB Image acquired by using grab_image_async. Parameters (Output) [HeightMap]: The height map image. [Intensity]: The intensity image. [FrameCount]: The number of frames. [Timestamp]: The timestamp. [Encoder]: The encoder position. [EncoderIndex]: The last index of the encoder. [Inputs]: The digital input states. [xOffset]: The X offset in millimeters. [xResolution]: The X resolution in millimeters. [yOffset]: The Y offset in millimeters. [yResolution]: The Y resolition in millimeters. [zOffset]: The Z offset in millimeters. [zResolution]: The Z resolution in millimeters. [Width]: The width (number of columns) of the image that contains the part. The part width can be less than the image width requested by the user. [Height]: The height or length (number of rows) of the image that contains the part. The part height or length can be less than the image height or length requested by the user. [HasIntensity]: Specifies if the intensity image is available. The intensity image is available if [Acquire Intensity] is enabled in the sensor's web interface. Each output is returned as decimal value. Example Go2GenTL_ParseData(Image, HeightMap, Intensity, FrameCount, Time-stamp, EncoderPosition, EncoderIndex, Inputs, xOffset, xResolution, yOffset, yResolution, zOffset, zResolution, Width, Height, HasIntensity)

Procedures	Description
Go2GenTL_ResampleMode	Returns the resample mode. Parameters (Input) [AcqHandle]: Acquisition handle created by open_framegrabber. Parameters (Output) [ResampleMode]: No - Resample is disabled. Yes - Resample is enabled. When resampling is enabled, the GenTL driver resamples the height map so that the pixel spacing is the same on the X and Y axis. Example Go2GenTL_ResampleMode (AcqHandle, ResampleMode) **Tips** To set the resample mode, you must directly modify Go2GenTL.xml, which is in the same directory as the sensor GenTL driver (Go2GenTL.cti).
Go2GenTL_ConfigFileName	Returns the current live sensor job file name. Parameters (Input) [AcqHandle]: Acquisition handle created by open_framegrabber. Parameters (Output) [ConfigFile]: The name of the job file. The file name includes the extension .job. Example Go2GenTL_ConfigFileName (AcqHandle, ConfigFile)
Go2GenTL_SetConfigFileName	Sets the sensor live configuration. Parameters (Input) [AcqHandle]: Acquisition handle created by open_framegrabber. [ConfigFile]: The name of the job file. The file name should include the extension .job. Example Go2GenTL_SetConfigFileName (AcqHandle, 'test2.cfg')
Go2GenTL_Encoder	Returns the current encoder value. When this function is called, the GenTL driver retrieves the latest encoder value from the sensor. The value is returned as a two-element tuple. The first element is the least significant 32-bit value, and the second element is the most significant 32-bit value. Parameters (Input) [AcqHandle]: Acquisition handle created by open_framegrabber. Parameters (Output) [EncoderValue]: The current encoder value. Example Go2GenTL_Encoder(AcqHandle, EncoderValue)

Procedures	Description
Go2GenTL_ImageSize	Returns the size of the image returned by the GenTL driver. Parameters (Input) [AcqHandle]: Acquisition handle created by open_framegrabber. Parameters (Output) [Width]: The width of the image. [Height]: The height of the image. Example Go2GenTL_ImageSize(AcqHandle, Width, Height) **Tips** To set the image size, you must directly modify Go2GenTL.xml, which is in the same directory as the sensor GenTL driver (Go2GenTL.cti).
Go2GenTL_CoordinateXYZ	Returns the real-world coordinates (X, Y, Z) of the part given the row and column position in the height map. The values of the offset and resolution input parameters can be retrieved using Go2GenTL_ParseData. Parameters (Input) [HeightMap]: The height map image. [Row]: The row in the height map. [Column]: The column in the height map. [xOffset]: The X offset in millimeters. [xResolution]: The X resolution in millimeters. [yOffset]: The Y offset in millimeters. [yResoluion]: The Y resolution in millimeters. [zOffset]: The Z offset in millimeters. [zResolution]: The Z resolution in millimeters. Parameters (Output) [coordinateXYZ]: The real-world coordinates.
Go2GenTL_Exposure	Returns the current exposure. Parameters (Input) [AcqHandle]: Acquisition handle created by open_framegrabber. Parameters (Output) [Exposure]: The current exposure value (in μs). The value is returned as an integer. Decimals are truncated. Example Go2GenTL_Exposure(AcqHandle, exposure)
Go2GenTL_SetExposure	Sets the current exposure. Parameters (Input) [AcqHandle]: Acquisition handle created by open_framegrabber. [Exposure]: The current exposure value (in μs), as an integer. Example Go2GenTL_SetExposure(AcqHandle, exposure)

Procedures	Description
set_framegrabber_param	Generic Halcon function to set parameters on the scanner. Can be used to set scanner specific settings. For a complete list of settings that can be changed, see the SDK interface files. In the generic form: set_framegrabber_param(AcqHandle, ‘Name’, ‘Value’) Parameters (Input) [AcqHandle]: Acquisition handle created by open_framegrabber. [Name]: The name of the parameter to set on the scanner. [Value]: The parameter value to set on the scanner. Examples To set the format of the image buffer to 16-bit packed: set_framegrabber_param(AcqHandle, ‘PixelFormat’, ‘RGB16Packed’) To set the Scan mode to HDR (1 = no HDR, 2 = HDR, 3 = Super HDR): set_framegrabber_param(AcqHandle, ‘Dynamic’, ‘2’) To set the brightness to ‘3’: set_framegrabber_param(AcqHandle, ‘Exposure’, ‘3’) To schedule a system to start in 1000000 ticks or microseconds (depends on current domain unit): set_framegrabber_param(AcqHandle, ‘XMLSetting’, ‘GenTL/System’) set_framegrabber_param(AcqHandle, ‘XMLSetting’, ‘ScheduledStart=1’) set_framegrabber_param(AcqHandle, ‘XMLSetting’, ‘000000’) set_framegrabber_param(AcqHandle, ‘XMLSetting’, ‘’) To schedule a sensor to start after a delay (ticks or microseconds), pass GenTL/Sensor in the first call to set_framegrabber_param, followed by the remaining calls to the function as described in the previous example: set_framegrabber_param(AcqHandle, ‘XMLSetting’, ‘GenTL/Sensor’) To clear data buffers:: set_framegrabber_param(AcqHandle,'XmlCommand','GenTL/ClearData\n')

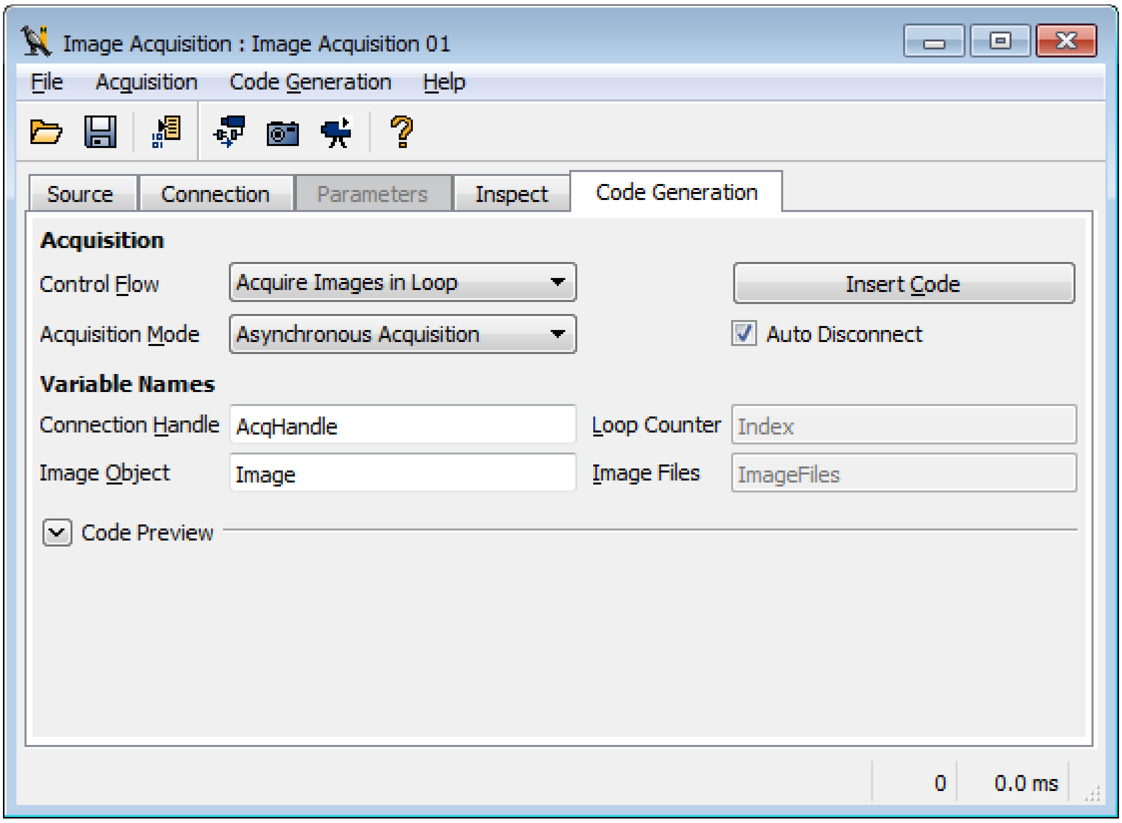
■ Generating Halcon Acquisition Code

Halcon lets you insert acquisition code into your code in the IDE.

To generate acquisition code:

1 In Halcon, in the [Assistants] menu, click [Open New Image Acquisition].

2 In the dialog that opens, in the [Code Generation] tab, set [Acquisition Mode] to [Asynchronous Acquisition].



3 Under [Acquisition], click [Insert Code] to generate the code that will open the acquisition device.

Tips
To handle cases when the grab_image function times out while waiting for data, add a try-catch statement around the grab_image function code.

After the example code is generated, you should add a catch instruction to bypass the acquisition time-out event, and use the 📖 "■Halcon Procedures" on page 940 function to extract information from the returned image.

An example, Continuous_Acq.hdev, is included in the Examples/Halcon directory.

MEMO

11 Development Kits

These sections describe the following development kits:

- Software Development Kit (GoSDK)
- SurfaceMeasure Development Kit(GDK)

11.1 GoSDK

The SurfaceMeasure1008S Software Development Kit (GoSDK) includes open-source software libraries and documentation that can be used to programmatically access and control SurfaceMeasure1008S sensors. To get the latest version of the SurfaceMeasure1008S SDK package, access the website at https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/ and download the appropriate package.

For information on the ports the SDK uses (for example, in order to ensure ports are not blocked over your network), see "2.5.3 Required Ports" on page 49.

IMPORTANT

- If you switch jobs or make changes to a job using the SDK or a protocol (from a PLC), the switch or changes are not automatically displayed in the web interface: you must refresh the browser to see these.
- The SurfaceMeasure1008S protocol is always on and its output is always available, regardless of the output you choose. This allows simultaneous connections via an SDK application and a PLC, letting you for example archive or display scan data on a PC while controlling equipment with a PLC.

You can download the SurfaceMeasure1008S SDK from within the Web interface.

To download the SDK:

1 **Go to the [Manage] page and click on the [Support] category**

2 **Next to [Software Development Kit (SDK)], click [Download]**

3 **Choose the location for the SDK on the client computer.**

If the SDK's version number matches the protocol's major version number, then the applications which were compiled with earlier SDK versions are compatible with the sensors' firmware. For example, an application compiled with version 5.0 of the SDK (which uses protocol version 5.0) will be compatible with a sensor running firmware version 5.1 (which uses protocol version 5.1). However, any new features in firmware version 5.1 would not be available.

Applications compiled using SDK version 4.x are compatible with sensors running firware 5.x.

Applications compiled using SDK version 3.x are not compatible with sensors running firmware 4.x. In this case, you must rewrite the application with the SDK version corresponding to the sensor firmware in use.

For more information about programming with the SDK, refer to the class reference and sample programs included in the SDK.

11.1.1 Setup and Locations

■ Class Reference

The full GoSDK class reference is found by accessing the following file:

14400-x.x.xx.x_SOFTWARE_SDK_SM1008S\doc\GoSdk\Gocator\GoSdk.html

■ Examples

Examples showing how to perform various operations are provided, each one targeting a specific area. For Microsoft Visual Studio, the examples can be found in solution files specific to different versions of Microsoft Visual Studio. For example, GoSdk-2017.sln is for use with Microsoft Visual Studio 2017. A make file for Linux systems is also provided.

IMPORTANT

To compile the examples in Microsoft Visual Studio, you may be need to retarget the solution to the installed Windows SDK version. You can do this through the [Retarget solution] option in the solution context menu.

To run the GoSDK examples, make sure the required DLLs are copied beside the executable. In most cases only GoSDK.dll and kApi.dll are required, but with .NET and the accelerator additional DLLs are needed. Please refer to the SDK samples to see which DLLs are required.

■ Example Project Environment Variable

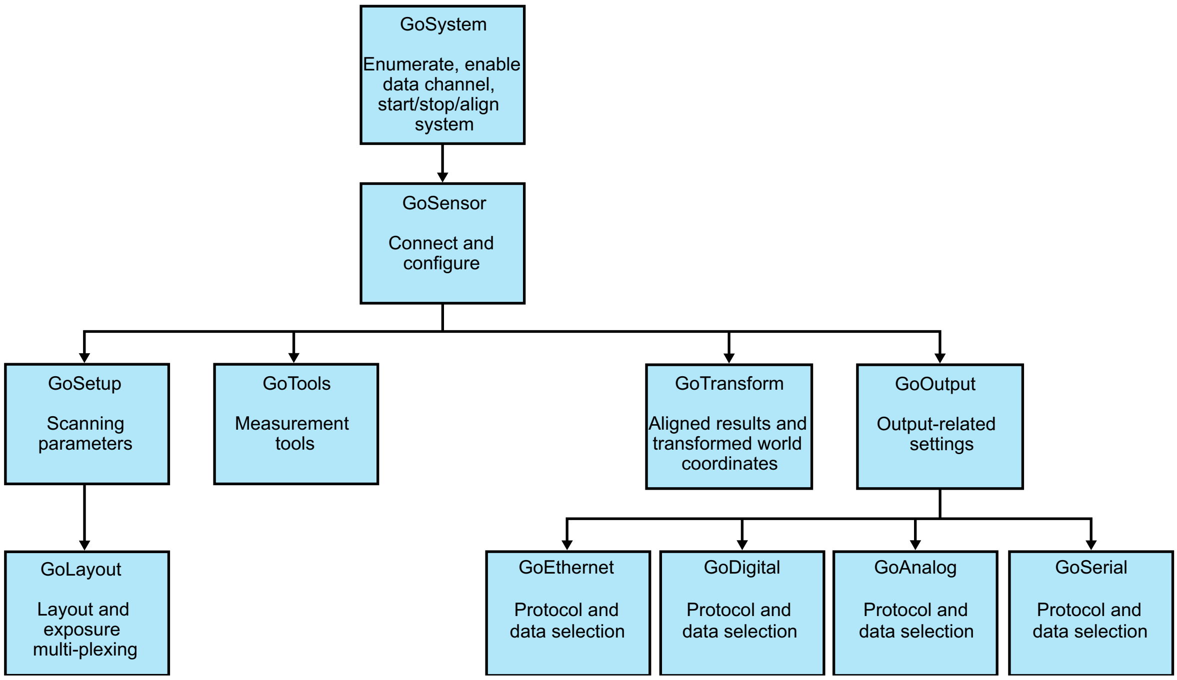
All GoSDK example projects use the environment variable GO_SDK_4. The environment variable should point to the GO_SDK directory, for example, C:\14400-6.1.39.1_SOFTWARE_SDK_SM1008S\GO_SDK.

■ Header Files

Header files are referenced with GoSdk as the source directory, for example: #include <GoSdk/GoSdk.h>. The SDK header files also reference files from the kApi directory.

11.1.2 Functional Hierarchy of Classes

This section describes the functional hierarchy of the classes in the SurfaceMeasure1008S SDK ("GoSDK"). In the following diagram, classes higher in the hierarchy often provide resources for classes lower in the hierarchy, and for this reason should be instantiated earlier in a client application.



■ GoSystem

The GoSystem class is the top-level class in the SDK. Multiple sensors can be enabled and connected in one GoSystem. Only one GoSystem object is required for multi-sensor control.

For details on how to control and operate a multi-sensor system using the SDK, refer to the How To Use The Open Source SDK To Fully Control A SurfaceMeasure1008S Multi-sensor System how-to guide in https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/.

IMPORTANT

All objects that are explicitly created by the user or passed via callbacks should be destroyed by using the GoDestroy function.

■ GoSensor

GoSensor represents a physical sensor. If the physical sensor is the Main sensor in a dual-sensor setup, it can be used to configure settings that are common to both sensors.

■ GoSetup

The GoSetup class represents a device's configuration. The class provides functions to get or set all of the settings available in the web interface.

GoSetup is included inside GoSensor. It encapsulates scanning parameters, such as exposure, resolution, spacing interval, etc. For parameters that are independently controlled for Main and Buddy sensors, functions accept a role parameter.

■ GoLayout

The GoLayout class represents layout-related sensor configuration.

■ GoTools

The GoTools class is the base class of the measurement tools. The class provides functions for getting and setting names, retrieving measurement counts, etc.

■ GoTransform

The GoTransform class represents a sensor transformation and provides functions to get and set transformation information, as well as encoder-related information.

■ GoOutput

The GoOutput class represents output configuration and provides functions to get the specific types of output (Analog, Digital, Ethernet, and Serial). Classes corresponding to the specific types of output (GoAnalog, GoDigital, GoEthernet, and GoSerial) are available to configure these outputs.

11.1.3 Data Types

The following sections describe the types used by the SDK and the kApi library.

■ Value Types

GoSDK is built on a set of basic data structures, utilities, and functions, which are contained in the kApi library.

The following basic value types are used by the kApi library.

Value Data Types

Type	Description
k8u	8-bit unsigned integer
k16u	16-bit unsigned integer
k16s	16-bit signed integer
k32u	32-bit unsigned integer
k32s	32-bit signed integer
k64s	64-bit signed integer
k64u	64-bit unsigned integer
k64f	64-bit floating number
kBool	Boolean, value can be kTRUE or kFALSE

kStatus	Status, value can be kOK or kERROR
kIpAddress	IP address

■ Output Types

The following output types are available in the SDK.

Output Data Types

Data Type	Description
GoAlignMsg	Represents a message containing an alignment result.
GoBoundingBox-MatchMsg	Represents a message containing bounding box based part matching results.
GoDataMsg	Represents a base message sourced from the data channel. See "■GoDataSet Type" on page 952 for more information.
GoEdgeMatchMsg	Represents a message containing edge based part matching results.
GoEllipseMatchMsg	Represents a message containing ellipse based part matching results.
GoExposureCalMsg	Represents a message containing exposure calibration results.
GoMeasurementMsg	Represents a message containing a set of GoMeasurementData objects.
GoProfileIntensityMsg	Represents a data message containing a set of profile intensity arrays.
GoProfileMsg	Represents a data message containing a set of profile arrays.
GoRangeIntensityMsg	Represents a data message containing a set of range intensity data.
GoRangeMsg	Represents a data message containing a set of range data.
GoResampledProfileMsg	Represents a data message containing a set of resampled profile arrays.
GoSectionMsg	Represents a data message containing a set of section arrays.
GoSectionIntensityMsg	Represents a data message containing a set of profile intensity arrays.
GoStampMsg	Represents a message containing a set of acquisition stamps.
GoSurfaceIntensityMsg	Represents a data message containing a surface intensity array.
GoSurfaceMsg	Represents a data message containing a surface array.
GoVideoMsg	Represents a data message containing a video image.

Refer to the GoSdkSamples sample code for examples of acquiring data using these data types.

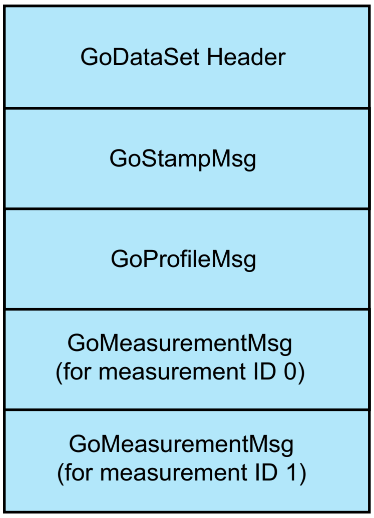
Tips

See "11.1.1 Setup and Locations" on page 948 for more information on the code samples.

■ GoDataSet Type

Data are passed to the data handler in a GoDataSet object. The GoDataSet object is a container that can contain any type of data, including scan data (profiles, sections, or surfaces), measurements, and results from various operations. Data inside the GoDataSet object are represented as messages.

The following illustrates the content of a GoDataSet object of a profile mode setup with two measurements. The content when using a surface mode setup is identical, except that a GoSurfaceMsg is sent instead of a GoProfileMsg.



After receiving the GoDataSet object, you should call GoDestroy to dispose the GoDataSet object. You do not need to dispose objects within the GoDataSet object individually.

IMPORTANT

All objects that are explicitly created by the user or passed via callbacks should be destroyed by using the GoDestroy function.

■ Measurement Values and Decisions

Measurement values and decisions are 32-bit signed values (k32s). See "■Value Types" on page 950 for more information on value types.

The following table lists the decisions that can be returned.

Measurement Decisions

Decision	Description
1	The measurement value is between the maximum and minimum decision values. This is a pass decision.
0	The measurement value is outside the maximum and minimum. This is a fail decision.
-1	The measurement is invalid (for example, the target is not within range). Provides the reason for the failure.
-2	The tool containing the measurement is anchored and has received invalid measurement data from one of its anchors. Provides the reason for the failure.

Refer to the SetupMeasurement example for details on how to add and configure tools and measurements. Refer to the ReceiveMeasurement example for details on how to receive measurement decisions and values.

IMPORTANT

You should check a decision against <=0 for failure or invalid measurement.

11.1.4 Operation Workflow

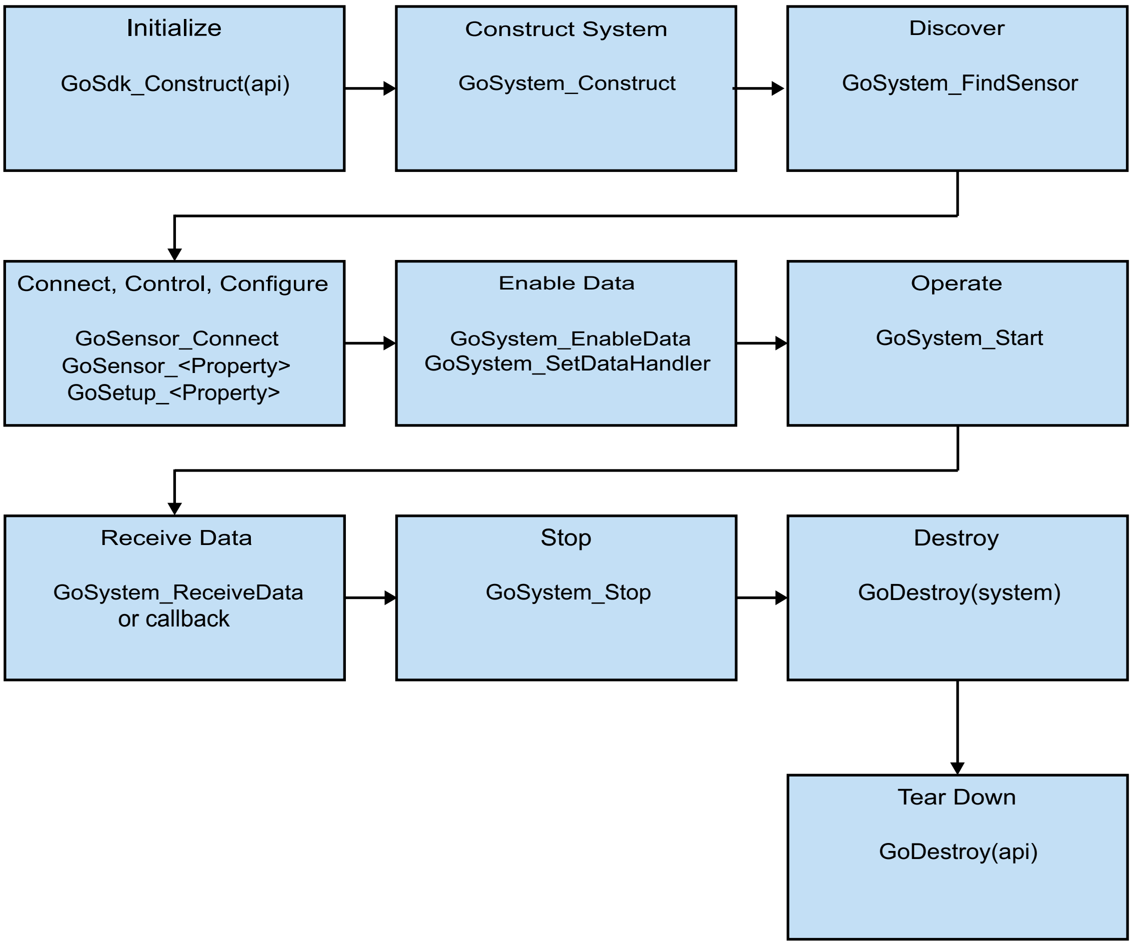
Applications created using the SDK typically use the following programming sequence

Tips

See "11.1.1 Setup and Locations" on page 948 for more information on the code samples referenced below.

