TECHNICAL USER MANUAL

Gocator Measurement Tools

Tool Algorithms

Document revision: A

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Table of Contents

Introduction

Several of LMI's measurement tools use complex algorithms to find features and then return measurements and decisions. This document describes the algorithms used by the following profile tools:

- Panel
- Groove
- Strip

This document also describes the algorithms used by the following surface tools (only available on Gocator line profile sensors and snapshot sensors):

- Hole
- Stud
- Opening

Notational Conventions
This documentation uses the following notational conventions:

	Consider this information in order to make best use of the product.

Built-in Measurement Tools

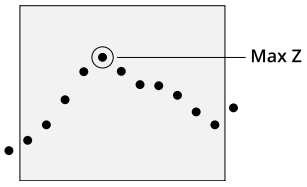
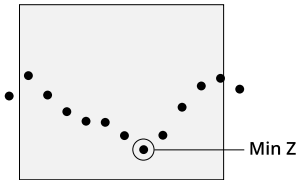
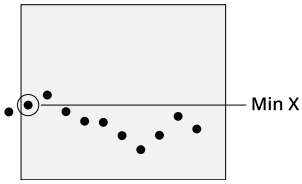
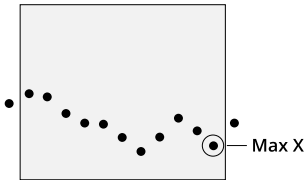
The following sections describe the algorithms and parameters used by some of Gocator's profile and surface measurement tools.

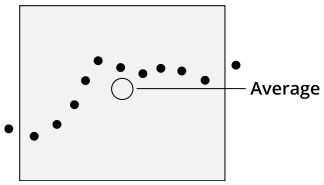
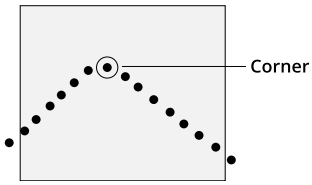
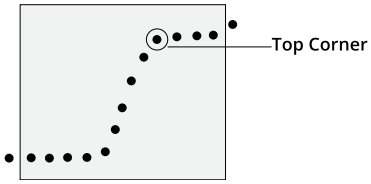
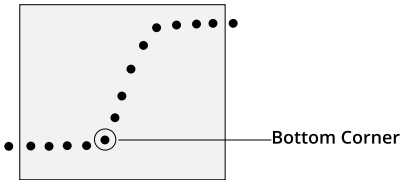
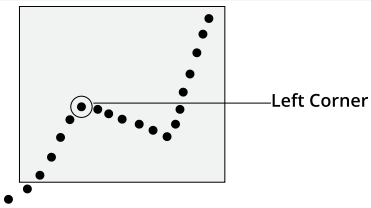
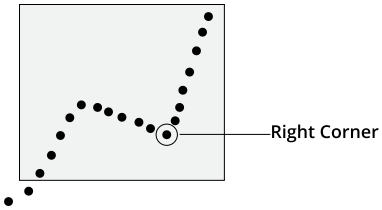
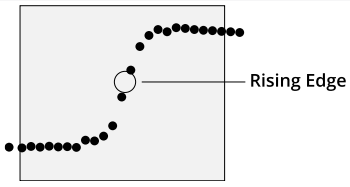
Profile Tools

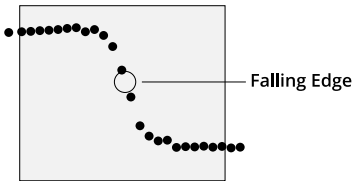
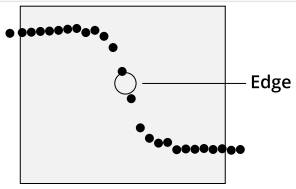
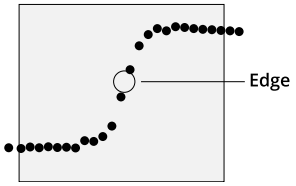
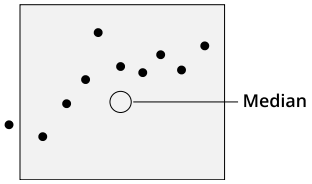
Feature Points

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.

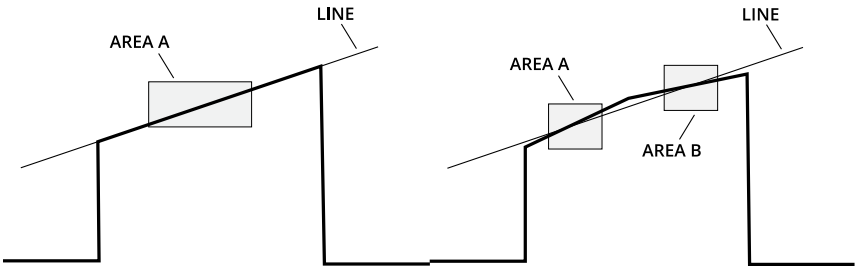
Point Type	Examples
Max Z Finds the point with the maximum Z value in the region of interest.	
Min Z Finds the point with the minimum Z value in the region of interest.	
Min X Finds the point with the minimum X value in the region of interest.	
Max X Finds the point with the maximum X value in the region of interest.	

Point Type	Examples
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.	
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).	

Point Type	Examples
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.	 
Median Determines the median location of points in the region of interest.	

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.

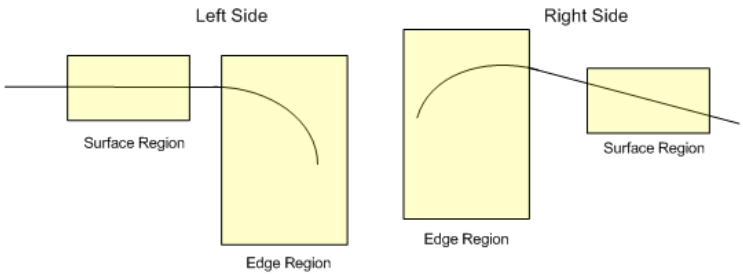


A line can be defined using one or two areas. Two areas can be used to bypass discontinuity in a line segment.

Panel (Gap and Flush) and Round Corner Algorithm

The Panel measurement tool uses the same algorithm to find a feature using either the Gap or the Flush measurement. The Round Corner tool uses the same algorithm, but applies it only to the left or the right; you must choose the side in the tool.

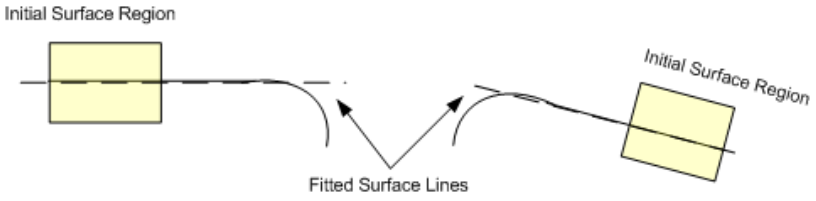
This algorithm first searches for two regions on a side: a surface region and an edge region. (See the tables below for the parameters used by the algorithm.)



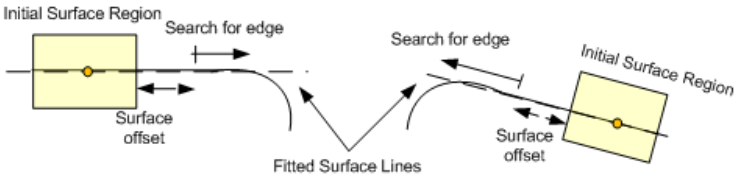
After the algorithm finds the regions, it places a feature point on the surface region based on a set of parameters. You can control the measurement regions, which contain the surface and the edge regions, for the left and the right side. A measurement region also defines the region in which the measurement tool will search for the feature points. Feature points are located on a side using the following algorithm.

1. On the left side, search from left to right to find a surface region with data that covers at least the value specified in the **Surface Width** setting. For the right side, do the same, searching from right to left.

2. If a surface region is found, fit a line, called the surface line, using the data within the area.

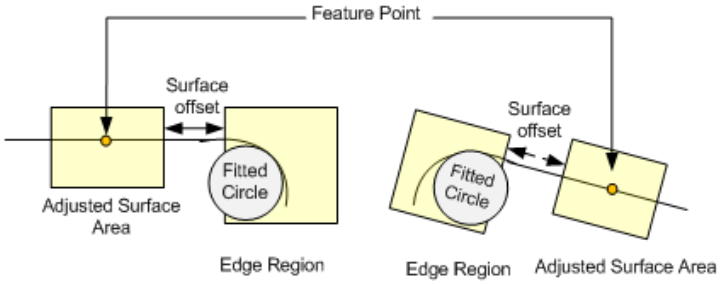


3. Search for a valid edge region that is located at least the distance specified in the **Surface Offset** setting from the end of the surface region. If a surface region is not found, move along the search direction and repeat step 1.