IMPORTANT

Sensors must be connected before the system can enable the data channel.



Tips

All GoSDK data functions are named Go<Object>_<Function>, for example, GoSensor_Connect. For property access functions, the convention is Go<Object>_<Property Name> for reading the property and Go<Object>_Set<Property Name> for writing it, for example, GoMeasurement_DecisionMax and GoMeasurement_SetDecisionMax, respectively.

■ Initialize GoSdk API Object

Before the SDK can be used, the GoSdk API object must be initialized by calling GoSdk_Construct(api):

```
kAssembly api = kNULL;
if ((status = GoSdk_Construct(&api)) != kOK)
{
printf("Error: GoSdk_Construct:%d\n", status);
return;
}
```

When the program finishes, call GoDestroy(api) to destroy the API object.

■ Discover Sensors

Sensors are discovered when GoSystem is created, using GoSystem_Construct. You can use GoSystem_SensorCount and GoSystem_SensorAt to iterate all the sensors that are on the network.

GoSystem_SensorCount returns the number of sensors physically in the network.

Alternatively, use GoSystem_FindSensorById or GoSystem_FindSensorByIpAddress to get the sensor by ID or by IP address.

Refer to the Discover example for details on iterating through all sensors. Refer to other examples for details on how to get a sensor handle directly from IP address.

■ Connect Sensors

Sensors are connected by calling GoSensor_Connect. You must first get the sensor object by using GoSystem_SensorAt, GoSystem_FindSensorById, or GoSystem_FindSensorByIpAddress.

■ Configure Sensors

Some configuration is performed using the GoSensor object, such as managing jobs, uploading and downloading files, scheduling outputs, setting alignment reference, etc. Most configuration is however performed through the GoSetup object, for example, setting scan mode, exposure, exposure mode, active area, speed, alignment, filtering, subsampling, etc. Surface generation is configured through the GoSurfaceGeneration object and part detection settings are configured through the GoPartDetection object.

See 📖 "11.1.2 Functional Hierarchy of Classes" on page 949 for information on the different objects used for configuring a sensor. Sensors must be connected before they can be configured.

Refer to the Configure example for details on how to change settings and to switch, save, or load jobs. Refer to the BackupRestore example for details on how to back up and restore settings.

■ Enable Data Channels

Use GoSystem_EnableData to enable the data channels of all connected sensors. GoSystem_EnableData should only be used when you also receive and discard the data in your application.

Perform Operations

Operations are started by calling GoSystem_Start, GoSystem_StartAlignment, and GoSystem_StartExposureAutoSet.

Refer to the StationaryAlignment and MovingAlignment examples for details on how to perform alignment operations. Refer to the ReceiveRange, ReceiveProfile, and ReceiveWholePart examples for details on how to acquire data.

Example: Configuring and starting a sensor with the API

```
#include <GoSdk/GoSdk.h>

void main()
{
kIpAddress ipAddress;
GoSystem system = kNULL;
GoSensor sensor = kNULL;
GoSetup setup = kNULL;

//Construct the GoSdk library.
GoSdk_Construct(&api);

//Construct a sensor system object.
GoSystem_Construct(&system, kNULL);

//Parse IP address into address data structure
kIpAddress_Parse(&ipAddress, SENSOR_IP);

//Obtain GoSensor object by sensor IP address
GoSystem_FindSensorByIpAddress(system, &ipAddress, &sensor)

//Connect sensor object and enable control channel
GoSensor_Connect(sensor);

//Enable data channel
GoSensor_EnableData(system, kTRUE)

//[Optional] Setup callback function to receive data asynchronously
//GoSystem_SetDataHandler(system, onData, &contextPointer)
//Retrieve setup handle
setup = GoSensor_Setup(sensor);

//Reconfigure system to use time-based triggering.
GoSetup_SetTriggerSource(setup, GO_TRIGGER_TIME);
```

```
//Send the system a "Start" command.
GoSystem_Start(system);

//Data will now be streaming into the application
//Data can be received and processed asynchronously if a callback function has been
//set (recommended)
//Data can also be received and processed synchronously with the blocking call
//GoSystem_ReceiveData(system, &dataset, RECEIVE_TIMEOUT)
//Send the system a "Stop" command.
GoSystem_Stop(system);

//Free the system object.
GoDestroy(system);

//Free the GoSdk library
GoDestroy(api);
}
```

11.1.5 Limiting Flash Memory Write Operations

Several operations and SurfaceMeasure1008S SDK functions write to the sensor's flash memory. The lifetime of the flash memory is limited by the number of write cycles. Therefore it is important to avoid frequent write operation to the sensor's flash memory when you design your system with the SDK.

> **Tips**
> Power loss during flash memory write operation will also cause sensors to enter rescue mode.

SDK Write-Operation Functions

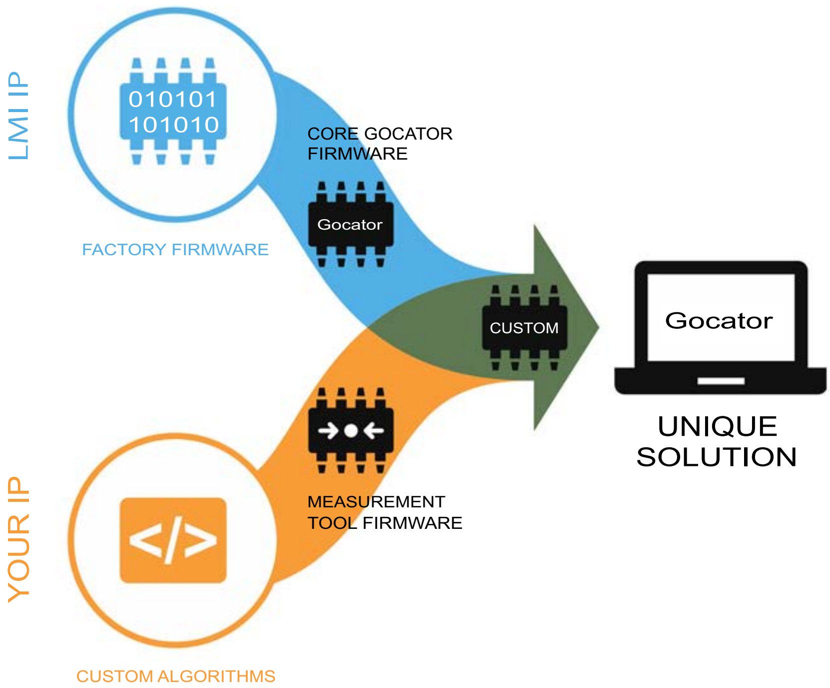
Name	Description
GoSensor_Restore	Restores a backup of sensor files.
GoSensor_RestoreDefaults	Restores factory default settings.
GoSensor_CopyFile	Copies a file within the connected sensor. The flash write operation does not occur if GoSensor_CopyFile function is used to load an existing job file. This is accomplished by specifying “_live” as the destination file name.
GoSensor_DeleteFile	Deletes a file in the connected sensor.
GoSensor_SetDefaultJob	Sets a default job file to be loaded on boot.
GoSensor_UploadFile	Uploads a file to the connected sensor.
GoSystem_StartAlignment	When alignment is performed with alignment reference set to fixed, flash memory is written immediately after alignment. GoSensor_SetAlignmentReference() is used to configure alignment reference.
GoSensor_SetAddress	Configures a sensor's network address settings.
GoSensor_ChangePassword	Changes the password associated with the specified user account.

Name	Description
GoTransform_SetEncoder-Resolution	Sets the encoder resolution.
GoTransform_SetSpeed	Sets the travel speed.
GoTransform_SetX	Sets the transformation X component.
GoTransform_SetY	Sets the transformation Y component.
GoTransform_SetZ	Sets the transformation Z component.
GoTransform_SetXAngle	Sets the transformation X-angle.
GoTransform_SetYAngle	Sets the transformation Y-angle.
GoTransform_SetZAngle	Sets the transformation Z-angle.

System created using the SDK should be designed in a way that parameters are set up to be appropriate for various application scenarios. Parameter changes not listed above will not invoke flash memory write operations when the changes are not saved to a file using the GoSensor_CopyFile function. Fixed alignment should be used as a means to attach previously conducted alignment results to a job file, eliminating the need to perform a new alignment.

11.2 GDK

The SurfaceMeasure Development Kit (GDK) is a framework for developing and testing custom SurfaceMeasure1008S tools containing your own algorithms, and then deploying them to SurfaceMeasure1008S.



Custom tools created with the GDK act much like native SurfaceMeasure1008S data output tools (providing measurements, geometric features, data and generic outputs) with support for multiple input parameters), running at native speeds and taking advantage of features such as anchoring. The GDK supports all data types, and tools created with the GDK use the same data visualization as native tools.

11.2.1 Benefits

When you use the GDK to create custom measurement tools, you have complete control over how and where your custom measurement tools can be used, which protects your intellectual property.

You can also easily troubleshoot and modify your tools on-site, letting you respond quickly to your customers' urgent issues.

11.2.2 Typical Workflow

The following is the typical workflow for creating and deploying custom measurement tools:

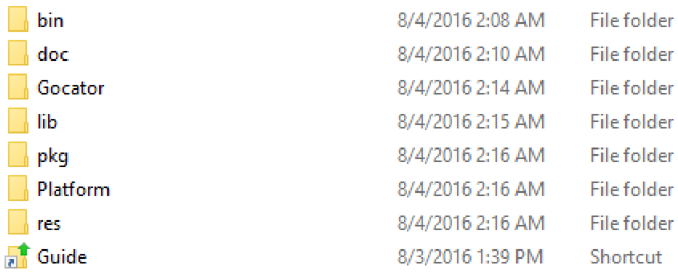
- Develop and build tools using the GDK project files and libraries in Microsoft Visual Studio, targeting Win32.
- Debug the tools using the emulator on a PC.
- Build the tools into a custom firmware binary.
- Upload the custom firmware to a sensor.

11.2.3 Installation and Class Reference

The GDK project and library files are in the GDK package (x.x.xx.x_SOFTWARE_GDK_SM1008S.zip). To download the package, go to https://www2.mitutoyo.co.jp/eng/contact/products/sm1008s/, choose your product from the Product Downloads section, and download it from the Download Center.

After downloading the package, extract the package to a directory.

You can access full installation and setup instructions, as well as the complete class reference documentation, by double-clicking the Guide shortcut under the root directory.



■ Required Tools

The GDK requires Microsoft Visual Studio 2017, as well as various other tools provided in the GDK Prerequisites package (14525_x.x.x.x_SOFTWARE_GDK_Prerequisites.zip). This package is available in Mitutoyo's Downloads Center (see above for download location).

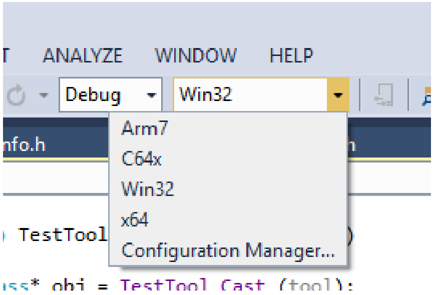
11.2.4 Getting Started with the Example Code

The best way to get started is with the GDK sample code. You can find the sample projects under Gocator\GDKSampleApp. This project is ready for you to build and use as a template for new projects.

Start by opening GDK.sln in Microsoft Visual Studio 2017.

Building the Sample Code

You can build the sample code for working with either the emulator or a sensor. To do this, choose the target and then build the solution.



The following targets are available:

- Win32/x64 for debugging code and emulating a sensor to test tools (on a PC)

The Win32 target supports Debug and Release builds. The Arm7 and C64x targets (sensors) only the support Release builds.

Tool Registration

For a tool to be available to a user in the sensor web interface, you must add it to the project assembly in Asm.c.

```
#include <GdkSampleApp/Asm.h>
#include <GdkSampleApp/TestProfileSelect.h>
#include <GdkSampleApp/TestSurfaceSelect.h>
#include <GdkSampleApp/TestSurfaceConfiguration.h>
#include <GdkSampleApp/TestSurfaceGraphics.h>
#include <Gdk/GdkLib.h>
#include <GoSensor/Version.h>
#include <GoSensorAppLib/GsaDef.h>
#include <GoSensorAppLib/GsaAsm.h>

kBeginAssembly(Tool, ToolAsm, TOOL_VERSION, GOCATOR_VERSION)
kAddDependency(GdkLib)
kAddType(TestProfileSelect)
kAddType(TestSurfaceSelect)
kAddType(TestSurfaceConfiguration)
kAddType(TestSurfaceGraphics)
kEndAssembly()
```

You can add multiple tools in a GDK project. As seen above, TestProfileSelect, TestSurfaceSelect, TestSurfaceConfiguration, etc. will be available for users from the drop-down menu in the [Tools] panel in sensor's web interface.

■ Tool Definitions

You must add standard entry functions (methods) for each tool. The class table declares the entry functions:

```
kBeginClass(Tool, TestTool, GdkTool)
kAddVMethod(TestTool, kObject, VRelease)
kAddVMethod(TestTool, GdkTool, VInit)
kAddVMethod(TestTool, GdkTool, VName)
kAddVMethod(TestTool, GdkTool, VDescribe)
kAddVMethod(TestTool, GdkTool, VNewToolConfigInstanced)
kAddVMethod(TestTool, GdkTool, VNewMeasurementConfigInstanced)
kAddVMethod(TestTool, GdkTool, VUpdateConfigInstanced)
kAddVMethod(TestTool, GdkTool, VNewFeatureConfigInstanced)
kAddVMethod(TestTool, GdkTool, VNewToolDataOutputConfigInstanced)
kAddVMethod(TestTool, GdkTool, VIsVisible)
kAddVMethod(TestTool, GdkTool, VCalcDataOutputRegionInstanced)
kAddVMethod(TestTool, GdkTool, VStart)
kAddVMethod(TestTool, GdkTool, VStop)
kAddVMethod(TestTool, GdkTool, VProcess)
kEndClass()

ToolFx (kStatus) TestTool_VDescribe(GdkToolInfo toolInfo)
{
GdkMeasurementInfo mmt;
GdkParamsInfo params;
GdkParamInfo paramInfo;

kCheck(GdkToolInfo_SetTypeName(toolInfo, TEST_PROFILE_SELECT_TOOL_NAME));
kCheck(GdkToolInfo_SetLabel(toolInfo, TEST_PROFILE_SELECT_TOOL_LABEL));

kCheck(GdkToolInfo_SetSourceType(toolInfo, GDK_DATA_TYPE_UNIFORM_PROFILE));
...
```

The function <Tool Name>_VDescribe describes the tool and its basic configuration. This function is called during sensor start-up. For more information on entry functions, see 📖 "■Entry Functions" on page 962.

IMPORTANT

- Make sure the VDescribe function for each tool is properly formed. Significant issues with this function (for example, overwriting memory) could prevent the sensor from starting.
- You should use the emulator to debug tools before deploying tools to sensors.

Entry Functions

The following table describes the main entry functions.

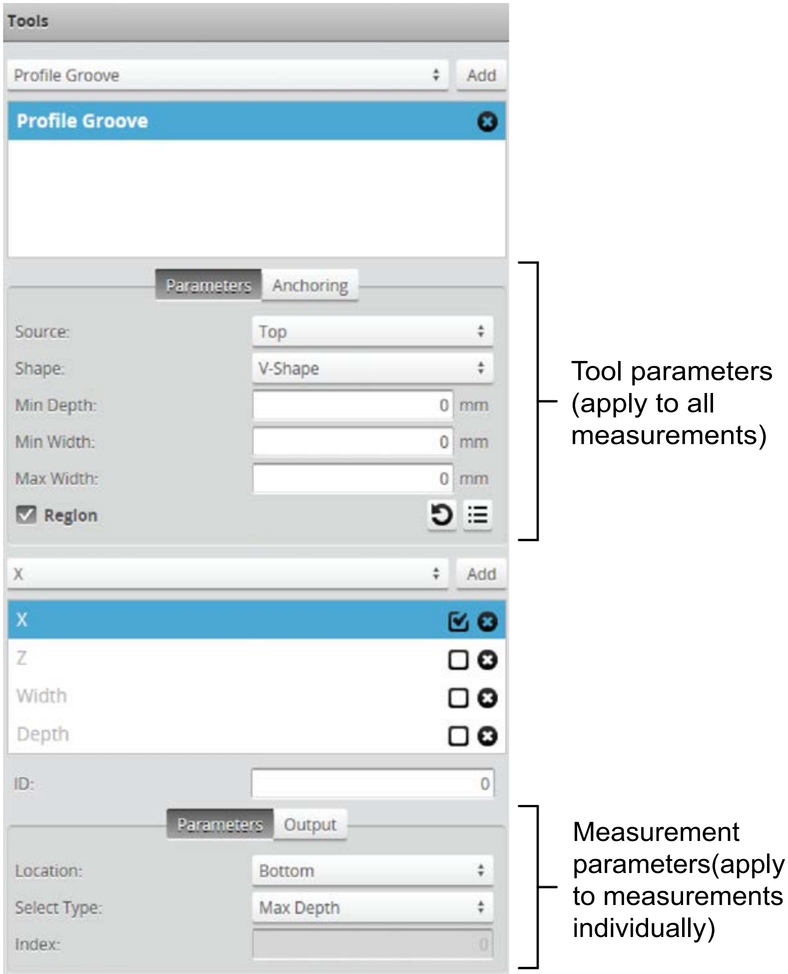
Function	Description
VDescribe	Defines the tool's name, data types, acceptable source options, configuration parameters, and at least one measurement.
VStart	Called when the sensor starts running (that is, the user clicks the Run button). The function gets parameters from GtTool. You typically allocate memory in this function.
VProcess	Called every time data is received while the sensor is running.
VStop	Called when the user clicks the Stop button.

The TestSurfaceConfiguration example shows how to create and modify parameters based on other user settings.

For full descriptions of these functions, see the GDK class reference documentation (see Installation and Class Reference on page 1035 for information on installing the documentation).

Parameter Configurations

Each tool has two levels of parameters: tool parameters and measurement parameters.



A tool can contain multiple measurements. In the image above, the Groove tool contains four measurements: X, Z, Width, and Depth. Each tool has one set of tool parameters and each measurement in a tool has one set of measurement parameters.

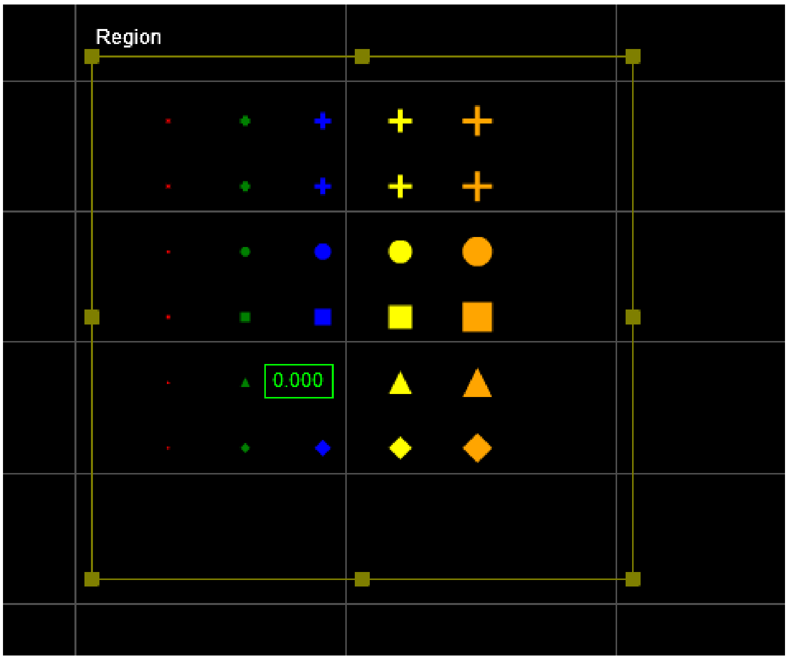
The following table lists the functions that provide advanced or interactive control for setting up tool and measurement parameters:

Function	Description
VNewToolConfig	Advanced method for setting default values of tool parameters based on the current sensor configuration (for example, active area). Called when a new tool is added in the interface.
VNewMeasure-mentConfig	Advanced method for setting default values of measurement parameters based on the current sensor configurations (for example, active area). Called when measurements in a tool is are added in the interface.
VUpdateConfig	Advanced method for updating the configuration based on parameters set by users.

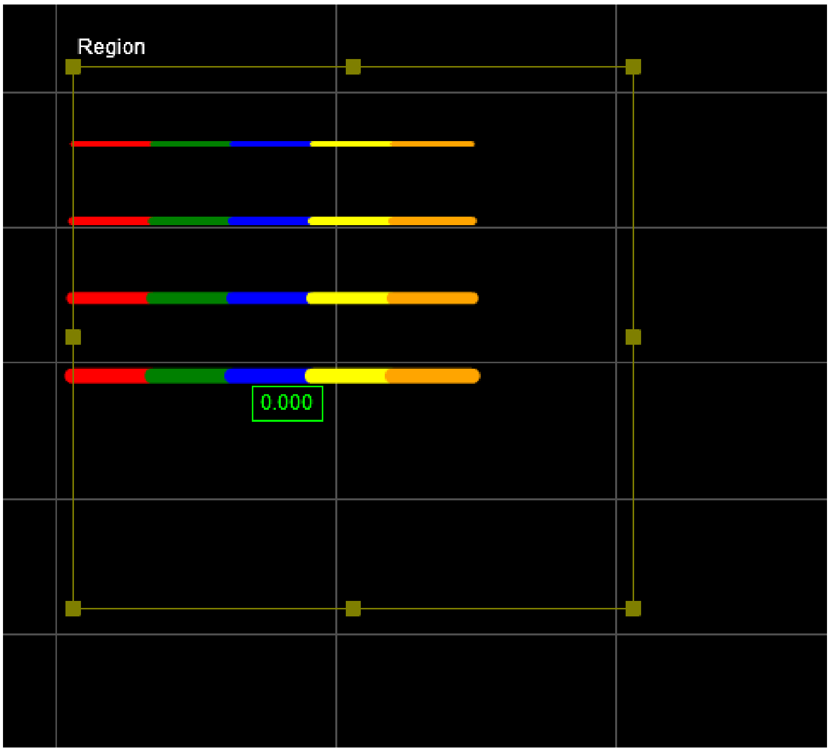
For full descriptions of these functions, see the GDK class reference documentation (see Installation and Class Reference on page 1035 for information on installing the documentation).

11.2.5 Graphics Visualization

The GDKGraphic function supports points and lines.