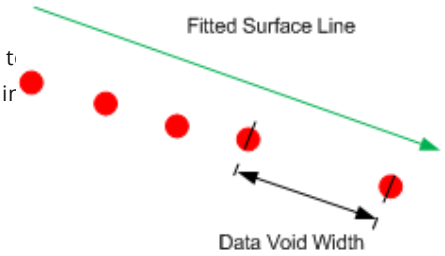


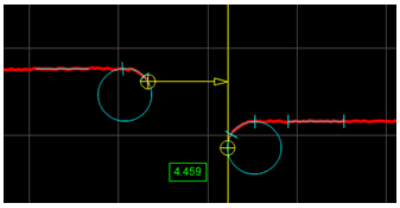
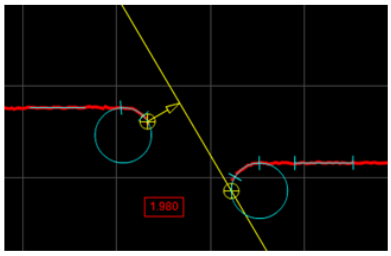
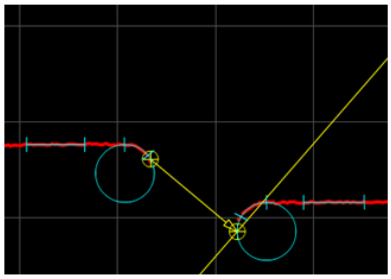
   A valid edge region is detected when an edge matches the value in the **Nominal Radius** setting or when the depth exceeds the value in the **Min Depth** setting. The search algorithm uses the **Max Void Width** setting to distinguish between an actual edge and an area of missing data.

4. If a valid edge region is detected, a model fit is applied to the surface and edge regions to accurately determine the region positions and feature point locations. The model fit takes into account the **Surface Width**, **Surface Offset**, **Edge Angle** and the **Edge Type** parameters.

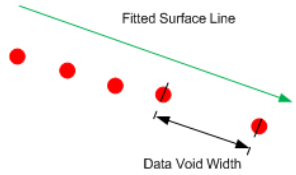
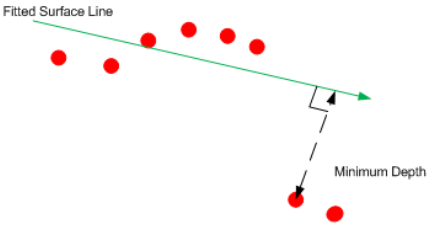
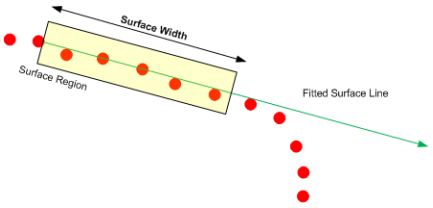
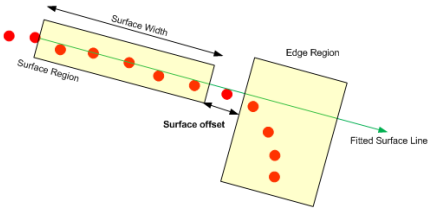
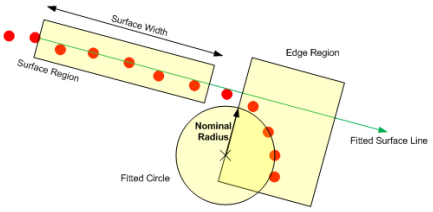


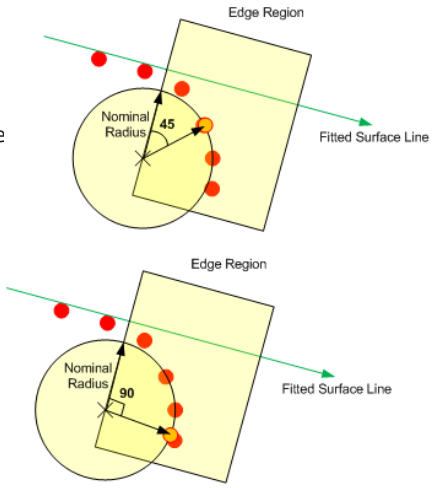
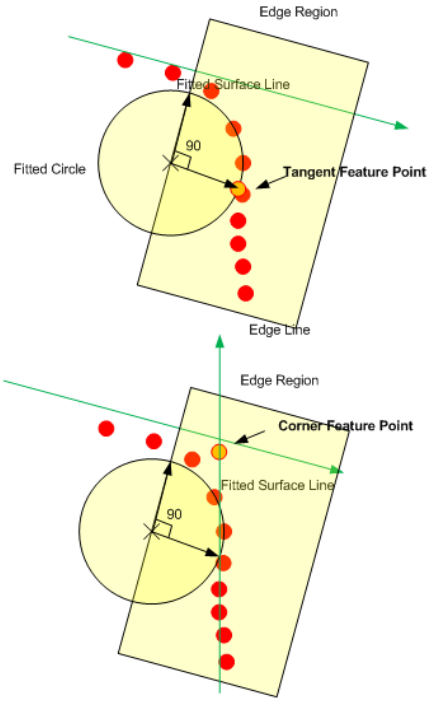
Parameters

Parameter	Description	Illustration
Source	The sensor, or combination of sensors, that provides data for the tool's measurements.	
Stream	The section profile data that the tool will apply measurements to. This setting is only displayed in Surface mode when a section is defined on the surface data.	
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 t single out the correct gap when there are multiple gaps ir the field of view.	

Parameter	Description	Illustration
Measurement Axis *Panel 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.	Surface Axis  Edge Axis  Distance Axis 
Absolute *Panel 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 30.	
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 28.	

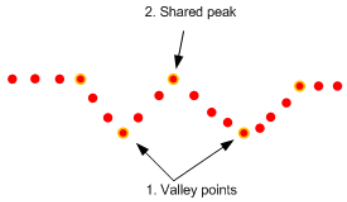
Left/Right SideEdge Parameters

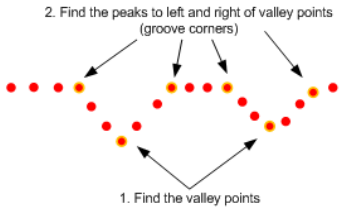
Parameter	Description	Illustration
Max Void Width	The maximum allowed width of missing data caused by occlusion or data dropout. A larger value prevents the algorithm from registering a section of missing data as an edge. Setting the value to 0 causes the algorithm to try to detect an edge in every missing data section.	
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 laser 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. The algorithm searches for a start position in which the remaining data most resemble a circle of the specified nominal radius.	

Parameter	Description	Illustration
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 31.	

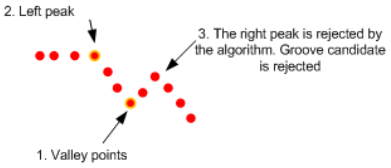
Groove Algorithm

The Groove measurement tool first locates valley along the profile line. The bottom point of a valley, the valley point, is the first estimation of the position of the groove bottom. For each valley, the algorithm searches for corner to the left and to the right to find the groove corners. A groove candidate is found when the groove corners are located on the left and right before the next valley is reached. Two groove candidates may share the same corner as shown in the right image below. (See the tables below for the parameters used by the algorithm.)

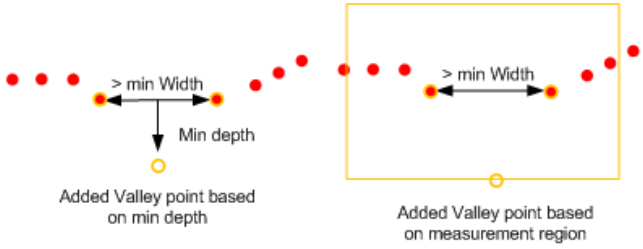




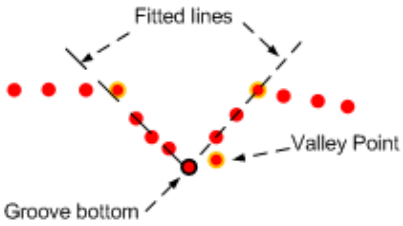
The algorithm derives search parameters from the user settings to prevent noise from triggering false detections. When detecting multiple grooves, an adaptive algorithm is used to ensure that candidate grooves are approximately the same scale.