Point graphics



Line graphics

To create graphics:

1. **Use GdkGraphic_Construct to create a graphic object.**

2. **Use GdkGraphicPointSet_Construct to create points or GdkGraphicLineSet_Construct to create lines.**

3. **Add the points and lines to the graphic object using GdkGraphic_AddPointSet and Gdk-Graphic_AddLineSet.**

4. **Output using GdkToolOutput_SetRendering.**

The following illustrates the process:

```
kTest(GdkGraphic_Construct(&graphic, kObject_Alloc(tool)));

kTest(GdkGraphicPointSet_Construct(&pointSet, 4.0, kMARKER_SHAPE_CROSS, kCOLOR_LIME,
&point32f, 1, kObject_Alloc(tool)));

kTest(GdkGraphic_AddPointSet(graphic, pointSet));

kTest(GdkToolOutput_SetRendering(output, measurementIndex, graphic));
```

The GDK example TestSurfaceGraphics shows how to use the graphics functions.

Tips
Graphic functions take an array of kPoint3d32f. It does NOT accept kPoint3d64f.

11.2.6 Debugging Your Tools

We highly recommend using the emulator to debug tools you create with the GDK. By using a sensor support file and previously recorded scan data, downloaded from a physical sensor, you can completely simulate standalone and multi-sensor configurations on a PC to test your tools.

To debug your tools in the emulator:

1. **Compile your code using the Win32 target (Debug or Release).**

2. **In the output directory, rename the DLL with the same name as your project to GdkApp.dll.**

   For example, if your project is called MyGDKTools, the resulting DLL should be called MyGDKTools.dll. You rename this DLL to GdkApp.dll.

   The output directories are as follows:

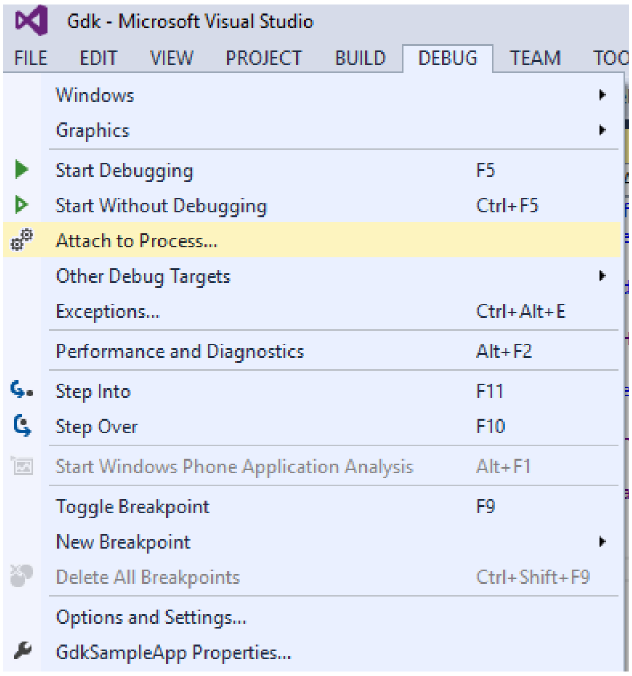
   Release: win32

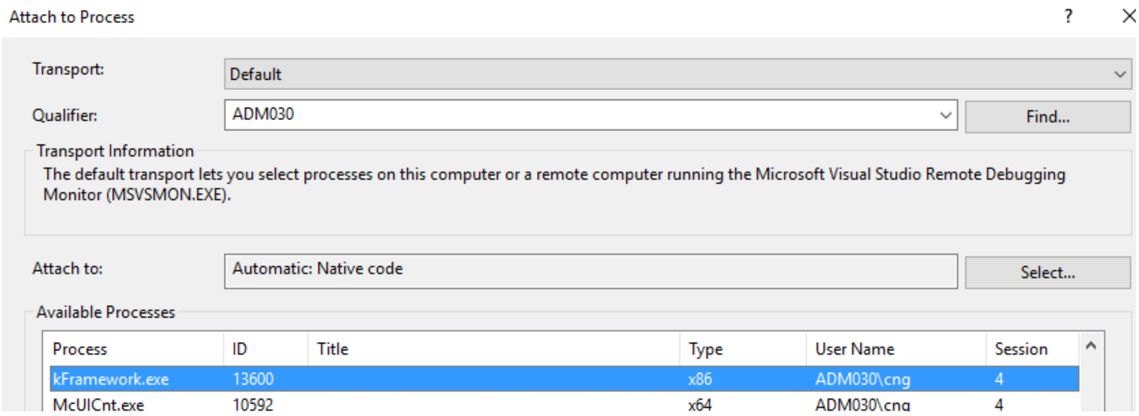
   Debug: win32d

3. **Launch the emulator from same output directory as in step 2.**

4. **In the emulator, choose a scenario and start it.**

5 **In Microsoft Visual Studio, attach the debugger to the kFramework.exe process.**





IMPORTANT

Framework.exe is only loaded after a user selects a scenario and starts the emulator session.

■ Debugging Entry Functions

VStart, VProcess, and VStop are called whenever a data record is played back in the emulator (that is, when a user clicks on the Next button or types the frame number in the frame field) with at least one tool instance. For more information on playback controls, see Recording, Playback, and Measurement Simulation in the SurfaceMeasure1008S user manual.

VDescribe however is called when the DLL loads, before the debugger can attach to the kFramework.exe process. To debug VDescribe, we recommend testing the function calls by putting them in VInit.

Tips

For information on building targets for testing in the emulator, see the GDK class reference documentation.

11.2.7 Tips

The following sections provide useful information for creating custom measurement tools.

■ Backward Compatibility with Older Versions of Tools

When loading a recording or job file that contains a custom measurement tool, the parameters in the loaded recording or job file must match those in the firmware.

By default, if declared parameters are missing from the configuration, a job file or a recording will fail to load.

There are two ways to provide backward compatibility with older parameter sets.

● Define new parameters as optional

Mark a parameter as optional with the function GdkParamInfo_SetIsOptional. When a parameter is marked as optional, parameter parsing functions succeed even if the parameter is missing from the configuration. The missing parameter is initialized with default value.

● Configuration Versioning

Over the lifetime of a tool, you may need to make changes to its interface (for example, changing or removing parameters). The user-defined aspects of a tool interface—its parameters and measurements—are captured by GDKToolVersionInfo objects.

By default, a tool has just one version (GdkToolInfo_FirstVersion), but more versions may be added using GdkToolInfo_AddVersion. Whenever the interface of a tool has changed, a new version can be registered so that the new interface can be correctly parsed by the framework.

When the configuration of a tool instance is saved, the version used at the time is also saved. This saved version is used by the framework to parse the configuration. If a version is not defined by the firmware implementation, then that tool instance will not be active.

During run-time, you can query the version of the configuration of a tool instance by using GdkToolCfg_Version. You can then interpret the parameters depending on the version the configuration is saved in.

```
GdkFx(kStatus) GdkExampleTool_VDescribe(GdkToolInfo info)
{
kCheck(GdkToolInfo_SetLabel(info, "Example"));

kCheck(GdkToolInfo_SetSourceType(info, GDK_DATA_TYPE_UNIFORM_PROFILE));
kCheck(GdkToolInfo_AddSourceOption(info, GDK_DATA_SOURCE_TOP));

kCheck(GdkExampleTool_DescribeV0(info));
kCheck(GdkExampleTool_DescribeV1(info));

kCheck(GdkToolInfo_SetDefaultVersion(info, GdkToolInfo_VersionAt(info, 1)));

return kOK;
}

GdkFx(kStatus) GdkExampleTool_DescribeV0(GdkToolInfo info)
```

```
{
kCheck(GdkParamsInfo_Add(GdkToolInfo_Params(info), "RefRegion", GDK_PARAM_TYPE_PRO-
FILE_REGION, "Ref Region", kNULL));
kCheck(GdkParamsInfo_Add(GdkToolInfo_Params(info), "Region", GDK_PARAM_TYPE_PRO-
FILE_REGION, "Region", kNULL));
kCheck(GdkToolInfo_SetFirstVersionName(info, ""));

return kOK;
}

GdkFx(kStatus) GdkExampleTool_DescribeV1(GdkToolInfo info)
{
GdkToolVersionInfo versionInfo;

// Auto-version

kCheck(GdkToolInfo_AddVersion(info, kNULL, &versionInfo));
kCheck(GdkToolVersionInfo_UseBase(versionInfo, GdkToolInfo_FirstVersion(info)));
kCheck(GdkParamsInfo_AddFloat(GdkToolVersionInfo_Params(versionInfo), "BaseScale", kNULL,
2.0, kNULL));

return kOK;
}
```

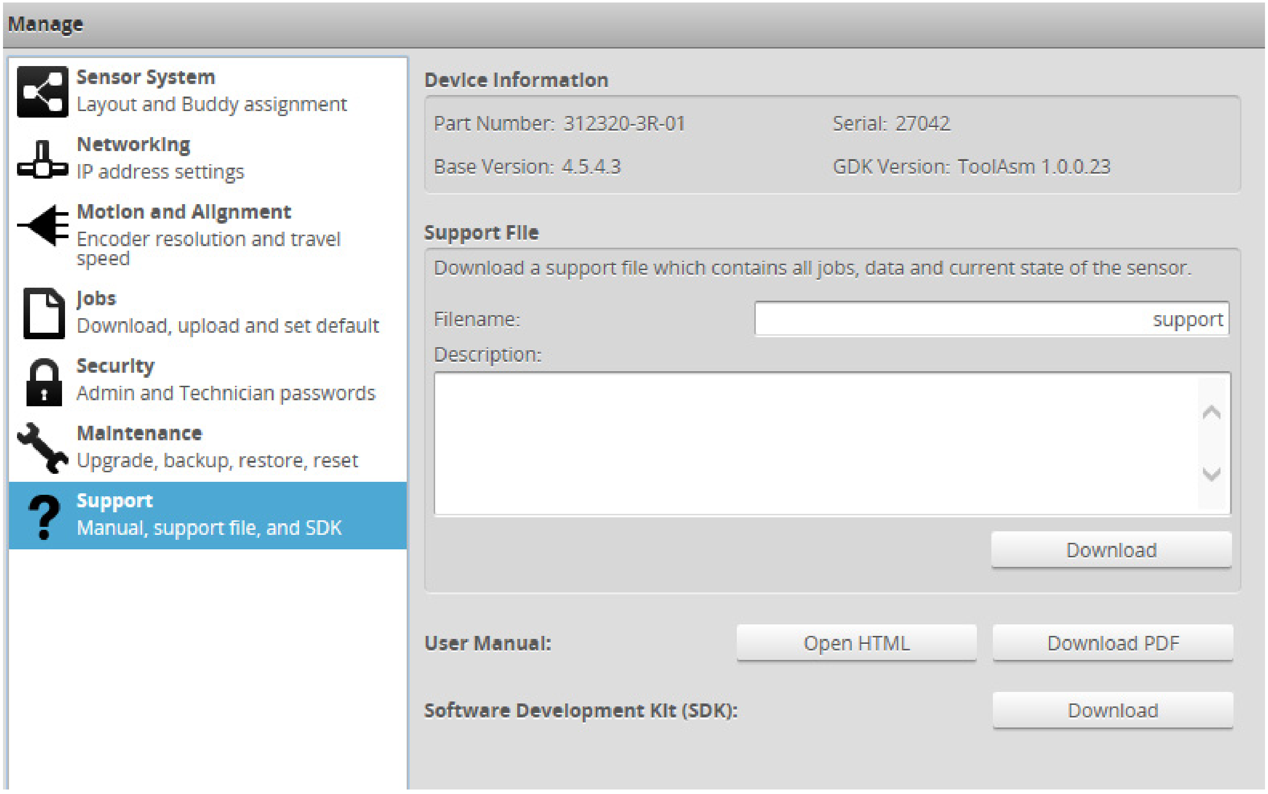
Adding a new measurement does not require special handling. The new measurement is just not instantiated in a previous configuration.

Version

You can define the version number of your tools in Asm.x.h.

#define TOOL_VERSION kVersion_Stringify_(1, 0, 0, 23)

The version is displayed on the [Manage] page, in the [Support] category.



Common Programming Operations

The following sections describe common programming operations.

- Input Data Objects

The VProcess function receives a GdkToolInput object as input. This object is a container where the information and actual data of the received input is stored.

GdkInputItem item = GdkToolInput_Find(input, obj->dataSource);

GdkDataInfo itemInfo = GdkInputItem_Info(item);

The GdkToolInput_Find and GdkInputItem_Info functions are used to extract the item and info objects. These objects can then be used to retrieve the input data and information (for example, offset and resolution) associated to the input. The following are some examples:

Computing actual height information using offset and scale

k64f height = rangeSrc[index] * scale->z + offset->z;

Extracting height information from profiles and surfaces.

The TestProfileSelect and TestSurfaceSelect examples show how to perform these operations.

- Setup and Region Info during Tool Initialization

  Memory allocation is often done in the VInit or VStart function. To retrieve sensor and data information such as active area settings and data scale outside of VProcess, you can use the following function:

  GdkDataInfo info = GdkSensorInfo_DataSource(GdkTool_SensorInfo(tool), GDK_DATA_-SOURCE_TOP);

- Computing Region Based on the Offset from an Anchor Source

  Just like built-in measurement tools, custom tools created with the GDK can be anchored to another tool (GDK-based tools or built-in tools).

  To compute the offset region:

  ```
  TestToolClass* obj = TestTool_Cast_(tool);
  GdkParams params = GdkToolCfg_Parameters(config);
  const kPoint3d64f* anchor = GdkToolInput_AnchorPosition(input);
  GdkRegionXZ64f offsetRegion = { k64F_NULL, k64F_NULL, k64F_NULL, k64F_NULL };

  param = GdkParams_Find(params, "Region");
  obj->region = *GdkParam_AsProfileRegion(param);

  offsetRegion = obj->region;
  offsetRegion.x += anchor->x;
  offsetRegion.z += anchor->z;
  ```

  In the code above, we first retrieve the tool's region settings (before anchoring is applied), and then adjust the region based on the results from the anchored source in VProcess. If the anchored source fails, the tools will not be invoked.

  The TestProfileSelect and TestSurfaceSelect examples show how to extract height information from anchored regions.

  For more information on anchoring, see Measurement Anchoring in the SurfaceMeasure1008S user manual.

- Part Matching

  When part matching is enabled, the tool receives translated and corrected surface data. If part matching fails for the current scan (for example, the quality score is too low), the tools will not be invoked.

  For more information on part matching, see Part Matching in the user manual.

Accessing Sensor Local Storage

You can access a sensor's local storage by using the kFile API.

For example, to read and write a file to a sensor's storage, you could use the following:

```
#include <kApi/Io/kFile.h>

…

ToolFx(kStatus) TestTool_VStart(TestTool tool)
{
…

kFile_Save("test.txt", stringBuf, (kSize) 1024);
kFile_Load("test.txt", stringBuf, &bufLen, kNULL);
```

Print Output

In the emulator, you can send output to Microsoft Visual Studio or to programs such as DebugView by using the OutputDebugString function.

```
GtsFx(kStatus) TestTool_Trace(const kChar* format, ...)
{
kStatus status = kOK;
kChar debugLine[256];

kVarArgList argList;
kVarArgList_Start_(argList, format);
{
status = kStrPrintvf(debugLine, 256, format, argList);
}
kVarArgList_End_(argList);
OutputDebugStringA(debugLine);
return status;
}
```

IMPORTANT

OutputDebugString is NOT supported on sensor targets. Use #ifdef to comment out the code when compiling against sensor targets.

MEMO

12 Tools

The following sections describe some of the tools provided with a SurfaceMeasure1008S sensor, as well as the CSV format that a sensor can export. For information on the integrations available with a sensor, see "10 Integrations" on page 747.

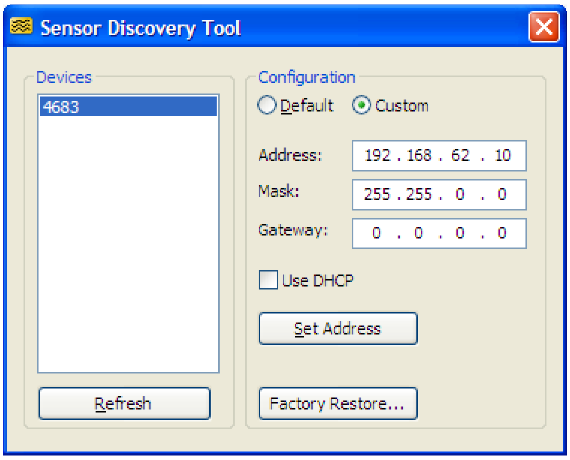
- Bandwidth Tool: Use this tool to diagnose bandwidth-related issues.
- CSV Converter Tool: Used to convert CSV data exported from a sensor to several formats. See "12.2 CSV Converter Tool" on page 974.
- Discovery Tool: Used to find sensors on a network. See "12.1 Sensor Discovery Tool" on page 973.
- Track Editor: Used with the Surface Track tool. For more information, see "6.34 Track" on page 593.

"Pattern Editor: Used to edit patterns created in the Surface Pattern Matching tool. For more information, see "12.3 Pattern Editor" on page 982.

12.1 Sensor Discovery Tool

If a sensor's network address or administrator password is forgotten, the sensor can be discovered on the network and/or restored to factory defaults by using the Sensor Discovery software tool. This tool can be obtained from the downloads area of the Mitutoyo website: https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/.

After downloading the utility package [14405-x.x.x.x_SOFTWARE_GO_Utilities.zip], unzip the file and run the Sensor Discovery Tool [Tools > Discovery > kDiscovery.exe].



Any sensors that are discovered on the network will be displayed in the Devices list.

To change the network address of a sensor:

1 Select the [Custom] option.

2 **Enter the new network address information.**

3 **Click [Set Address].**

To restore a sensor to factory defaults:

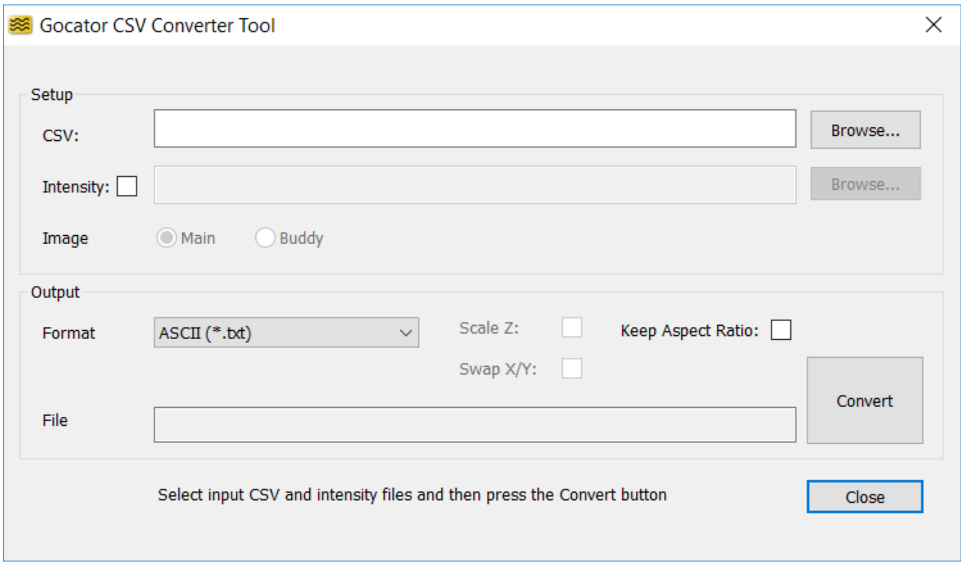
1 **Select the sensor serial number in the [Devices] list.**

2 **Press the [Factory Restore...] button.**
Confirm when prompted.

IMPORTANT
The Sensor Discovery tool uses UDP broadcast messages to reach sensors on different subnets. This enables the Sensor Discovery tool to locate and re-configure sensors even when the sensor IP address or subnet configuration is unknown.

12.2 CSV Converter Tool

The CSV Converter tool lets you convert data exported from a SurfaceMeasure1008S sensor in the CSV format to several formats (see table below). For more information on exporting recorded data, see 📖 "■Downloading, Uploading, and Exporting Replay Data" on page 84.
For information on the CSV file format that the sensor exports, see the next section.



Tips
The tool supports data exported from Profile or Surface mode.

Access the website at https://www.mitutoyo.co.jp/downloads/software-drivers/sm1008s/ and download the appropriate package.
After downloading the tool package, unzip the file and run the SurfaceMeasure1008S CSV Converter tool [Tools > CSV Converter > kCsvConverter.exe].
The tool supports the following output formats:

Output formats

Format	Description
ASCII (XYZI)	Comma-separated points in X, Y, Z, Intensity (if available) format.
16-bit BMP	Heightmap with 16bit height values in a 5-5-5 RGB image. Not intended for visualization.
16-bit TIFF	Heightmap as grayscale image.
16-bit PNG	Heightmap as grayscale image.
GenTL RGB	For more information, see "10.2.1 16-bit RGB Image" on page 932.
GenTL Mono	For more information, see "10.2.2 16-bit Grey Scale Image" on page 933.
Raw CSV	Mitutoyo SurfaceMeasure1008S CSV format for a single frame.
HexSight HIG	Mitutoyo HexSight heightmap.
STL ASCII	Mesh in standard STL text format (can become very large).
STL Binary	Mesh in binary STL format.
Wavefront OBJ	Mesh with comma-separated vertices and facets in text format.
ODSCAD OMC	ODSCAD heightmap.
MountainsMap SUR	DigitalSurf MountainsMap heightmap.
24-bit Spectrum	Color spectrum bitmap for visualization of heightmap. Does not contain height values.

With some formats, one or more of the following options are available:

Output options

Option	Description
Scale Z	Resamples the Z values to use the full value range.
Swap X/Y	Swaps the X and Y axes to obtain a right-handed coordinate system.
Keep Aspect Ratio	Resamples the X and Y axes to obtain the proper aspect ratio.

IMPORTANT

The GenTL format is a 48-bit RGB or grey scale PNG. Height map, intensity and stamp information are stored as defined in the GenTL Driver section ("10.2 GenICam GenTL Driver" on page 928). You can load the exported data into image processing software to provide simulation data for developing applications using the GenTL driver.

To convert exported CSV into different formats:

1. **Select the CSV file to convert in the [CSV] field.**

2. **(Optional) If intensity information is required, check the [Intensity] box and select the intensity bitmap.**

   Intensity information is only used when converting to ASCII or GenTL format. If intensity is not selected, the ASCII format will only contain the point coordinates (XYZ).

3. **If a dual-sensor system was used, choose the source sensor next to [Image].**

4 **Select the output format.**

For more information on output formats, see 📖 "• Output formats" on page 975.

5 **(Optional) Set the [Scale Z, Swap X/Y], and [Keep Aspect Ratio] options.**

Availability of these options depends on the output format you have chosen. For more information, see 📖 "• Output options" on page 975.

6 **Click [Convert].**

The converter converts the input files.

The converted file will be in the same directory as the input file. It will also have the same name as the input file but with a different file extension. The converted file name is displayed in the [Output File] field.

12.2.1 CSV File Format

The CSV Converter tool can convert from the CSV format that a sensor can export to several other formats. If you want to work with the exported file directly, use the following information.

An exported CSV file contains a series of "sections." Each section begins with a row containing the name of the section, and ends with a row containing the string "End." An empty line separates each section.

Each section usually contains one or more subsections. Each subsection has a header row containing a list of field names, followed by one or more rows of data. There is usually no empty line between the subsections.

Other structures within sections are possible.

Example:

■ Info

CSV Version,Sensor Count,Trigger Mode,...

2,1,0,32000.00000,...

End

■ DeviceInfo

ID,Model,Version,...

13434,311320-2M-01,4.8.2.29,...

End

Ranges

...

End

Usually all available data in the recording buffer is exported. The exceptions are Surface and SurfacePointCloud. For these sections, only the currently selected frame is exported.

Info

This section contains basic system information. It has one header row and one value row. The fields are described below:

Info Fields

Field	Description
CSV Version	Version of the CSV file format.
Sensor Count	Number of sensors in the system.
Trigger Mode	Trigger source: 0 – Time 1 – Encoder 2 – Digital input 3 – Software
Trigger Rate	Frame rate for time trigger (Hz).
Trigger Delay Domain	Output delay domain: 0 – Time (μs) 1 – Encoder (mm)
Trigger Delay	Output delay (μs or mm, depending on delay domain defined above).
Operation Mode	The scan mode.
XResolution	System X resolution (mm).
YResolution	System Y resolution (mm).
ZResolution	System Z resolution (mm).
Yspeed	Y Speed (mm/s).
Layout	Sensor orientation: 0 – Normal (single-sensor system) / Wide (dual-sensor system) 1 – Opposite 2 – Reverse 3 – Grid

DeviceInfo

This section contains information about each device in the system. There is one header row, and one value row per device.

DeviceInfo Fields

Field	Description
ID	Device serial number
Model	Device part number
Version	Firmware version
Exposure Mode	Exposure mode: 0 – Single exposure 1 – Multiple exposures 2 – Dynamic exposure
Exposure 0 through Exposure 4	Multiple exposures
Exposure Min	Dynamic exposure min
Exposure Max	Dynamic exposure max

Field	Description
FOV X	Active area X
FOV Y	Active area Y
FOV Z	Active area Z
FOV Width	Active area width
FOV Height	Active area length (Y). (Note difference in terminology.)
FOV Depth	Active area height (Z). (Note difference in terminology.)
Transform X	Transform X offset (mm)
Transform Y	Transform Y offset (mm)
Transform Z	Transform Z offset (mm)
Transform X Angle	Transform X Angle (degrees)
Transform Y Angle	Transform Y angle (degrees)
Transform Z Angle	Transform Z angle (degrees)

■ RecordingFilter

This section lists the filters used during recording. Unlike the other sections, it contains multiple sub-sections within, separated by spaces (but not the “End” keyword).

Example:

RecordingFilter

Section1 Param 1, Section1 Param2

value, value

Section2 Param 1

value

Section3 Param1, Section3 Param2

value

End

Each section will be described by a separate table below. They appear in the same order as documented.

RecordingFilter Fields

Field	Description
Condition Combination Type	Any or All

"Any Measurement" Filter Fields

Field	Description
Type	Any Measurement
Enabled	Whether or not is enabled. Yes/No
Result	Accepted result type: Pass/Fail/Invalid/Valid

"Any Data" Filter Fields

Field	Description
Type	Any Data
Enabled	Whether or not is enabled: Yes/No

Threshold Case	How to threshold: At or Above, or Below
Range Count Threshold	Threshold value (point count)

"Measurement" Filter Fields

Field	Description
Type	Measurement
Enabled	Whether or not is enabled: Yes/No
Result	Accepted result type: Pass/Fail/Invalid/Valid
Selection ID	First measurement ID

■ Ranges

This section describes single-point range data. It has two sub-sections: attributes and data.

The attribute section has only one row of data

Attribute Section Fields

Field	Description
Frame Count	Total number of frames
X Offset	X offset (mm)
Y Offset	Y offset (mm)
Z Offset	Z offset (mm)

The data section has one or more rows of data per frame (for example, range and intensity).

Data Section Fields

Field	Description
Frame	Frame index
Source	Source (for example, 0 for Top)
Time	Stamp time
Encoder	Stamp encoder
Z Encoder	Stamp encoder Z
Inputs	Stamp inputs
Exposure	Stamp exposure (us)
Y	Y value (mm)
Axis	Axis: Z (range) or I (Intensity)
Value	Range value (mm) or intensity (count)

■ Profile

This section describes uniform (or resampled) profile data, which is produced when the sensor is in Profile mode and uniform spacing is enabled. It has two sub-sections: attributes and data.

The attribute section has only one row of data.

Attribute Section Fields

Field	Description
Frame Count	Total number of frames
Column Count	Number of columns
X Offset	X offset (mm)

Y Offset	Y offset (mm)
Z Offset	Z offset (mm)

The data section has one or more rows of data per frame (for example, range and intensity).

Data Section Fields

Field	Description
Frame	Frame index
Source	Source (for example, 0 for Top)
Time	Stamp time
Encoder	Stamp encoder
Z Encoder	Stamp encoder Z
Inputs	Stamp inputs
Exposure	Stamp exposure (μs)
Y	Y value (mm)
Axis	Axis: Z (range) or I (Intensity)
(x values)	Each column in header is a resampled X position Each column in data is the range (mm) or intensity (count)

■ RawProfile

This section describes point cloud profile data (or unresampled / raw data), which is produced when the sensor is in Profile mode and uniform spacing is disabled. It has two sub-sections: attributes and data.

The attribute section has only one row of data.

Attribute Section Fields

Field	Description
Frame Count	Total number of frames
Column Count	Number of columns
X Offset	X offset (mm)
Y Offset	Y offset (mm)
Z Offset	Z offset (mm)

The data section has one or more rows of data per frame (for example, range and intensity).

Data Section Fields

Field	Description
Frame	Frame index
Source	Source (for example, 0 for Top)
Time	Stamp time
Encoder	Stamp encoder
Z Encoder	Stamp encoder Z
Inputs	Stamp inputs
Exposure	Stamp exposure (μs)
Y	Y value (mm)
Axis	Axis: X, Z, or I (Intensity)
(x values)	Each column in header is an index. Each column in data is the X/Z value (mm) or intensity (count)

Part

This section describes uniform (or resampled) surface data, which is produced when the sensor is in Surface mode and uniform spacing is enabled.

Tips
Only the data for the frame currently selected in the UI is exported when you export part data to a CSV file.

The section has two sub-sections: attributes and data.

The attribute section has only one row of data.

Attribute Section Fields

Field	Description
Frame	Frame index
Source	Source (for example, 0 for Top)
Time	Stamp time
Encoder	Stamp encoder
Z Encoder	Stamp encoder Z
Inputs	Stamp inputs
Row Count	Number of rows
Column Count	Number of columns
X Offset	X offset (mm)
Y Offset	Y offset (mm)
Z Offset	Z offset (mm)

The data section contains the data of a single surface scan. Each data row corresponds to one Y position. The first row contains the X values, and the first column contains the Y values. The region inside contains the range values (mm) for the corresponding row and column.

Surface Section

This section describes surface section data, which is produced when a section is added to uniform surface data. A surface section is similar to a uniform profile.

The data section contains the following fields.

Data Section Fields

Field	Description
Frame	Frame Index
Source	Source (e.g. 0 for Top)
Time	Stamp time
Encoder	Stamp encoder
Z Encoder	Stamp encoder Z
Inputs	Stamp inputs
Exposure	Exposure
Column Count	Number of columns
Start X	X Start
Start Y	Y Start
End X	X End

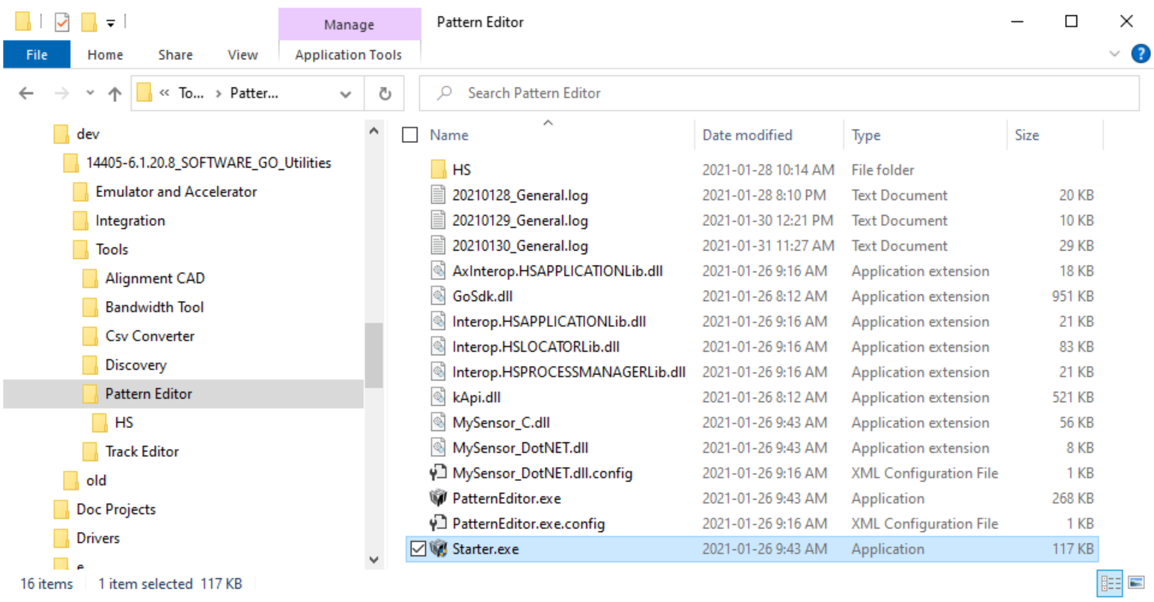
Field	Description
End Y	Y End
Pose Angle	Pose Angle
Pose X	Pose X Offset
Pose Y	Pose Y Offset
X Offset	X Offset
Y Offset	Y Offset
Z Offset	Z Offset
XResolution	X Resolution
ZResolution	Y Resolution
Axis	Axis: Z (range) or I (Intensity)
(x values)	Each column in header is a resampled X position Each column in data is the range (mm) or intensity (count)

12.3 Pattern Editor

The pattern editor lets you modify patterns created in the Surface Pattern Matching tool (for more information on the tool, see "6.25 Pattern Matching" on page 549). Although the patterns created in the Surface Pattern Matching tool will often result in good matches with your targets, you can use the pattern editor to improve the models, specifically by doing the following:

- "Add or remove contours the Surface Pattern Matching tool has detected on edges in the scan data.
- "Re-detect contours from the scan data using higher or lower levels of input image resolution (taken from the scan data) or contrast levels, compared to what the Surface Pattern Matching tool does internally.
- "Identify certain contours as being required for a match to occur.
- "Identify certain contours as being used to determine the position of a matched instance.

The pattern editor is available in the Utilities package (14405-x.x.xx.x_SOFTWARE_Utilities_SM1008S.zip, in the Tools\Pattern Editor folder.

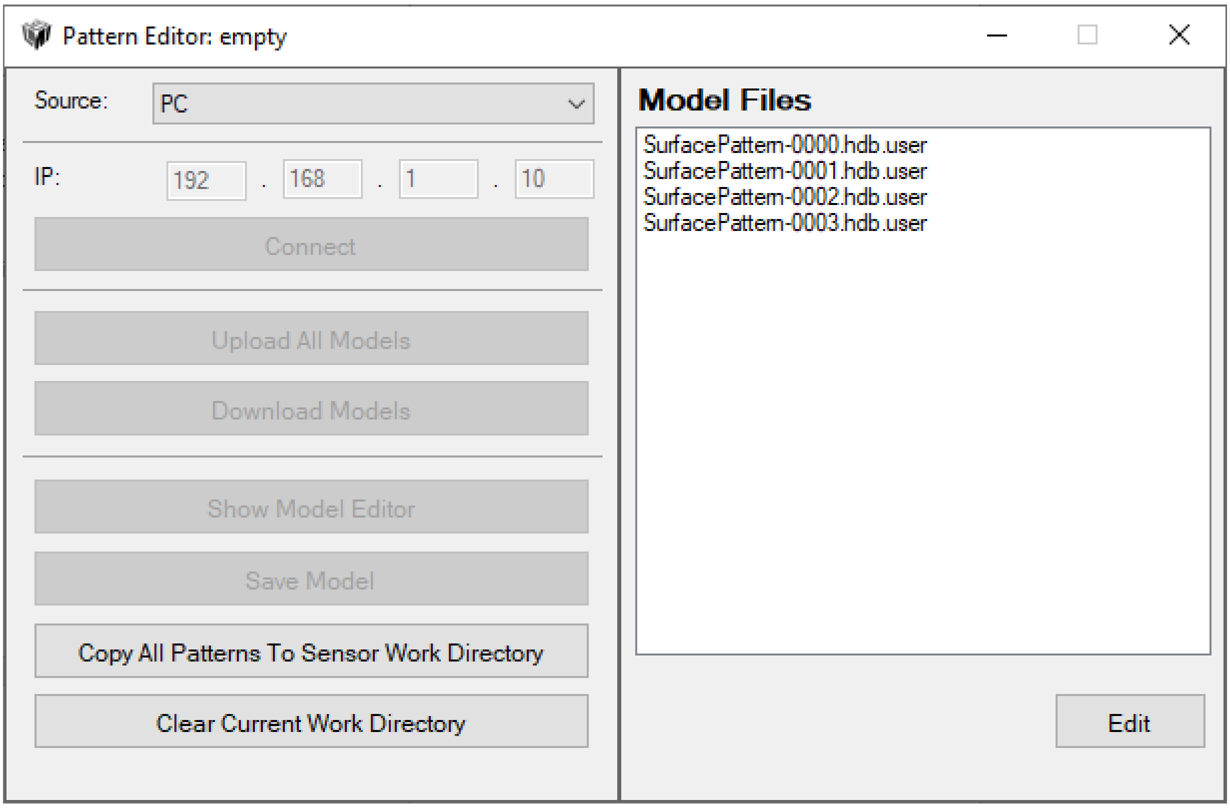


■ Launching the Pattern Editor

Before running the pattern editor for the first time, you must run Starter.exe, which you will find in the same folder as the pattern editor. Starter.exe registers certain DLLs required by the pattern editor, and then launches the editor itself. After you have run Starter.exe, you can launch the pattern editor (PatternEditor.exe) directly.

The pattern editor can work with model files that come from a sensor (accelerated or unaccelerated) or from the emulator. In all cases, files are accessed by the pattern editor in working folders in the local PC filesystem. When working with model files created with an unaccelerated sensor, you must use the helper application (see below) to transfer models between the PC and the sensor.

After you launch PatternEditor.exe (either directly or via Starter.exe), a helper application launches that lets you choose which model to edit, and also lets you connect to a sensor and copy models to the working folder on the PC.



[Source]: When working with an accelerated sensor (recommended) or the emulator, choose PC. When working with an unaccelerated sensor, choose Sensor.

[IP]: The address of the unaccelerated sensor.

[Connect]: Connects to the unaccelerated sensor at the provided IP.

[Upload All Models / Download All Models]: Upload the models from the working folder to the unaccelerated sensor, and download models from the sensor to the working folder.

[Show Model Editor / Edit]: Open the selected model in the model editor. For more information, see 📖 "■Overview of the Editor" on page 984.

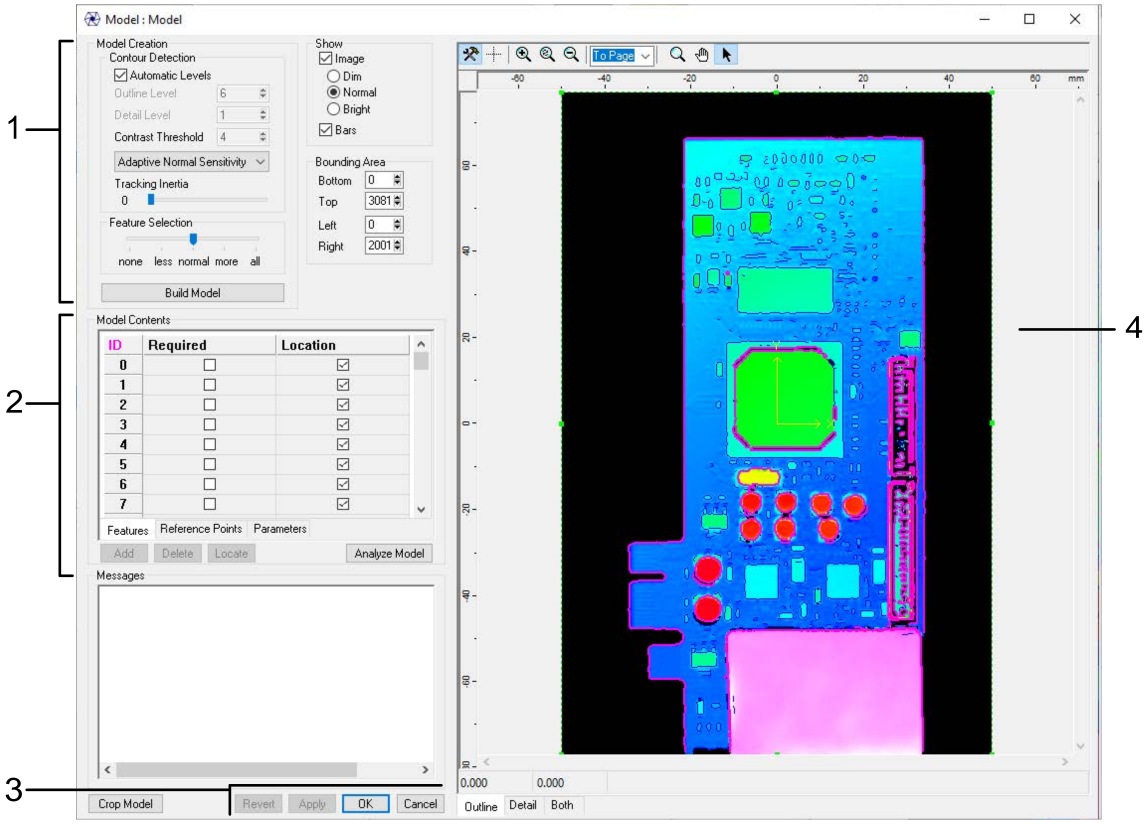
[Save Model]: Saves changes made with the model editor to the working folder.

[Copy All Patterns To Sensor Work Directory]: Copies patterns to the sensor work folder. Use this to transfer patterns to an unaccelerated sensor.

[Clear Current Work Directory]: Removes all models from the current working folder.

■ Overview of the Editor

After clicking Edit in the pattern editor helper application, the selected model opens in the editor window.



	Element	Description
1	Model Creation pane	Settings related to contour detection and feature selection. After configuring these settings, or resizing the model's bounding box (green dotted line), you must rebuild the model using the [Build Model] button.
2	Model Contents	The list of the features in a model (contours used in recognition and location of an instance). Note that some model contents (reference points and some settings in the [Parameters] tab) are not currently supported by the Surface Pattern Matching tool.
3	Save and discard buttons	Used to apply changes to a model, revert to the model's original state when it was loaded, and so on.
4	Outline, Detail, and Both tabs	The editor tabs that show the Outline and Detail levels of the model. The [Both] tab shows both levels together, but you can't edit models on this tab.

■ Models

Models are made up of features selected from the source contours detected either by the Surface Pattern Matching tool or by the model editor itself (if you rebuild the model using the [Build Model] button). The features are used to identify and locate instances in the scan data.

Contours, and the features selected from the contours for use in recognizing and locating an instance, work on two "coarseness" levels: the Outline level and the Detail level.

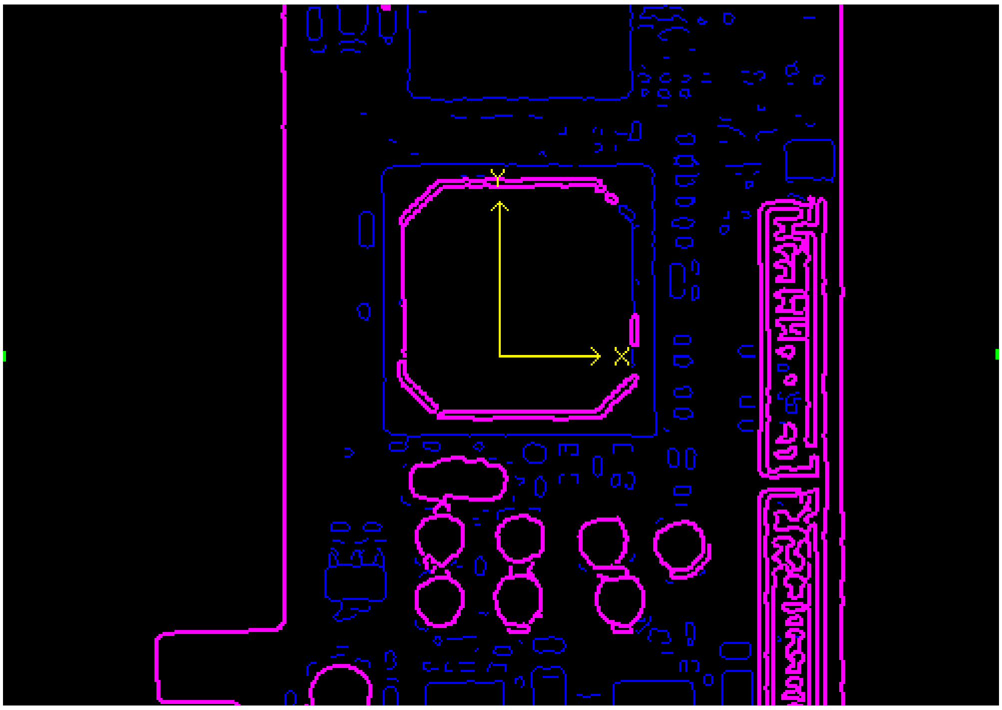
[Outline]: Used to quickly identify potential instances of a pattern in scan data. The Outline level is the "coarse" level of contours / features. The features at this level can be less stable, as they are not used to calculate the location of the instance. For example, a label whose position might change from frame to frame or a hole whose size might change from frame to frame could be kept at the Outline level.

[Detail]: Used to confirm whether an instance is in fact valid and to refine its location. The Detail level is the "fine" level of contours / features. The features at this level must be more stable and rigid with respect to one another. For this reason, given Surface scan data, include features that are all on the same plane to ensure that their positions will not be unstable due to parallax or other scanning issues. Furthermore, features on a part that might vary in size from frame to frame, or change position (such as a label), should be excluded.

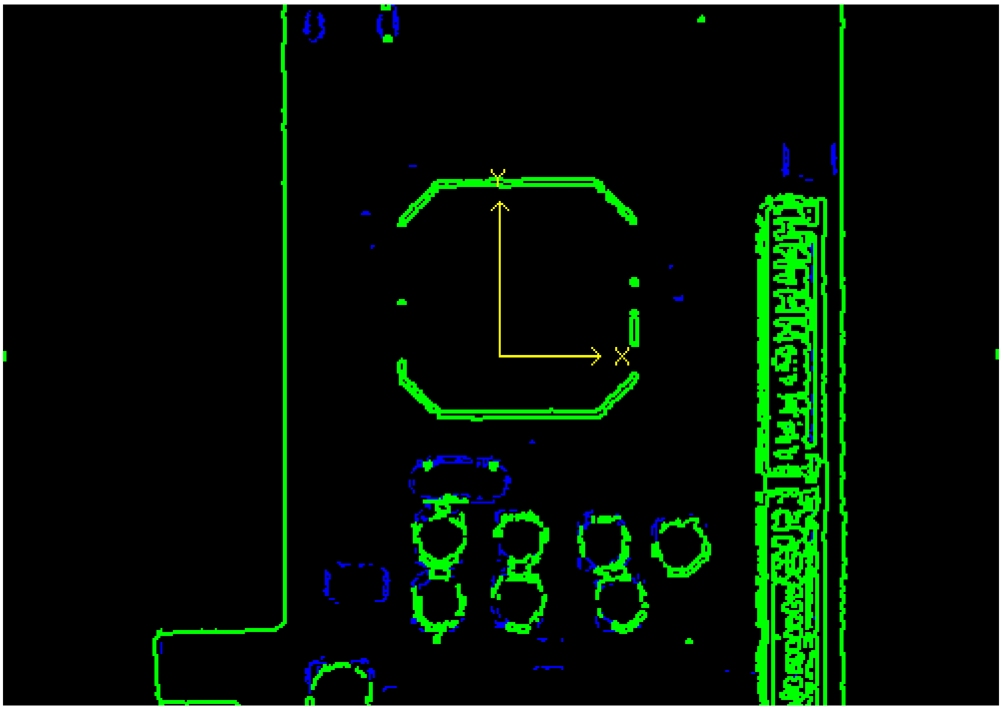
That said, the Outline and Detail levels will often be similar in terms of which features are included.

You can edit (add and remove) features at these levels separately, in the Outline and Detail panels in the main editor window. For more information on adding and removing features, see 📖 "■Adding and Removing Features Manually" on page 986.

In the editor, "unused" contours (those not selected to take part in instance recognition or locating) are indicated with dark blue paths. Features (contours selected to take part in instance recognition or locating) are indicated with either magenta paths (at the Outline level) or with green paths (at the Detail level); the features in a model are listed in the **[Model Contents]** pane.