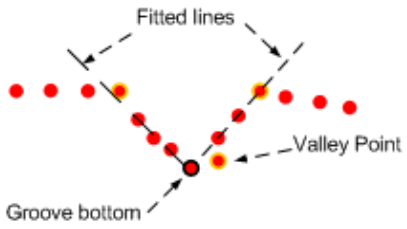
The valley points of open grooves may not be visible or may fall outside of the measurement region. Voids in the data (regions with no profile data) between pairs of valid points are detected. A valley point is added midway between the pair of valid points. The Z position of the valley point is either the minimum groove depth below the lower of the corners or the bottom edge of the measurement region. The algorithm then proceeds as if to find a U-shaped groove.



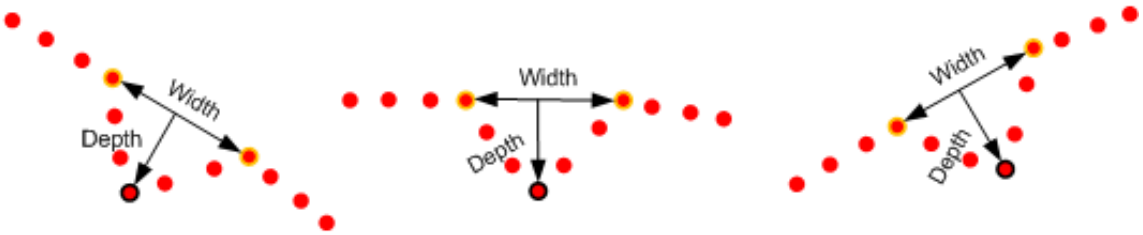
The actual groove bottom is calculated differently for different shapes. For a V-shaped groove, a line is fitted to the sides of the valley points starting from the corners, up to (but not including) the valley point. The groove bottom is the intersection of the left and right lines. Line fitting is used such that an accurate groove bottom can be found even when the real bottom is not visible (i.e., blocked by reflections).



For U-shaped and open groove, the distance from each point within the groove (including the added point for open-shaped groove) is projected onto the width line. The groove bottom's X is at the centroid of the projected values along the width. The groove bottom's Z is at the maximum depth of the groove.

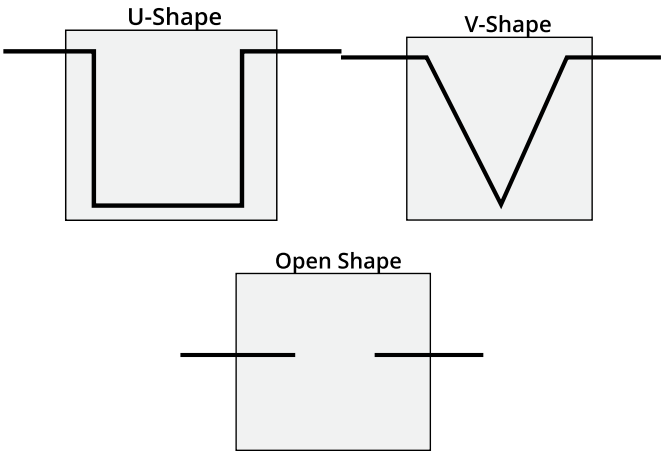
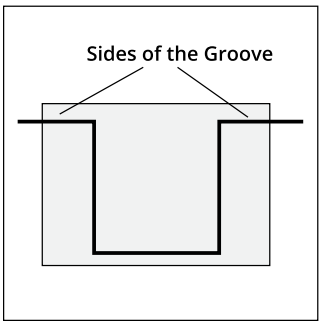


Groove candidates that do not meet the minimum and maximum width and depth settings are rejected. The width and depth measurements are invariant to the groove rotation. The width is the distance between the groove corners and the depth is perpendicular distance of the groove bottom from the groove width.