Dark blue unused contours and magenta features at the Outline level.


Dark blue unused contours and green features at the Detail level.

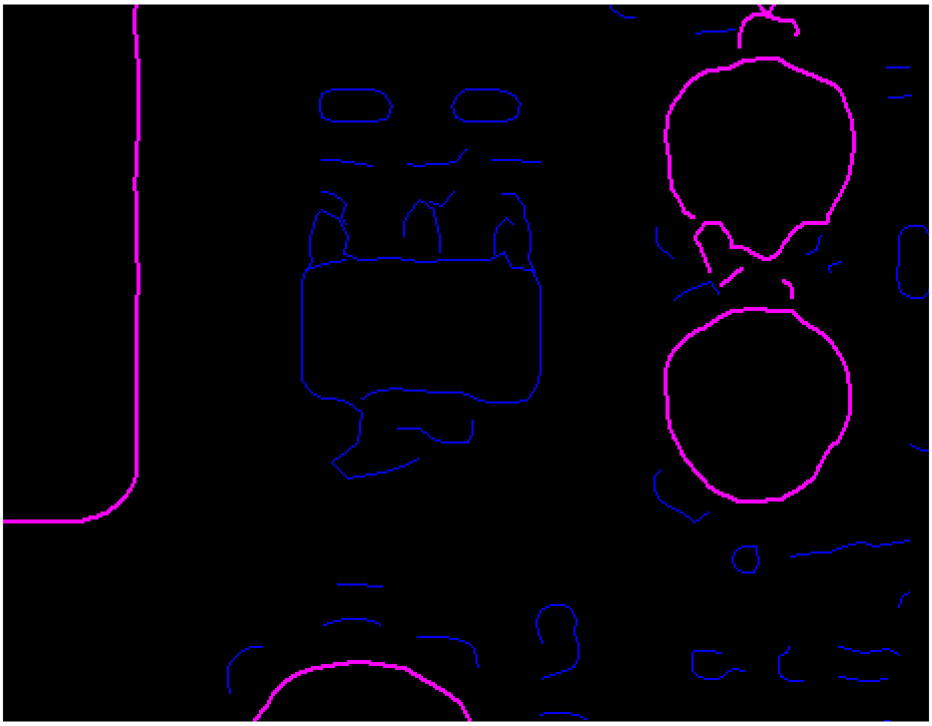
> **Tips**
> In the Surface Pattern Matching tool, only the Detail level of features is displayed.

■ Adding and Removing Features Manually

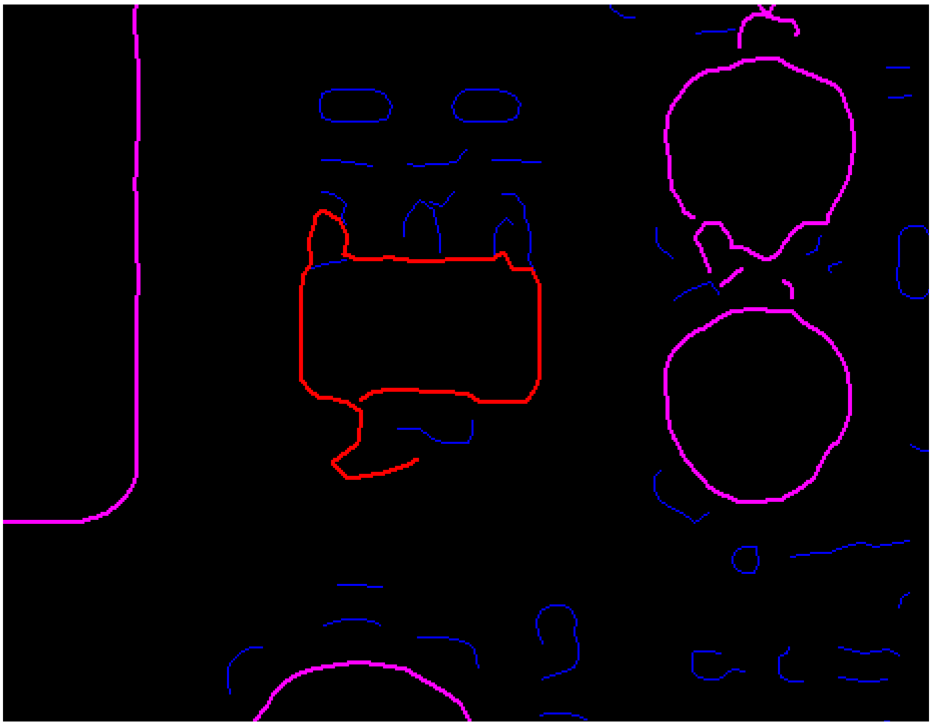
You can manually add features to a model from the source contours, or remove features currently in a model, at both the Outline and Detail levels. This can be useful if the model produced by the Surface Pattern Matching tool includes features related to parts of targets that could change or be present/absent from frame to frame. You should only include features that are constant from frame to frame.

> **Tips**
> Adding and removing features works in the same way in the Outline and Detail tabs.

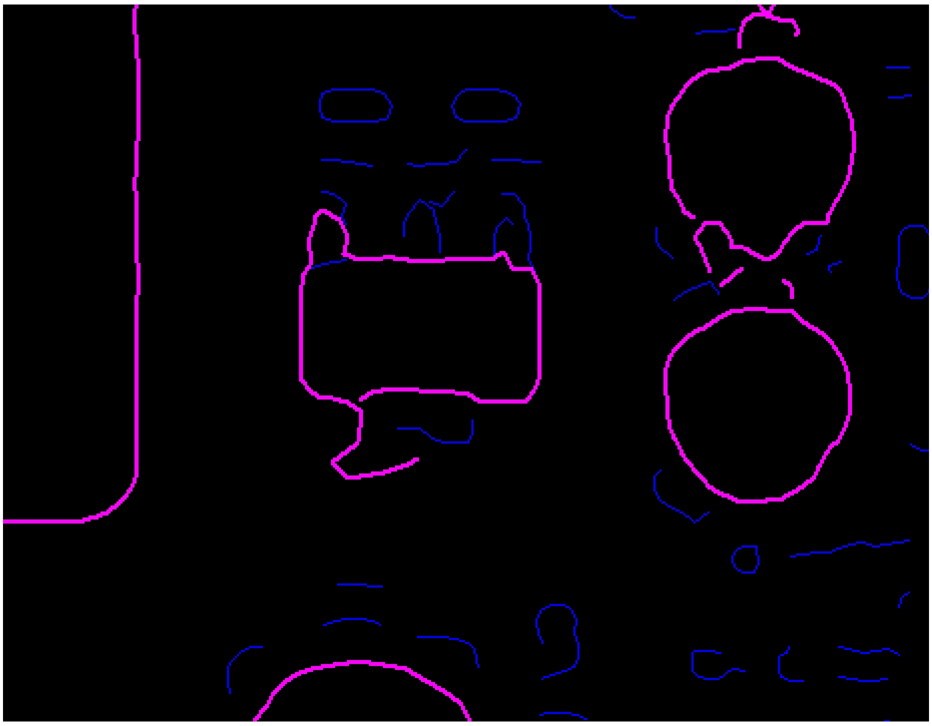
To add a feature from a source contour, double-click a dark blue contour in either the Outline or Detail tab and click Add or press the Insert key on your keyboard.



Dark blue unused contour (contours already added as features in the model are magenta).

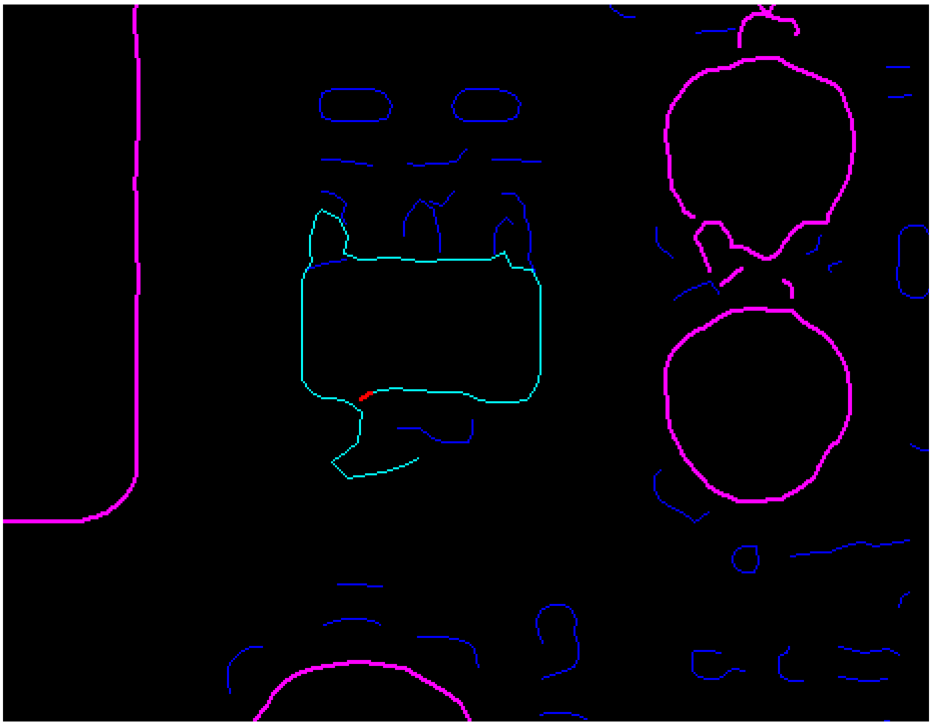


Contour selected by double-clicking it.



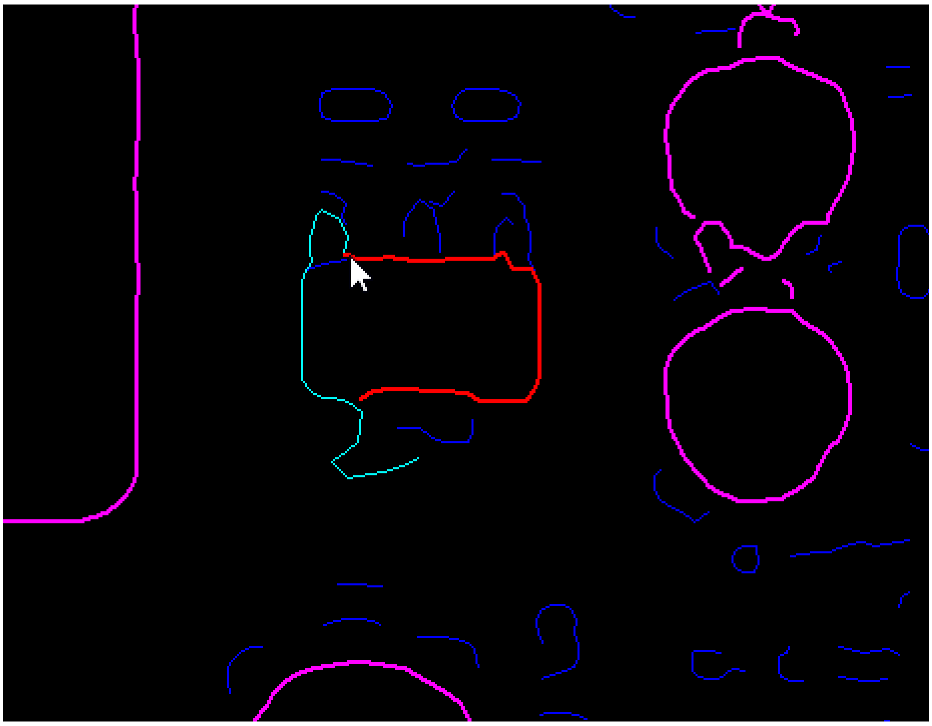
Contour added as a feature in the model (magenta).

If you single-click a dark blue unused contour, it turns cyan and lets you select segments of the contour.

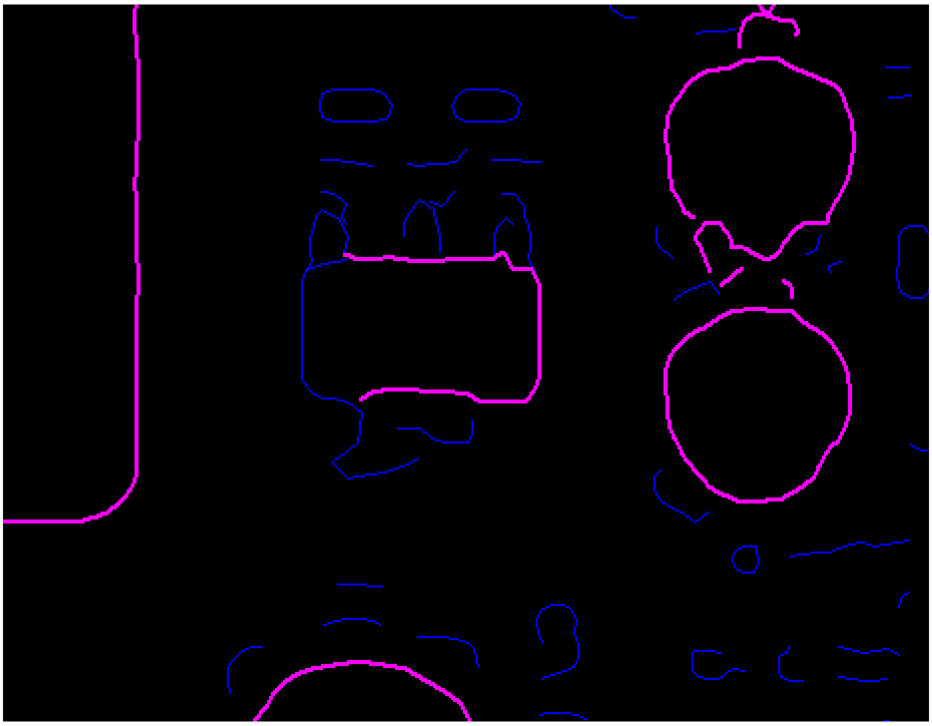


Contour highlighted in cyan with a selected segment (red).

Pressing the Ctrl key on your keyboard and clicking another segment selects a portion of the cyan path.



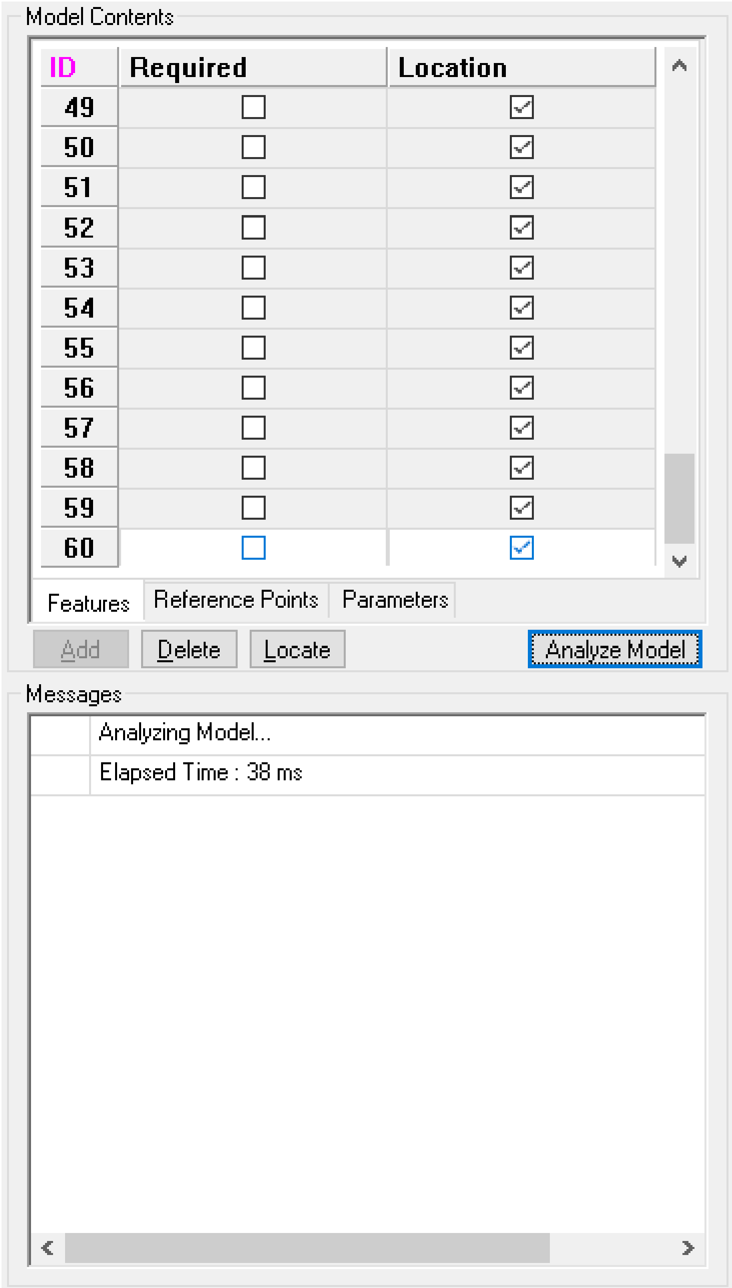
Clicking [Add] or pressing the Insert key on your keyboard adds the segment of the contour as a feature to the model.



After adding a feature, it is added to the list of features on the [Feature] tab in the [Model Contents] panel. You do not need to build the model after adding or removing features, but you must save the changes; for more information, see 📖 "■Saving and Discarding Changes" on page 996.

To remove a feature, click a magenta or green path in the editor to select it and click [Delete] or press the Delete key on your keyboard. After removing a feature, it is removed from the list of features on the Feature tab in the Model Contents panel. You do not need to build the model, but must save the changes; for more information, see 📖 "■Saving and Discarding Changes" on page 996.

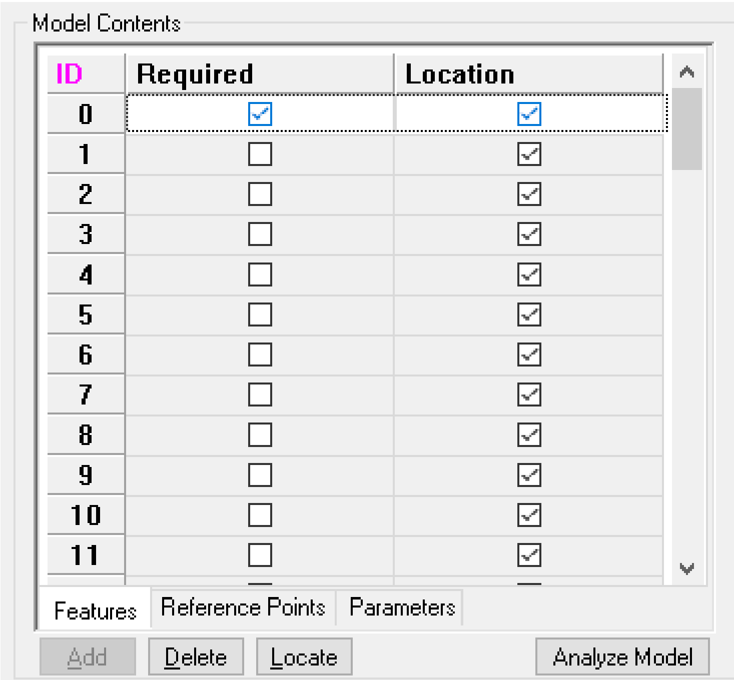
After adding a feature to a model or removing a feature from a model, you should analyze the model by clicking [Analyze Model]. Make note of any errors in the [Messages] panel.



No error messages after clicking Analyze Model.

■ Setting Required and Locating Features

In the list of features in the [Model Contents] pane, you can indicate that a feature is "required" or that it is used to calculate the location of an instance by checking the appropriate checkbox next to the feature.



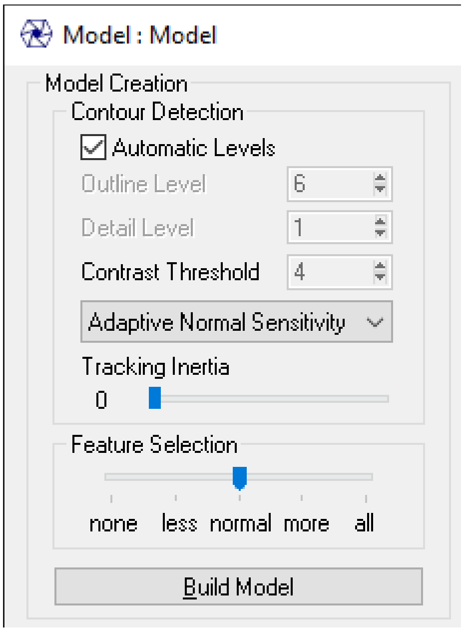
When Required is checked for a feature, it must be found by the Surface Pattern Matching tool in order for an instance to be identified.

When Location is checked for a feature, the Surface Pattern Matching tool uses the feature to calculate the location of instances. If a feature's location is not checked, it is only used for instance recognition. An example of the latter is a tag or label glued to an object. Although the label's contours (it's shape or what is written on it) might be unique enough to help recognize an instance, it's position on the object (that is, relative to the other features) might vary in its position from frame to frame. For this reason, it might be useful for instance recognition, but not for determining the location of the object.

■ Model Creation Settings and Rebuilding

The Surface Pattern Matching tool uses internally fixed settings to detect contours in the scan data and then select features from those source contours. In the pattern editor, you can increase or decrease the contour detection levels, change the contrast threshold, and so on, and then rebuild the model. This can be useful if the Surface Pattern Matching tool's internal settings do no produce the right amount of source contours and subsequently features.

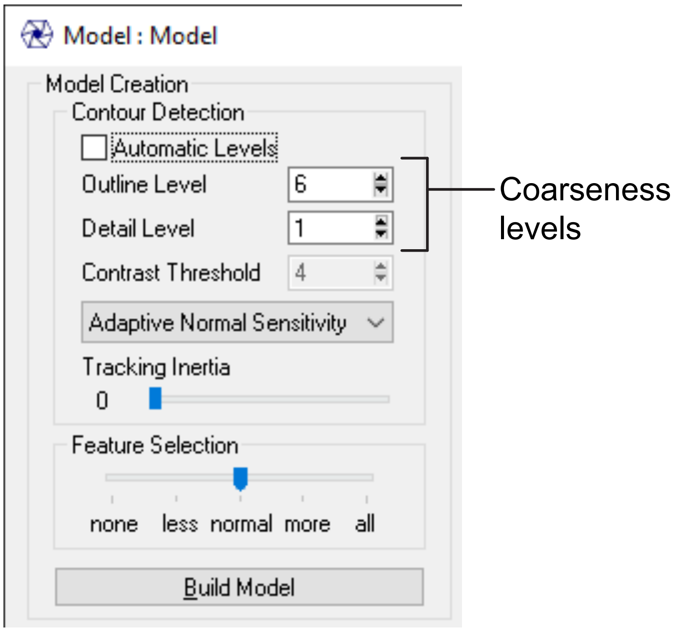
The settings described here are found in the [Model Creation] section of the model editor.



After making changes to any of these settings, you must rebuild the model by clicking [Build Model], and then save the changes. You should also click [Analyze Model] after rebuilding a model. Pay special attention to messages in the [Messages] pane at the bottom of the editor to make sure there are no errors. For more information on saving changes, see 📖 "■Saving and Discarding Changes" on page 996.

- Coarseness Levels

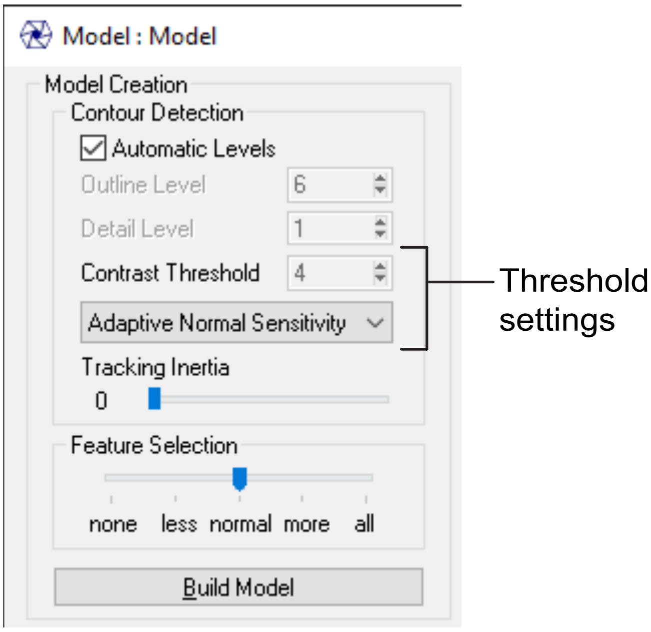
By default, the pattern editor uses automatically determined contour coarseness values (at both the Outline and Detail levels) to detect contours in the scan data image. If you uncheck [Automatic Levels], you can change the [Outline Level] and [Detail Level] values to generate more or fewer contours, from which you can then select features that more reliably represent your target.



The [Outline Level] and [Detail Level] values range from 1 to 16. At the lowest value, contours are detected in a full-resolution version of the image based on the scan data, which results in more contours from which to choose features. At higher values, contours are detected in a reduced-resolution version of the image based on the scan data: the resolution is reduced by the setting's value, which results in fewer contours being detected. Note that [Detail Level] must be less than or equal to [Outline Level].

- Thresholds

You can adjust the level of sensitivity the pattern editor uses to detect contours in the scan data image.



By default, the sensitivity is set to Adaptive Normal Sensitivity, but you can set it to one of the following adaptive sensitivity levels, or to a fixed threshold value (see below).

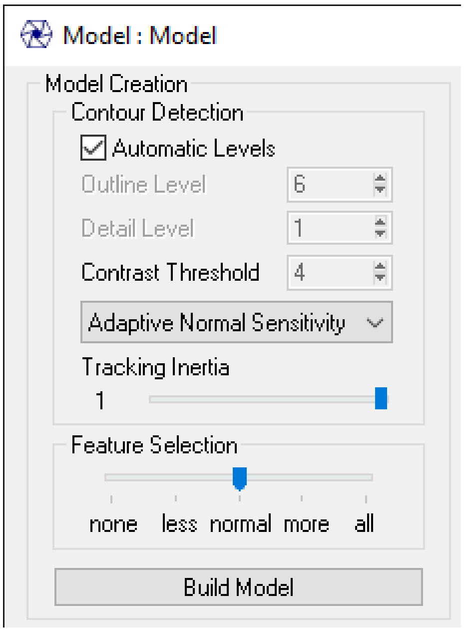
[Adaptive High Sensitivity]: Results in more low-contrast contours, but also noise.

[Adaptive Low Sensitivity]: Results in strongly defined contours and eliminates noise, but may miss important contour segments.

If you set the dropdown to Fixed Value, you can then set a fixed threshold in [Contrast Threshold]. The [Contrast Threshold] value corresponds to the minimum step required to detect corners. A lower value generates more contours when you rebuild the model, but may also result in noise.

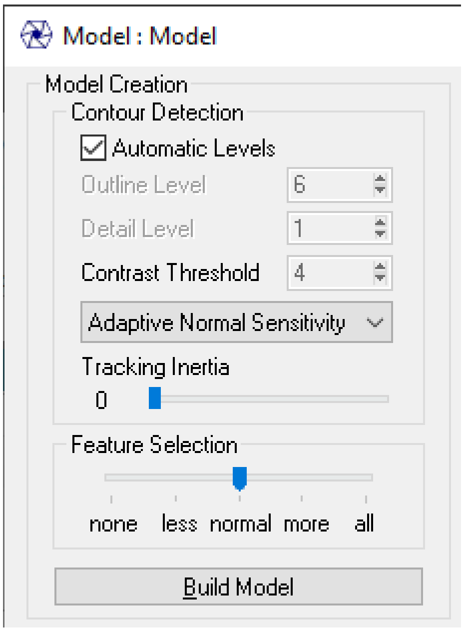
- **Tracking Inertia**

Setting the Tracking Inertia slider to 1 closes small gaps in the source contours, connecting contours that might otherwise be broken into smaller sections.



- **Feature Selection**

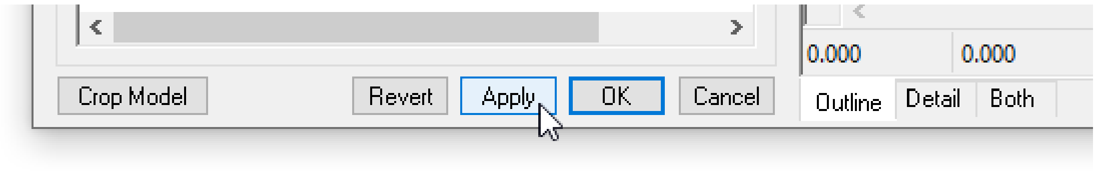
This setting ranges from [none] to [all], which determines which features the pattern editor selects from the detected contours and adds to the model when you rebuild it. You should use [none] (which adds no features to the model) if you want to manually add features to the model from the detected contours. The [normal] setting tries to add the most appropriate features to the model; use this setting with simple to moderately complex parts. The [all] setting adds all detected contours as features to the model; only use this with very complex parts, such as electronic parts.



Saving and Discarding Changes

After making changes to a model (either adding or removing features, or re-detecting contours by clicking [Build Model]), you must do the following:

1 In the model editor, at the bottom of the window, click [Apply] or [OK].

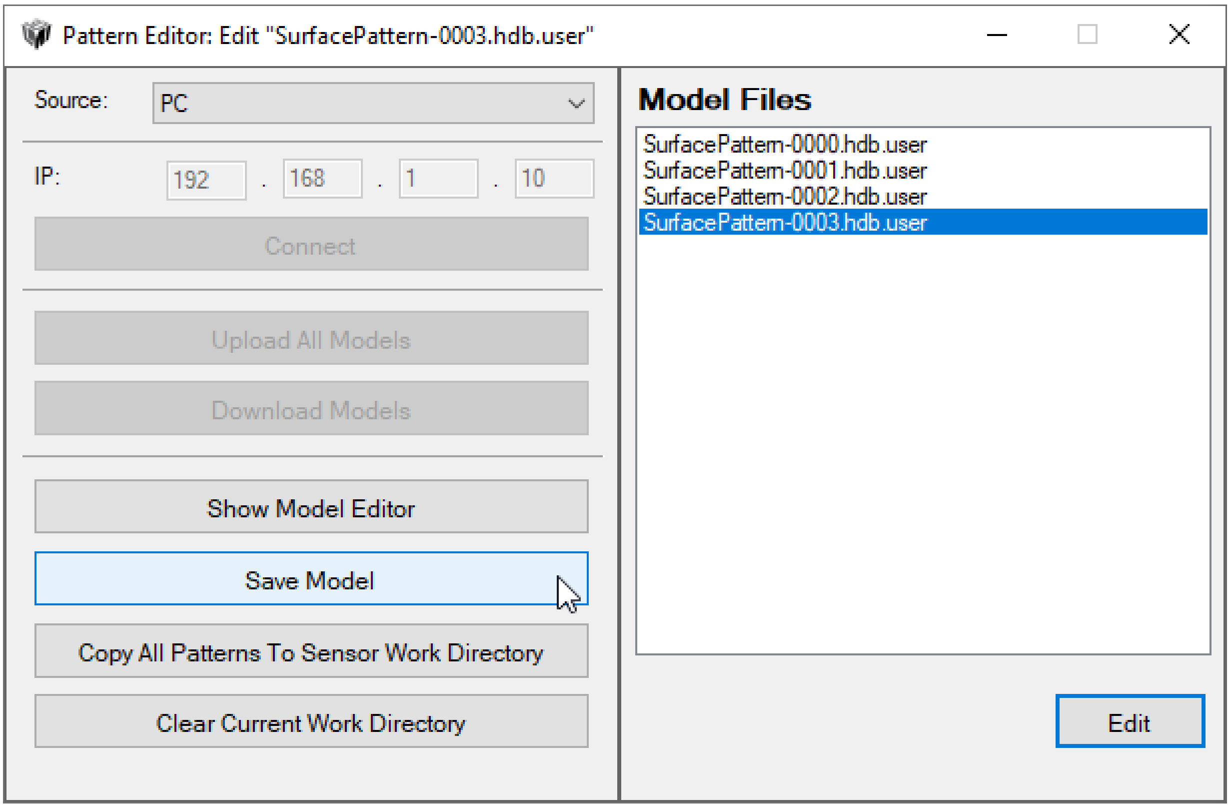


» Clicking [Apply] leaves the model editor open.

Do this if you want to continue working on a model (for example, if you want to test the model in Gocator before closing the model).

» Clicking [OK] closes the model editor.

2 In the pattern editor helper application, click the model you were working on, and click [Save Model].



» The model is saved to the working folder.

Tips

After making changes to a model, you must re-load the pattern in the instance of Surface Pattern Matching to see the changes.

Before saving changes (either by clicking [Apply] or [OK]), you can revert the model to its initial state by clicking [Revert].

■ Miscellaneous

Reference points, which you can create in the pattern editor on the [Reference Points] tab in the [Model Contents] panel, are not currently supported by the Surface Pattern Matching tool.

The Surface Pattern Matching tool does not currently support the custom shading area (on the [Parameters] tab in the [Model Contents] panel).

You can crop models by resizing the green bounding box (or setting its dimensions in the [Bounding Area] section in the model editor) and rebuilding the model.

In the Show section in the model editor, you can hide the scan data to see only the contours and features by unchecking [Image]. Note that the Dim / Normal / Bright options below [Image] only apply to intensity data.

MEMO

13 Troubleshooting

Review the guidance in this chapter if you are experiencing difficulty with a sensor system.

If the problem that you are experiencing is not described in this section, see 📖 "Precautions for Use" on page 12.

If the problem is still unresolved, see 📖 "SERVICE NETWORK" on page App-1, and contact Mitutoyo, or the agent where you purchased the product.

■ Mechanical/Environmental

● The sensor is warm.

- It is normal for a sensor to be warm when powered on. A sensor is typically 15° C warmer than the ambient temperature.

■ Connection

● When attempting to connect to the sensor with a web browser, the sensor is not found (page does not load).

- Verify that the sensor is powered on and connected to the client computer network. The Power Indicator LED should illuminate when the sensor is powered.
- Check that the client computer's network settings are properly configured.
- Use the Sensor Recovery tool to verify that the sensor has the correct network settings. See 📖 "12.1 Sensor Discovery Tool" on page 973 for more information.

● When attempting to log in, the password is not accepted.

- Use the Sensor Recovery tool. See 📖 "12.1 Sensor Discovery Tool" on page 973 for steps to reset the password.

■ Data Acquisition

● The sensor emits laser light, but the Range Indicator LED does not illuminate and/or points are not displayed in the Data Viewer.

- Verify that the measurement target is within the sensor's field of view and measurement range. See 📖 "14 Specifications" on page 1001 to review the measurement specifications for your sensor model.
- Check that the exposure time is set to a reasonable level. See 📖 "4.4.4 Sensor" > "■Exposure" on page 130 for more information on configuring exposure time.

■ Performance

● The sensor CPU level is near 100%.

- Consider reducing the speed. If you are using a time or encoder trigger source, see 📖 "4.4.3 Triggers" on page 117 for information on reducing the speed. If you are using an external input or software trigger, consider reducing the rate at which you apply triggers.
- Consider reducing the resolution.

  See 📖 "4.4.4 Sensor" > "■Spacing" on page 135 for more information on configuring resolution.
- Review the measurements that you have programmed and eliminate any unnecessary measurements.

14 Specifications

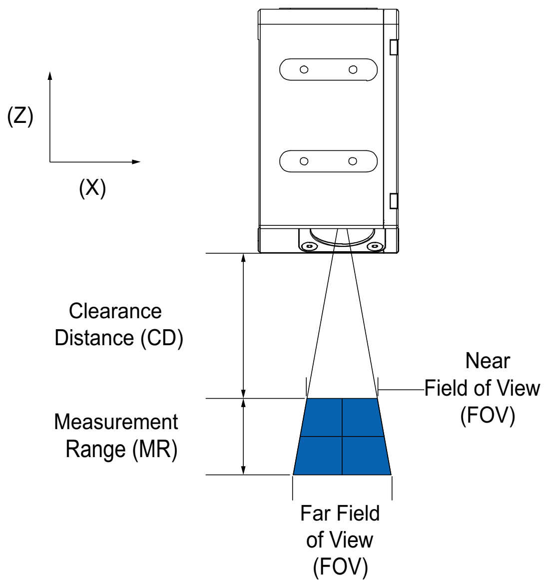
The following sections describe the specifications of SurfaceMeasure1008S sensors and connectors, as well as Master 810/2410.

14.1 Sensors

The following sections provide the specifications of SurfaceMeasure1008S sensors.

Model number	SurfaceMeasure1008S
Data Points / Profile	1920
Resolution X (Profile Data Interval)(μm)	28.0 - 54.0
Linearity Z (+/- % of MR)	0.01
Repeatability Z (μm)	0.5
Clearance Distance (CD) (mm)	40
Measurement Range (MR) (mm)	80
Field of View (FOV) (mm)	48 - 100(diffuse)
Scan Rate	2 kHz to 10 kHz
Laser Classes	2 (blue, 405 nm)
Dimensions (mm)	46x80x110
Weight (kg)	0.65

The following diagram and explanations explain some of the terms used in the table above.



Point of the sensor's housing, not the laser window.

Specifications stated are based on standard laser classes. Linearity Z and Repeatability Z may vary for other laser classes.

All specification measurements are performed on Mitutoyo’s standard calibration target (a diffuse, painted white surface).

- Linearity Z is the worst case difference in average height measured, compared to the actual position over the measurement range.
- Resolution X is the distance between data points along the laser line.
- Repeatability Z is measured with a flat target at the middle of the measurement range. It is the 95% confidence variation of the average height over 4096 frames. Height values are averaged over the full FOV.

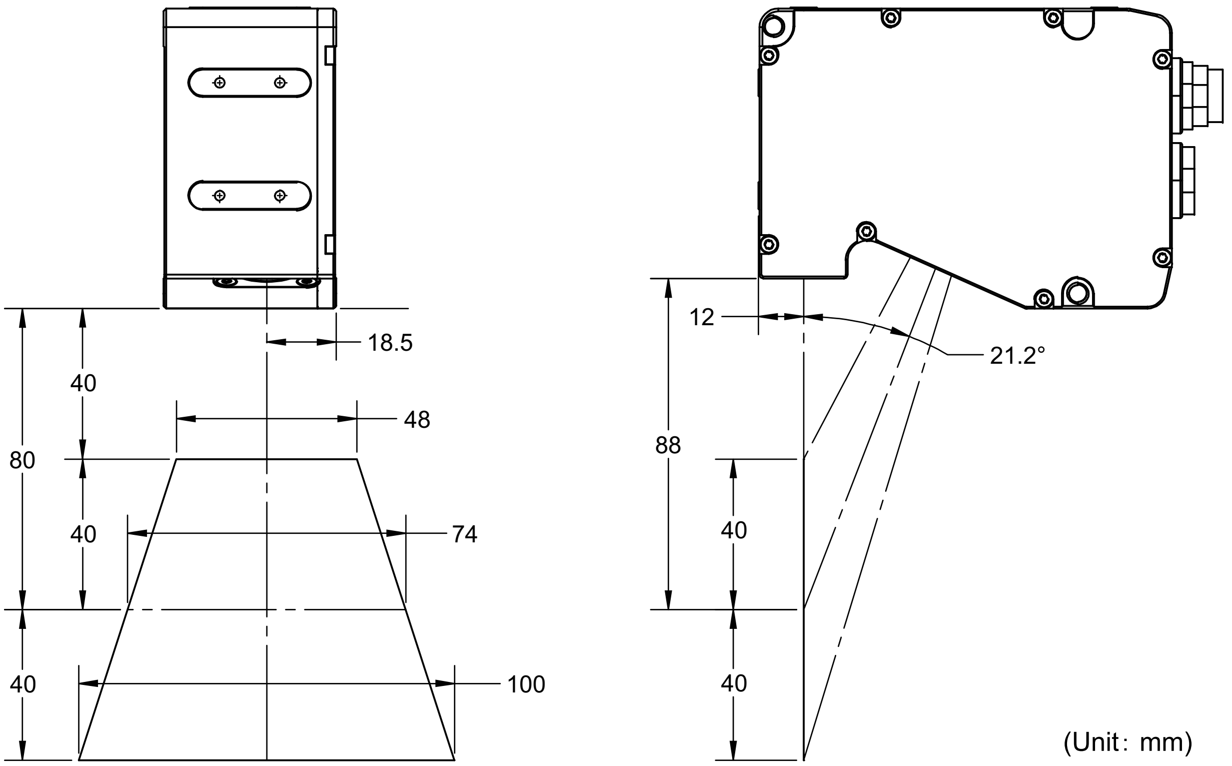
See 📖 "3.1.2 Resolution and Accuracy" on page 54 for more information.

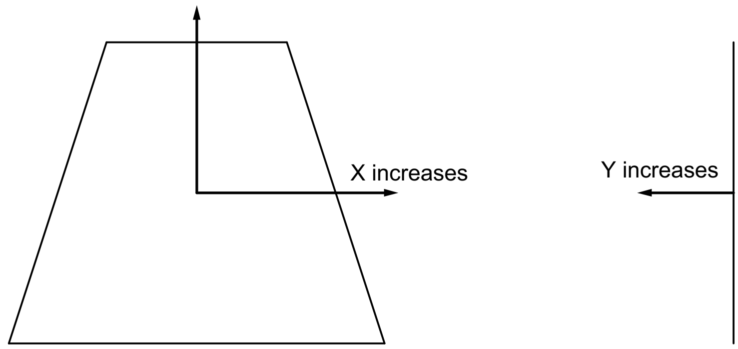
SurfaceMeasure1008S	
Interface	Gigabit Ethernet
Inputs	Differential Encoder, Laser Safety Enable, Trigger
Outputs	2x Digital output, RS-485 Serial (115 kBaud)
Housing	Gasketed aluminum enclosure, IP67
Input Voltage (Power)	+24 to +48 VDC (15 W); Ripple +/- 10%
Operating Temp.	0 to 40° C
Storage Temp.	-30 to 70° C

Mechanical dimensions, CD/FOV/MR, and the envelope for each sensor model are illustrated on the following pages.

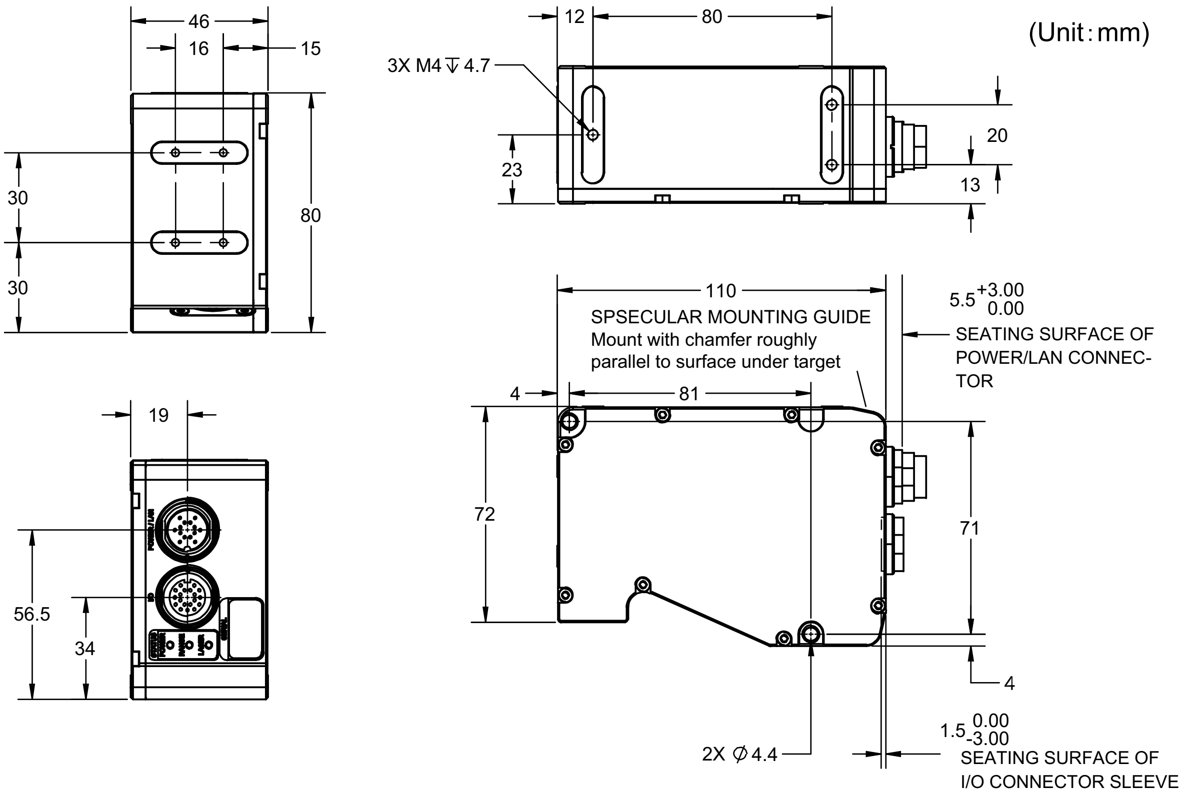
■ SurfaceMeasure1008S

Field of View / Measurement Range / Coordinate System Orientation



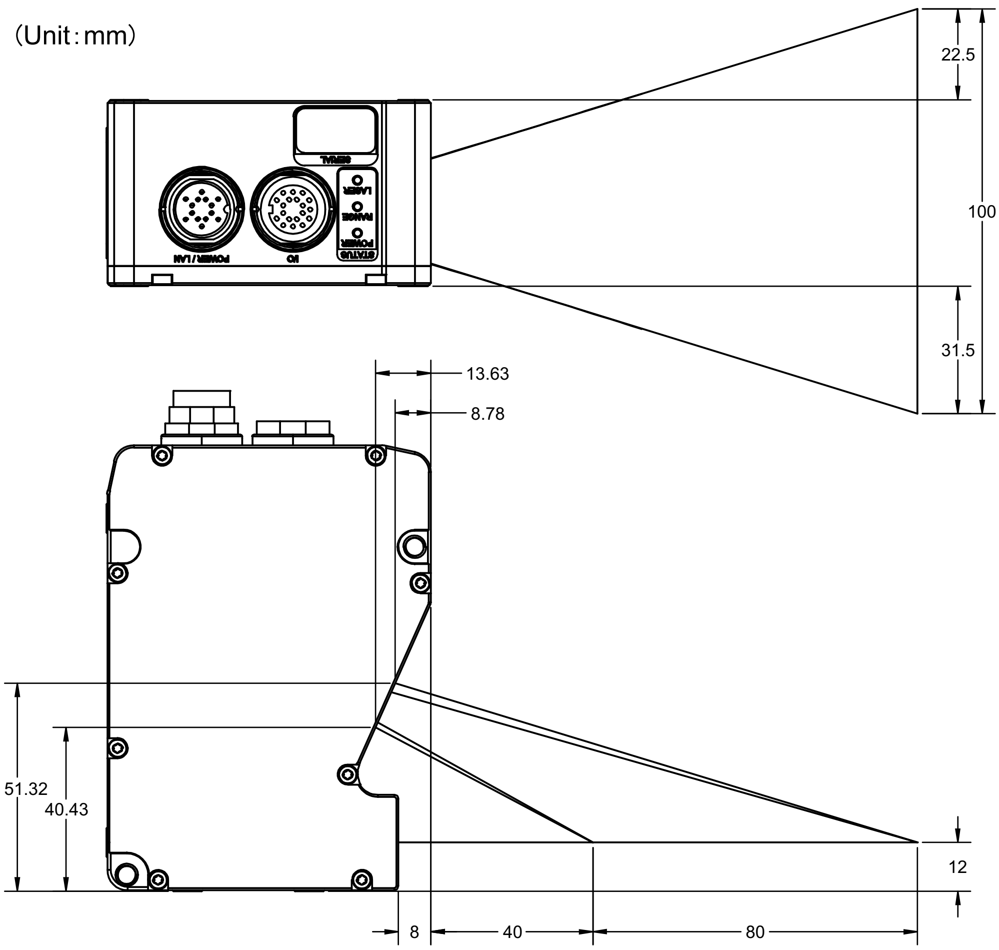


External dimensions



Laser beam

(Unit: mm)



Estimated Performance

This section provides estimated measurement tool performance.