Parameters

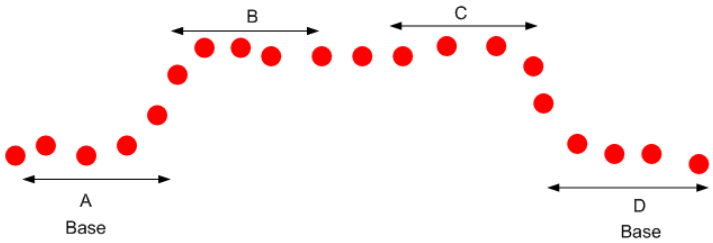
Parameter	Description
Source	The sensor, or combination of sensors, that provides data for the tool's measurements.
Stream	The section profile data that the tool will apply measurements to. This setting is only displayed in Surface mode when a section is defined on the surface data.

Parameter	Description
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 made large enough to cover some laser data on the left and right sides of the groove.  For more information on regions, see *Regions* on page 31.
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 30.
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 28.

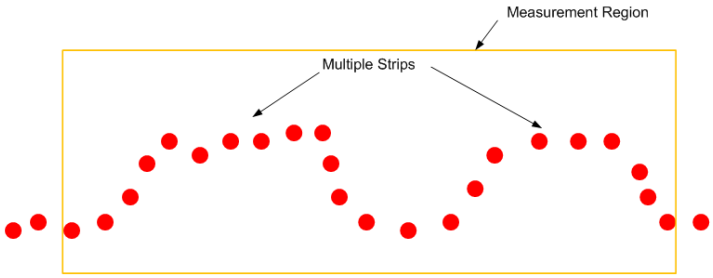
Strip Algorithm

A strip is a flat region bounded on the left and on the right by edges. The Strip tool can measure the edge positions, width, and height of a strip. The Strip tool assumes that regions outside the strip, referred to as the base regions (Region A and D below), deviate in height from the start and end parts of a strip (Region B and C). (See the tables below for the parameters used by the algorithm.)

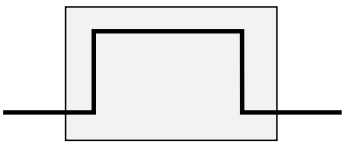
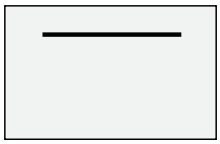
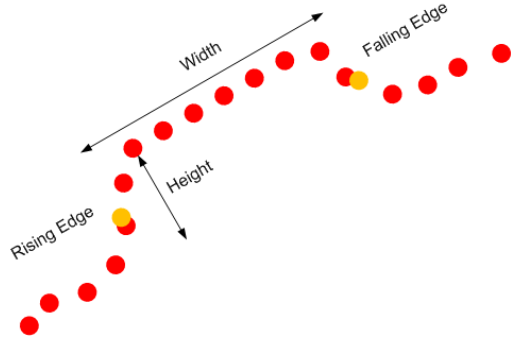


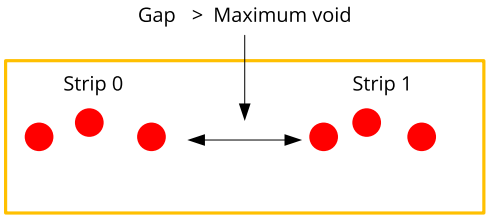
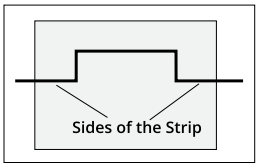
When the target is sitting on the surface, the base is lower than the strip (as shown above). Alternatively for a groove the base is above the strip surface. The base could be missing when the target is hanging in the air or the surface holding the target falls outside the sensor's active area. You can control the base type in the measurement panel.

The Strip tool can detect multiple strips. You can select a region of interest, referred to as the measurement region, from which the algorithm search for multiple strips.



Parameters

Parameter	Description
Source	The sensor, or combination of sensors, that provides data for the tool's measurements.
Stream	The section profile data that the tool will apply measurements to. This setting is only displayed in Surface mode when a section is defined on the surface data.
Base Type	Affects detection of rising and falling edges. 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 *Gocator Measurement Tool Technical Manual* for the definitions of these conditions.
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. 