The following hardware was used to produce the estimates:

PC

- Intel i7 5960X
- 16 GB RAM
- Windows 8.1 Pro

Graphics Card

- NVIDIA GeForce GTX 970
- 12 GB DDR5 RAM

The following table lists the running time of various measurement tools, with and without GoMax, as well as the performance increase factor when running with GoMax.

Note that although sensor models and job file configurations will affect running times, the performance increase factor for tools should be consistent across models and configurations.

SurfaceMeasure1008S Performance Increase Factors

Measurement Tool	Running Time on Sensor (ms)	Running Time with GoMax (ms)	Performance Increase Factor
Surface Hole	40	11	3.5
Surface Bounding Box	30	9	3.3
Surface Plane	2.3	0.4	6
Profile Dimension	0.054	0.037	1.5
Profile Intersect	0.075	0.028	2.7

14.2 Sensor Connectors

The following sections provide the specifications of the connectors on SurfaceMeasure1008S sensors.

14.2.1 SurfaceMeasure1008S Power/LAN Connector

The Power/LAN connector is a 14 pin, M16 style connector that provides power input, laser safety input, and Ethernet.

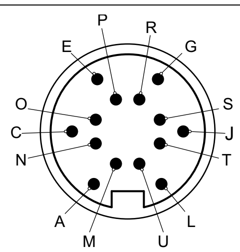
IMPORTANT

- This connector is rated IP67 only when a cable is connected or when a protective cap is used.
- The sensors require an input voltage of 24 VDC to 48 VDC. Verify the accepted input voltage for your sensor in the sensor's specifications; for specifications, see "14.1 Sensors" on page 1001.

This section defines the electrical specifications for Power/LAN Connector pins, organized by function.

SurfaceMeasure1008S Power/LAN Connector Pins

Function	Pin	Lead Color on Standard Cordsets	Lead Color on Cordsets
GND_24-48V	L	White/Orange & Black	Orange/Red
GND_24-48V	L	Orange/Black	Orange/Black
DC_24-48V	A	White/Green & Black	Green/Red
DC_24-48V	A	Green/Black	Green/Black
Safety-	G	White/Blue &Black	Blue/Black
Safety+	J	Blue/Black	Blue/Red
Sync+ (*)	E	White/Brown & Black	Brown/Red
Sync- (*)	C	Brown/Black	Brown/Black
Ethernet MX1+	M	White/Orange	White/Orange
Ethernet MX1-	N	Orange	Orange
Ethernet MX2+	O	White/Green	White/Green
Ethernet MX2-	P	Green	Green
Ethernet MX3-	S	White/Blue	White/Blue
Ethernet MX3+	R	Blue	Blue
Ethernet MX4+	T	White/Brown	White/Brown
Ethernet MX4-	U	Brown	Brown



View: Looking into the connector on the sensor

Two wires are connected to the ground and power pins.

*: The Sync leads are not connected in the open wire versions of the Power/LAN cordsets.

Grounding Shield

WARNING

The grounding shield should be mounted to the earth ground.

Power

Apply positive voltage to DC_24-48V.

IMPORTANT

The sensors require an input voltage of 24 VDC to 48 VDC. Verify the accepted input voltage for your sensor in the sensor's specifications; for specifications, see "14.1 Sensors" on page 1001.

Tips

It is not necessary to power down a sensor's power source such as a Master before unplugging the sensor from the Master. (Sensors can be "hot-swapped.")

Power requirements

Function	Pins	Min	Max
DC_24-48V	A	24 V	48 V
GND_24-48VDC	L	0 V	0 V

Laser Safety Input

The Safety_in+ signal should be connected to a voltage source in the range listed below. The Safety_in- signal should be connected to the ground/common of the source supplying the Safety_in+.

Laser safety requirements

Function	Pins	Min	Max
Safety_in+	J	24 V	48 V
Safety_in-	G	0 V	0 V

NOTICE

Confirm the wiring of Safety_in- before starting the sensor. Wiring DC_24-48V into Safety_in- may damage the sensor.

14.2.2 SurfaceMeasure1008S I/O Connector

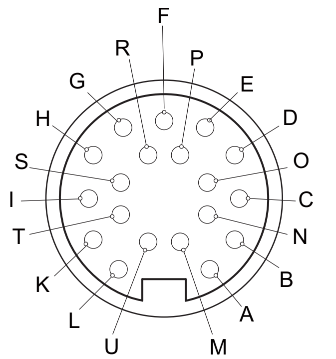
The SurfaceMeasure1008S I/O connector is a 19 pin, M16 style connector that provides encoder, digital input, digital outputs, serial output, and analog output signals.

IMPORTANT
This connector is rated IP67 only when a cable is connected or when a protective cap is used.

This section defines the electrical specifications for I/O connector pins, organized by function.

SurfaceMeasure1008S I/O Connector Pins

Function	Pin	Lead Color on Standard Cordset	Lead Color on Cordset
Trigger_in+	D	Grey	Blue / Red
Trigger_in-	H	Pink	Blue / Black
Out_1+ (Digital Output 0)	N	Red	Brown / Red
Out_1- (Digital Output 0)	O	Blue	Brown / Black
Out_2+ (Digital Output 1)	S	Tan	Green / Red
Out_2- (Digital Output 1)	T	Orange	Green / Black
Encoder_A+	M	White / Brown & Black	Pink / Red
Encoder_A-	U	Brown / Black	Pink / Black
Encoder_B+	I	Black	Yellow / Red
Encoder_B-	K	Violet	Yellow / Black
Encoder_Z+	A	White / Green & Black	White / Red
Encoder_Z-	L	Green / Black	White / Black
Serial_out+	B	White	Purple / Red
Serial_out-	C	Brown	Purple / Black
Serial_out2+	E	Blue / Black	Red
Serial_out2-	G	White / Blue & Black	Black
Analog_out+ (Reserved on SurfaceMeasure1008S)	P	Green	Gray / Red
Analog_out- (Reserved on SurfaceMeasure1008S)	F	Yellow & Maroon / White	Gray / Black & Orange / Black
Reserved	R	Maroon (not connected)	Orange / Red (not connected)



View: Looking into the connector on the sensor

Grounding Shield

WARNING

The grounding shield should be mounted to the earth ground.

Digital Outputs

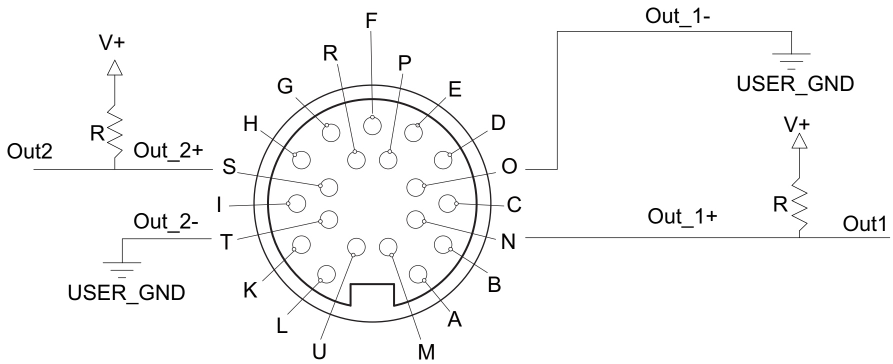
Each sensor has two optically isolated outputs. Both outputs are open collector and open emitter, which allows a variety of power sources to be connected and a variety of signal configurations.

IMPORTANT

Digital outputs cannot be used when taking scans using the Snapshot button, which takes a single scan and is typically used to test measurement tool settings. Digital outputs can only be used when a sensor is running, taking a continuous series of scans.

Out_1 (Collector – Pin N and Emitter – Pin O) and Out_2 (Collector – Pin S and Emitter – Pin T) are independent and therefore V+ and GND are not required to be the same.

Function	Pins	Max Collector Current	Max Collector–Emitter Voltage	Min Pulse Width
Out_1	N, O	40 mA	70 V	20 µs
Out_2	S, T	40 mA	70 V	20 µs

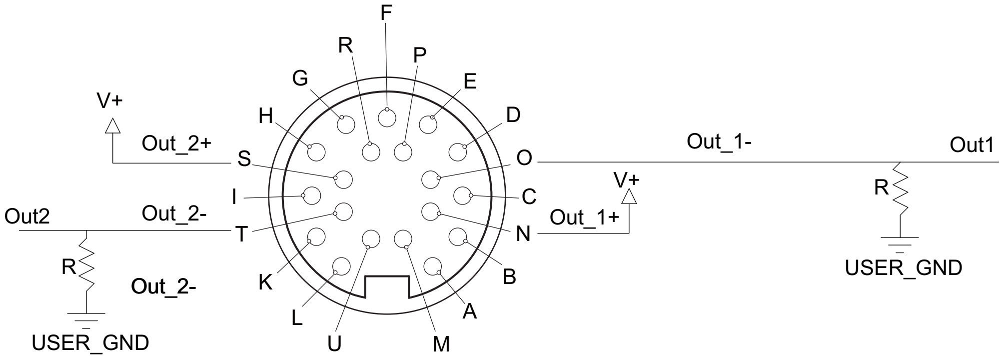


The resistors shown above are calculated by R = (V+) / 2.5 mA.

The size of the resistors is determined by power = (V+)^2 / R.

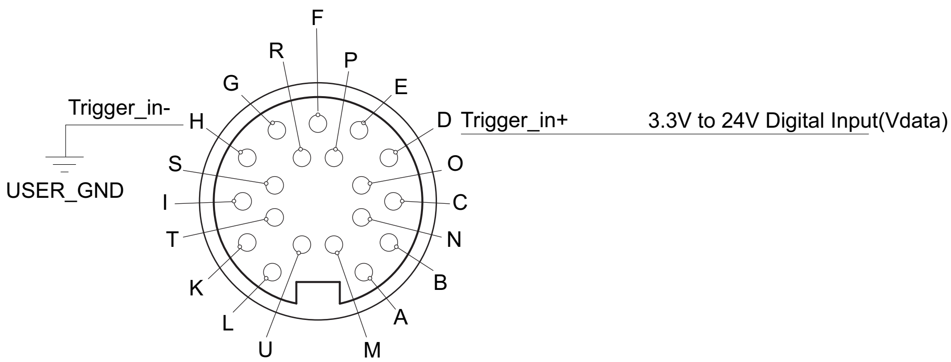
- Inverting Outputs

To invert an output, connect a resistor between ground and Out_1- or Out_2- and connect Out_1+ or Out_2+ to the supply voltage. Take the output at Out_1- or Out_2-. For resistor selection, see above.



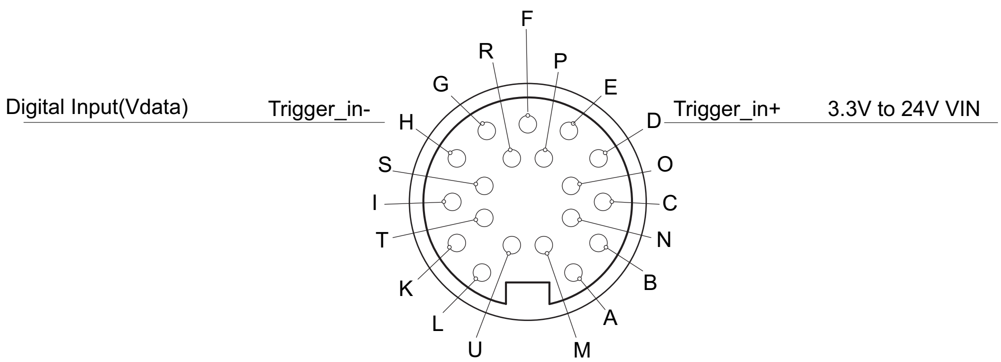
Digital Input

Every sensor has a single optically isolated input. To use this input without an external resistor, supply 3.3 - 24 V to the positive pin and GND to the negative.



Active High

If the supplied voltage is greater than 24 V, connect an external resistor in series to the positive. The resistor value should be R = [(Vin-1.2V)/10mA]-680.



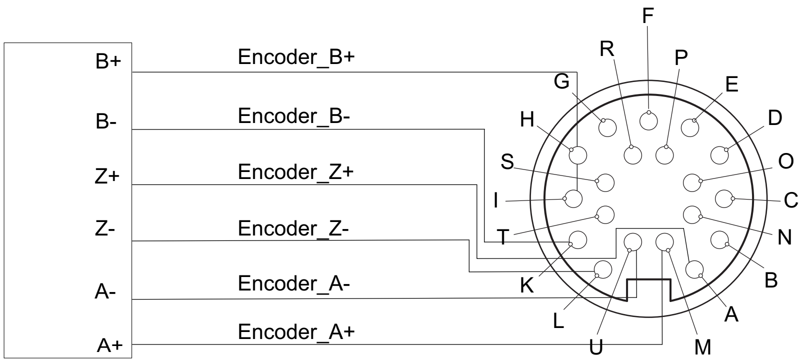
Active Low

To assert the signal, the digital input voltage should be set to draw a current of 3 mA to 40 mA from the positive pin. The current that passes through the positive pin is I = (Vin – 1.2 – Vdata) / 680. To reduce noise sensitivity, we recommend leaving a 20% margin for current variation (i.e., uses a digital input voltage that draws 4mA to 25mA).

Function	Pins	Min Voltage	Max Voltage	Min Current	Max Current	Min Pulse Width
Trigger_in	D, H	3.3 V	24 V	3 mA	40 mA	20 μs

Encoder Input

Encoder input is provided by an external encoder and consists of three RS-485 signals. These signals are connected to Encoder_A, Encoder_B, and Encoder_Z.



Function	Pins	Common Mode Voltage		Differential Threshold Voltage			Max Data Rate
		Min	Max	Min	Typ	Max	
Encoder_A	M, U	-7 V	12 V	-200 mV	-125 mV	-50 mV	1 MHz
Encoder_B	I, K	-7 V	12 V	-200 mV	-125 mV	-50 mV	1 MHz
Encoder_Z	A, L	-7 V	12 V	-200 mV	-125 mV	-50 mV	1 MHz

IMPORTANT

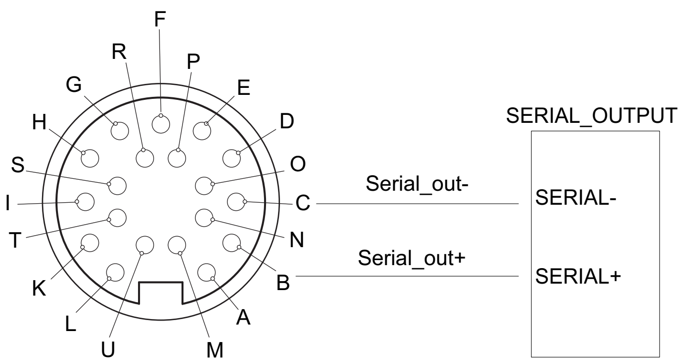
SurfaceMeasure1008S only supports differential RS-485 signalling. Both + and - signals must be connected.

Encoders are normally specified in pulses per revolution, where each pulse is made up of the four quadrature signals (A+ / A- / B+ / B-). Because the sensor reads each of the four quadrature signals, you should choose an encoder accordingly, given the resolution required for your application.

Serial Output

Serial RS-485 output is connected to Serial_out as shown below.

Function	Pins
Serial_out	B, C



14.3 Master Network Controllers

The following sections provide the specifications of Master network controllers.

For information on maximum external input trigger rates, see "■Maximum Input Trigger Rate" on page 122.

14.3.1 Master 810/2410

Master 810/2410 provide sensor power and safety interlock, and broadcast system-wide synchronization information (i.e., time, encoder count, encoder index, and digital I/O states) to all devices on a sensor network.

IMPORTANT

The sensors require an input voltage of 24 VDC to 48 VDC. Verify the accepted input voltage for your sensor in the sensor's specifications; for specifications, see "14.1 Sensors" on page 1001.

Tips

It is not necessary to power down a sensor's power source such as a Master before unplugging the sensor from the Master. (Sensors can be "hot-swapped.")

The following table summarizes Master 810 and 2410:

Master 810 and 2410	
Input Voltage (Power)	+24-48 VDC (2 Watts)
Total Power	Master 810 / 2410 input power + (sensor input power x number of sensors)
Capacity	Master 810: up to 8 sensors Master 2410: up to 24 sensors
I/O	4 digital inputs2 Single-Ended Active LOW: 0 to +0.8 VDC Single-Ended Active HIGH: +3.3 to +24 VDC Differential LOW: 0.8 to -24 VDC Differential HIGH: +3.3 to +24 VDC 10-pin Phoenix For more information, see "■Electrical Specifications" on page 1016.
Encoder	Differential (5 VDC, 12 VDC) Single-ended (5 VDC, 12 VDC)3 For more information, see "■Electrical Specifications" on page 1016.
LED Indicators	Safety, power, encoder, input. For more information, see "• LED Indicators" on page 1013.
Cable	Dual CAT5e cable for power / safety / synchronization / data
Weight (kg)	Master 810: 0.6 Master 2410: 0.9

Tips

- see "14.1 Sensors" on page 1001 for additional power required by sensors.
- SurfaceMeasure1008S only supports one digital input.
- Supports open collector, pull-up resistor, line driver, push-pull, and TTL.

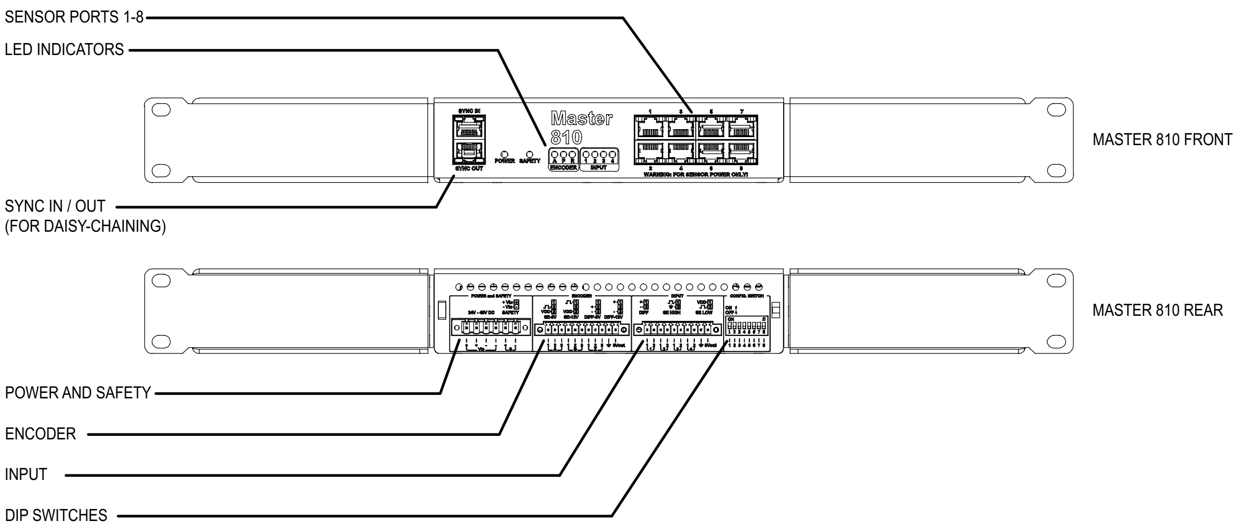
The following table describes the meanings of the encoder and sensor port LED indicators:

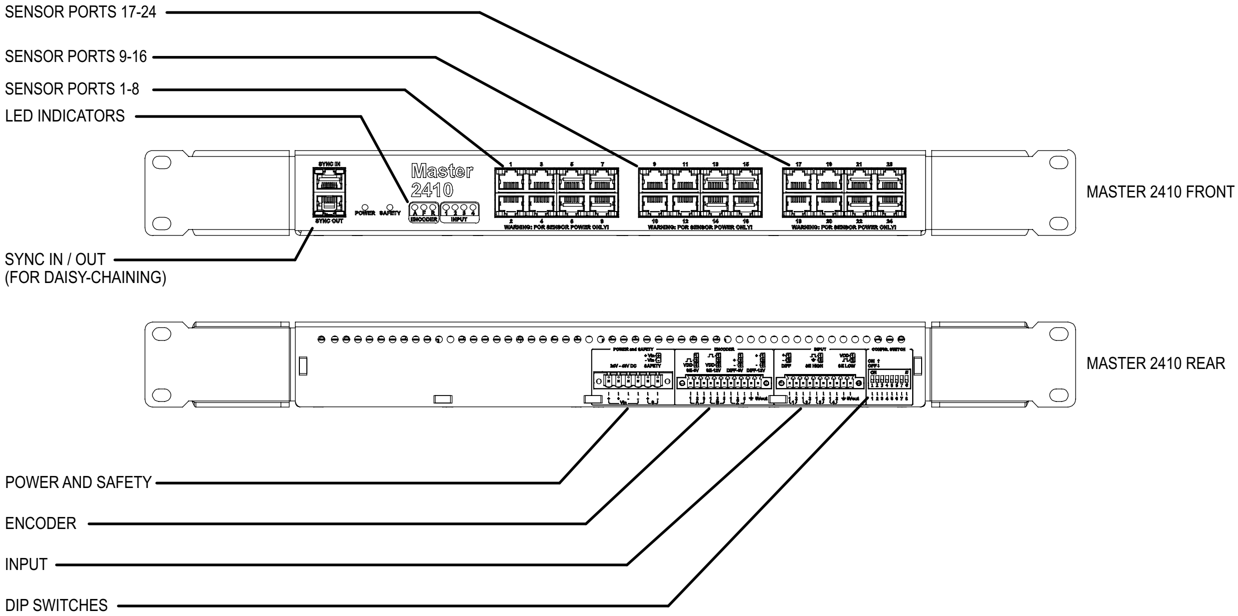
LED Indicators

Indicator	Description
Power	Device is on.
Safety	Indicates the status of the Safety Interlock circuitry. The “On” state indicates that all sensor light sources are active.
Encoder A	Reserved
Encoder F	[On continuously]: Forward motion with no indexing is detected. [Blinking]: Forward motion with indexing is detected.
Encoder R	[On continuously]: Forward motion with no indexing is detected. [Blinking]: Forward motion with indexing is detected.
Input 1-4	Digital input ports 1-4 active.
SYNC IN and SYNC OUT Ports (Green and Orange LEDs)	Reserved.
Sensor Port Green LED	Indicates that a sensor is connected to the port and is powered up.
Sensor Port Orange LED	Not used.

Master 810 and 2410 can be mounted to DIN rails using the adapter that is provided with each Master (for more information, see "2.4.5 Installing DIN Rail Clips: Master 810 or 2410" on page 38). A removable adapter for 1U rack mounting is also provided with each Master.

Master 2410 can currently be used with encoders with a maximum quadrature frequency of 300 kHz. Master 810 can be configured to work with a maximum encoder quadrature frequency of 6.5 MHz. For more information, see "2.4.6 Configuring Master 810" on page 40.





Power and Safety (6 pin connector)

Function	Pin
Power In+	1
Power In+	2
Power In-	3
Power In-	4
Safety Control+	5
Safety Control–	6

The following are the 6 pin connector's specifications:

CONNECTOR, 6 Position Terminal Block Plug, Female Sockets 0.200" (5.08mm) 180° Free Hanging (In-Line)

Supplier Part Number 277-11017-ND

Manufacturer: Phoenix Contact

Manufacturer PN: 1912223

IMPORTANT

- The power supply must be isolated from AC ground. This means that AC ground and DC ground are not connected.
- The Safety Control requires a voltage differential of 24 VDC to 48 VDC across the pin to enable the laser.

The following are the 10 pin connector's specifications:

CONNECTOR, 10 Position Terminal Block Plug, Female Sockets 0.138" (3.50mm) 180° Free Hanging (In-Line)

Supplier Part Number 277-6350-ND

Manufacturer: Phoenix Contact

Manufacturer PN: 1847204

Input (10 pin connector)

Function	Pin
Input 1 Pin 1	1
Input 1 Pin 2	2
Reserved	3
Reserved	4
Reserved	5
Reserved	6
Reserved	7
Reserved	8
GND (output for powering other devices)	9
+5VDC (output for powering other devices)	10

Tips

The Input connector does not need to be wired up for proper operation.

For Input connection wiring options, see 📖 "●Input" on page 1019.

The following are the 11 pin connector's specifications:

CONNECTOR, 11 Position Terminal Block Plug, Female Sockets 0.138" (3.50mm) 180° Free Hanging (In-Line)

Supplier Part Number 277-8897-ND

Manufacturer: Phoenix Contact

Manufacturer PN: 1847217

Encoder (11 pin connector)

Function	Pin
Encoder_A_Pin_1	1
Encoder_A_Pin_2	2
Encoder_A_Pin_3	3
Encoder_B_Pin_1	4
Encoder_B_Pin_2	5
Encoder_B_Pin_3	6
Encoder_Z_Pin_1	7
Encoder_Z_Pin_2	8
Encoder_Z_Pin_3	9
GND (output for powering external devices)	10
+5VDC (output for powering external devices)	11

Tips

For Encoder connection wiring options, see 📖 "●Encoder" on page 1017.

■ Electrical Specifications

> **IMPORTANT**
> The sensors require an input voltage of 24 VDC to 48 VDC. Verify the accepted input voltage for your sensor in the sensor's specifications; for specifications, see "14.1 Sensors" on page 1001.

Electrical Specifications

Specification	Value
Power Supply Voltage	+24 VDC to +48 VDC
Power Supply Current (Max.)*	Master 810: 9 A Master 2410: 25 A * Fully loaded with 1 A per sensor port.
Power Draw (Min.)	Master 810: 1.7 W Master 2410: 4.8 W
Safety Input Voltage Range	+24 VDC to +48 VDC
Encoder Signal Voltage	Single-Ended Active LOW: 0 to +0.8 VDC Single-Ended Active HIGH: +3.3 to +24 VDC Differential LOW: 0.8 to -24 VDC Differential HIGH: +3.3 to +24 VDC For more information, see "●Encoder" on page 1017.
Digital Input Voltage Range	Single-Ended Active LOW: 0 to +0.8 VDC Single-Ended Active HIGH: +3.3 to +24 VDC Differential LOW: 0.8 to -24 VDC Differential HIGH: +3.3 to +24 VDC For more information, see "●Input" on page 1019. **IMPORTANT** If the input voltage is above 24 V, use an external resistor, using the following formula: R = [(Vin - 1.2V) / 10mA] - 680

> **⚠ WARNING**
> Failure to follow the guidelines described in this section may result in electrical shock or equipment damage.

When using a Master hub, the chassis must be well grounded.

IMPORTANT

- The power supply must be isolated from AC ground. This means that AC ground and DC ground are not connected.
- 24 VDC power supply is only supported if all connected sensors support an input voltage of 24 VDC.

Tips

The Power Draw specification is based on a Master with no sensors attached. Every sensor has its own power requirements that need to be considered when calculating total system power requirements.

- Encoder

Master 810 and 2410 support the following types of encoder signals: Single-Ended (5 VDC, 12 VDC) and Differential (5 VDC, 12 VDC).

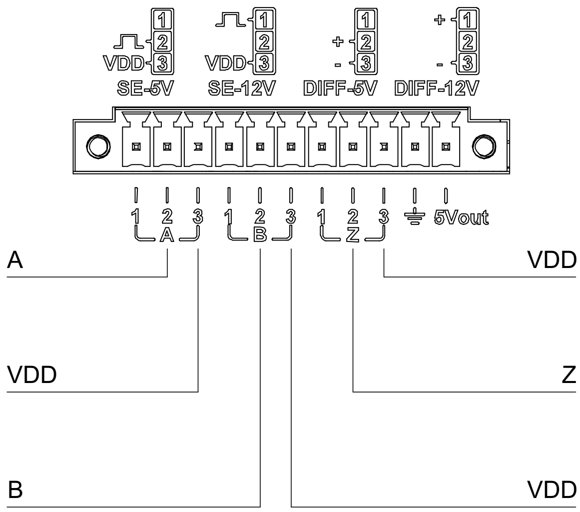
For 5 VDC operation, pins 2 and 3 of each channel are used.

For 12 VDC operation, pins 1 and 3 of each channel are used.

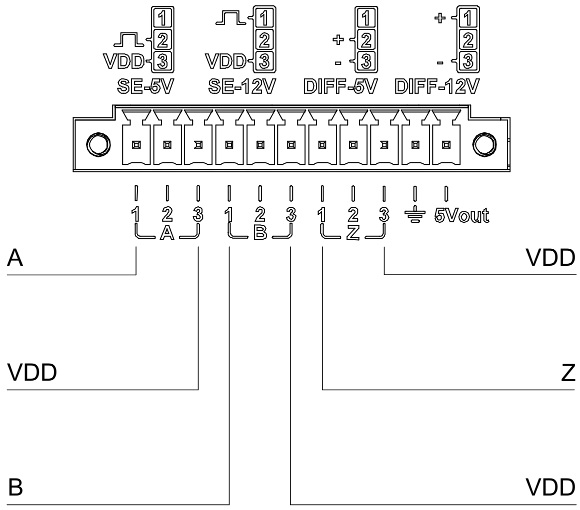
IMPORTANT

The 5-volt encoder input supports up to 12 volts for compatibility with earlier Master network controllers. However, we strongly recommend connecting 12-volt output encoders to the appropriate 12-volt input to attain maximum tolerance.

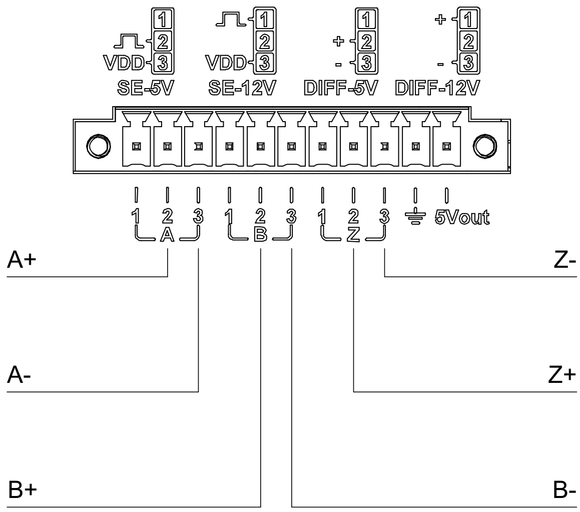
To determine how to wire a Master to an encoder, see the illustrations below.



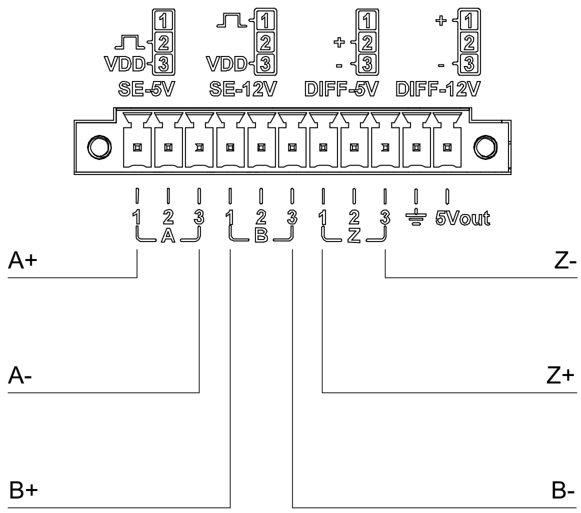
Single-Ended 5 VDC



Single-Ended 12 VDC



Differential 5 VDC



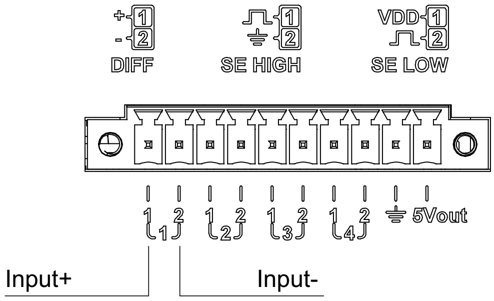
Differential 12 VDC

- Input

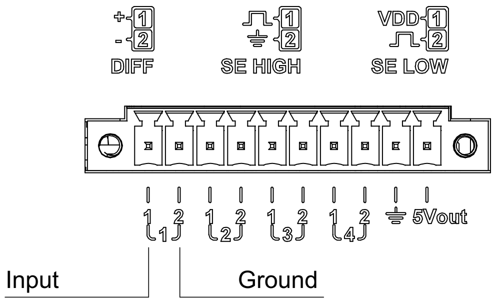
Master 810 and 2410 support the following types of input: Differential, Single-Ended High, and Single-Ended Low.

> **IMPORTANT**
> Currently, SurfaceMeasure1008S only supports Input 0.

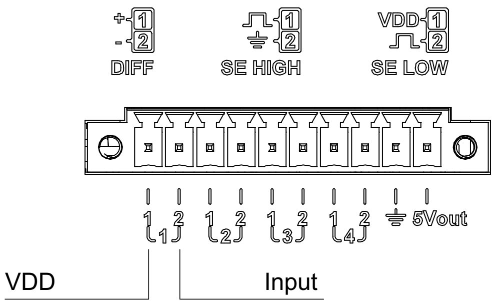
For digital input voltage ranges, see the table below.



Differential



Single-Ended Active High



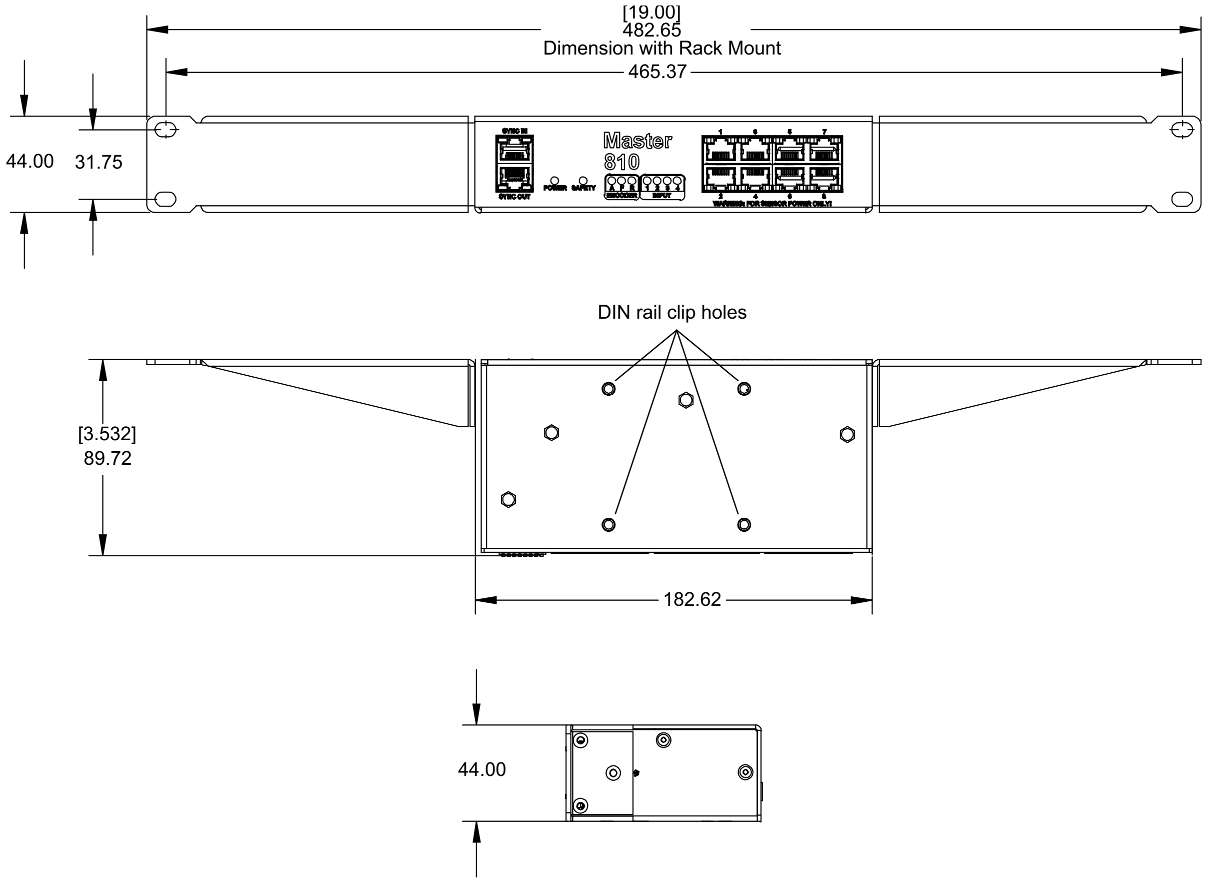
Single-Ended Active Low

Digital Input Voltage Ranges

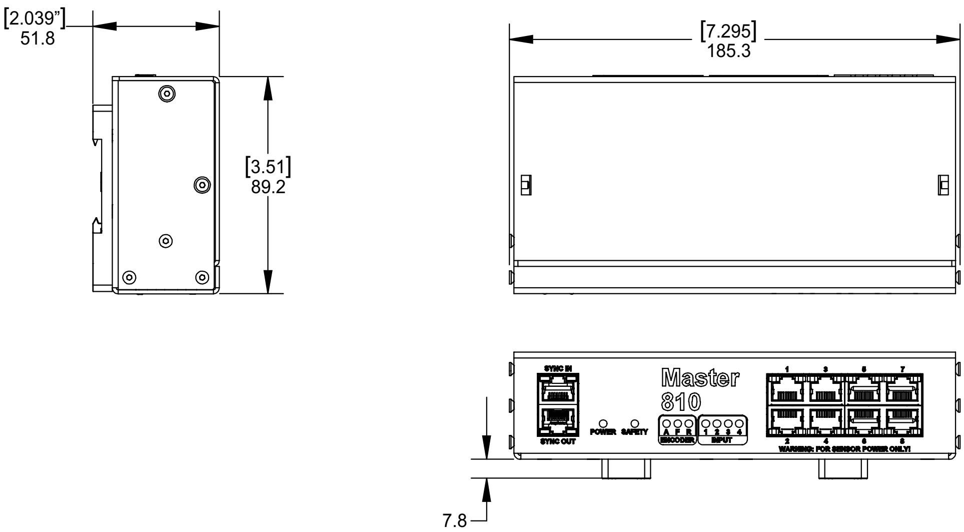
	Input Status	Min (VDC)	Max (VDC)
Single-ended Active High	Off	0	+0.8
	On	+3.3	+24
Single-ended Active Low	Off	(VDD -0.8)	VDD
	On	0	(VDD -3.3)
Differential	Off	-24	+0.8
	On	+3.3	+24

■ Master 810 Dimensions

With 1U rack mount brackets:



With DIN rail mount clips:



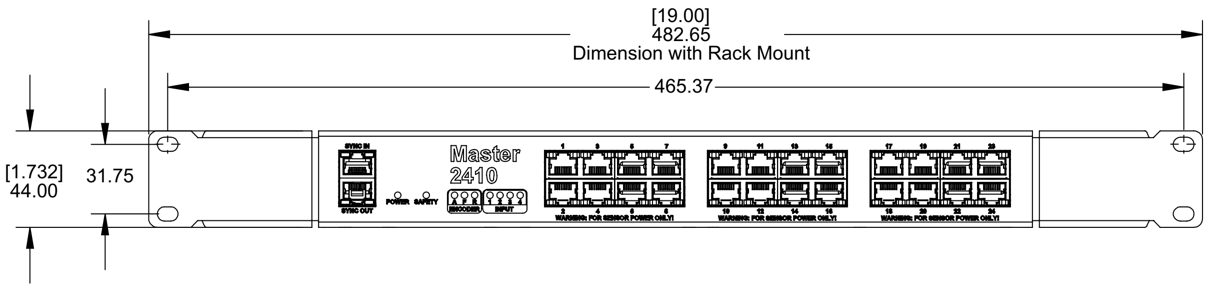
Older revisions of Master 810 and 2410 network controllers use a different configuration for the DIN rail clip holes.

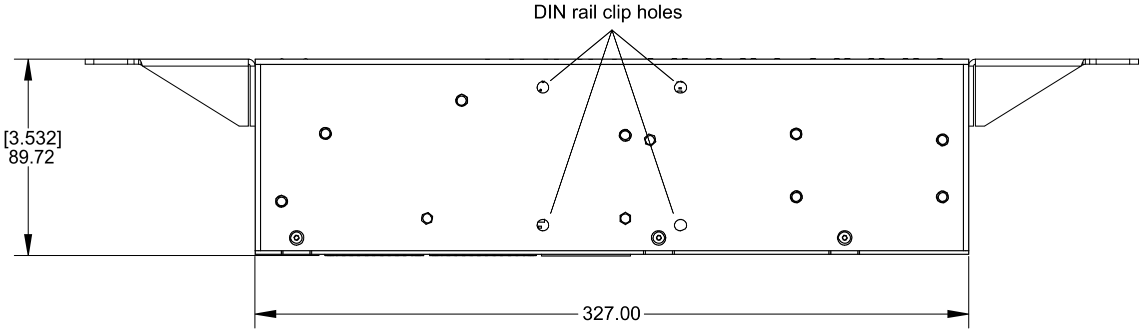
For information on installing DIN rail clips, see 📖 "2.4.5 Installing DIN Rail Clips: Master 810 or 2410" on page 38.

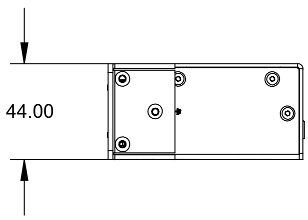
The CAD model of the DIN rail clip is available at https://www.winford.com/products/cad/dinm12-rc.igs.

Master 2410 Dimensions

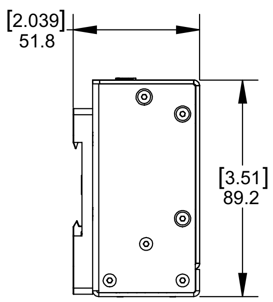
With 1U rack mount brackets:

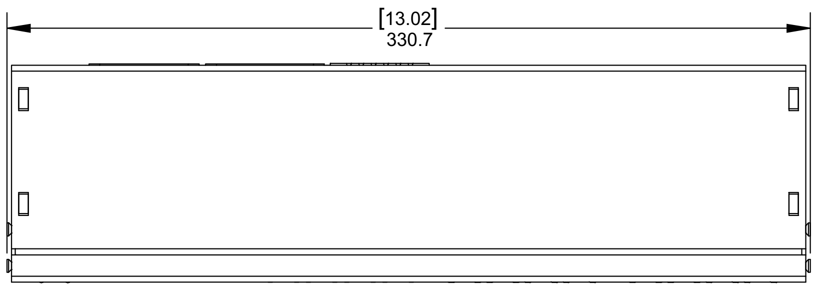


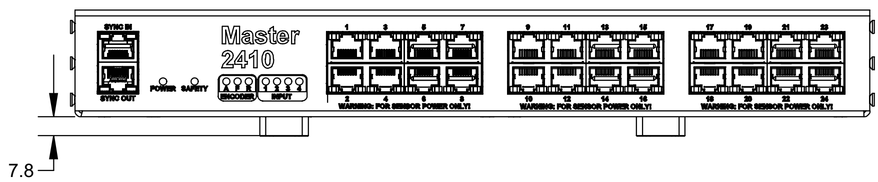




With DIN rail mount clips:







Older revisions of Master 810 and 2410 network controllers use a different configuration for the DIN rail clip holes.

For information on installing DIN rail clips, see "2.4.5 Installing DIN Rail Clips: Master 810 or 2410" on page 38.

The CAD model of the DIN rail clip is available at https://www.winford.com/products/cad/dinm12-rc.igs.

MEMO

15 Accessories

15.1 Standard accessories

Name	Part Number	Amount
Calibration Disk	02AQL299	1
Instruction Manual [Japanese Version]	99MCA914J	1
Instruction Manual [English Version]	99MCA914A	1
USB memory for electronic file distribution	02AQL350	1
- User's Manual [Japanese Version]	99MCA912J	-
- User's Manual [English Version]	99MCA912A	-

15.2 Options

Masters

Name	Description	Part Number
Master 810	For networking up to 8 sensors	02AQL401
Master 2410	For networking up to 24 sensors	02AQL402

High Flex SurfaceMeasure1008S Cordsets - Straight Connectors

Name	Description	Part Number
2m I/O	open wire end	02AQL361
5m I/O	open wire end	02AQL362
10m I/O	open wire end	02AQL363
15m I/O	open wire end	02AQL364
20m I/O	open wire end	02AQL365
25m I/O	open wire end	02AQL366
2m Power and Ethernet	1x open wire end, 1x RJ45 end	02AQL367
5m Power and Ethernet	1x open wire end, 1x RJ45 end	02AQL368
10m Power and Ethernet	1x open wire end, 1x RJ45 end	02AQL369
15m Power and Ethernet	1x open wire end, 1x RJ45 end	02AQL370
20m Power and Ethernet	1x open wire end, 1x RJ45 end	02AQL371
25m Power and Ethernet	1x open wire end, 1x RJ45 end	02AQL372
2m Power and Ethernet to Master	2x RJ45 ends	02AQL373
5m Power and Ethernet to Master	2x RJ45 ends	02AQL374
10m Power and Ethernet to Master	2x RJ45 ends	02AQL375
15m Power and Ethernet to Master	2x RJ45 ends	02AQL376
20m Power and Ethernet to Master	2x RJ45 ends	02AQL377

Name	Description	Part Number
25m Power and Ethernet to Master	2x RJ45 ends	02AQL378

High Flex SurfaceMeasure1008S Cordsets - 90-degree Connectors

Name	Description	Part Number
2m I/O	90-deg, open wire end	02AQL379
5m I/O	90-deg, open wire end	02AQL380
10m I/O	90-deg, open wire end	02AQL381
15m I/O	90-deg, open wire end	02AQL382
20m I/O	90-deg, open wire end	02AQL383
25m I/O	90-deg, open wire end	02AQL384
2m Power and Ethernet	90-deg, 1x open wire end, 1x RJ45 end	02AQL385
5m Power and Ethernet	90-deg, 1x open wire end, 1x RJ45 end	02AQL386
10m Power and Ethernet	90-deg, 1x open wire end, 1x RJ45 end	02AQL387
15m Power and Ethernet	90-deg, 1x open wire end, 1x RJ45 end	02AQL388
20m Power and Ethernet	90-deg, 1x open wire end, 1x RJ45 end	02AQL389
25m Power and Ethernet	90-deg, 1x open wire end, 1x RJ45 end	02AQL390
2m Power and Ethernet to Master	90-deg, 2x RJ45 ends	02AQL391
5m Power and Ethernet to Master	90-deg, 2x RJ45 ends	02AQL392
10m Power and Ethernet to Master	90-deg, 2x RJ45 ends	02AQL393
15m Power and Ethernet to Master	90-deg, 2x RJ45 ends	02AQL394
20m Power and Ethernet to Master	90-deg, 2x RJ45 ends	02AQL395
25m Power and Ethernet to Master	90-deg, 2x RJ45 ends	02AQL396

Notes related to cordsets

For information on cordset bend radius limits, see 📖 "2.4.3 Cordset Bend Radius Limits" on page 33.

Extension cordsets with one male and one female SurfaceMeasure1008S connector are also available on request.

Calibration Disks

Name	Description	Part Number
Calibration Disk	40mm	02AQL299

16 Software Licenses

CLI11

Website:

https://github.com/CLIUtils/CLI11

License:

xxhash

Website:

https://github.com/Cyan4973/xxHash

License:

xxHash Library

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xxhsum command line interface

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JSON for C++

Website:

https://github.com/nlohmann/json

License:

MIT License

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OpENer

Website:

https://github.com/EIPStackGroup/OpENer

License:

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picoc

Website:

https://github.com/jpoirier/picoc

License:

tar (binary only)

License:

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1. Source Code.

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A “Standard Interface” means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

The “System Libraries” of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A “Major Component”, in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The “Corresponding Source” for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work's System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

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rc-menu

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https://github.com/react-component/menu

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react

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react-dnd

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react-router

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rxjs

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