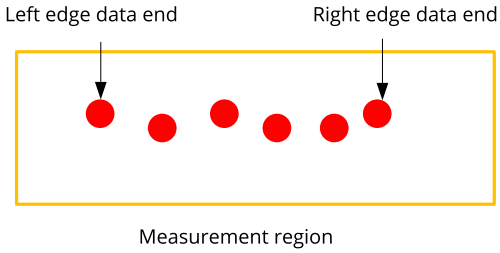
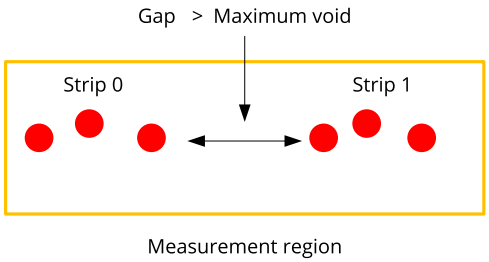
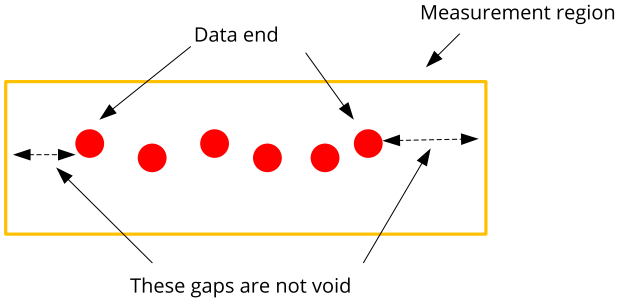
Parameter	Description
Support Width	Specifies the width of the region around the edges from which the data is used to calculate the step change. See "Strip Step Edge Definitions" in the *Gocator Measurement Tool Technical Manual* on how this parameter is used by different base types.
Transition Width	Specifies the nominal width needed to make the transition from the base to the strip. See "Strip Step Edge Definitions" in the *Gocator 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 *Gocator 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**.  Measurement region When occlusion and exposure causes data drops, users should use the gap filling function to fill the gaps.
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 31.
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.

Parameter	Description
Filters	The filters that are applied to measurement values before they are output. For more information, see *Filters* on page 30.
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 28.

Strip Start and Terminate Conditions

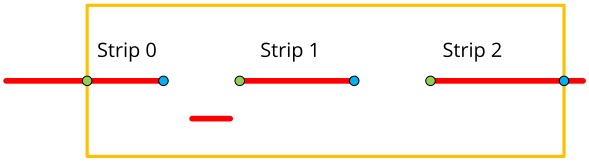
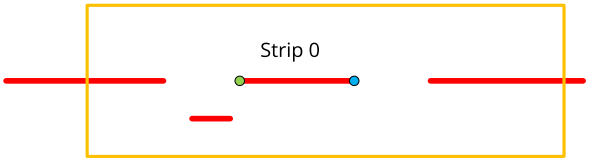
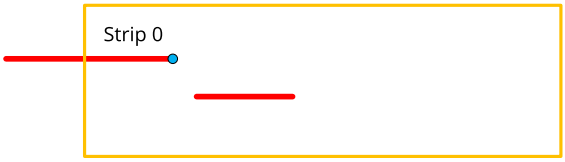
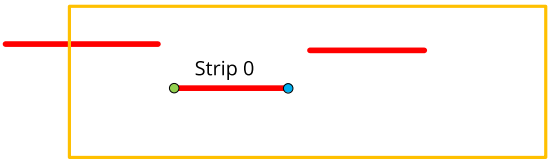
The Strip tool allows you to define how a strip starts and ends. The Left Edge parameter controls how a strip starts and the Right Edge parameter controls how a strip ends.

Start / terminate conditions

Condition	Description
Rising	Rising step edge detected based on the strip edge parameters. See *Strip Step Edge Definitions* on the next page for details on how the step edge is detected.
Falling	Falling step edge detected based on the strip edge parameters. See *Strip Step Edge Definitions* on the next page for details on how the step edge is measured.
Data end	The first (for the left edge) or the last (for the right edge) valid profile data point in the measurement region. 
Void	Gaps in the data that are larger than the maximum void threshold.  Gaps at the ends of the measurement region's boundary are not considered as a void. 

The following examples show how the parameters affect the strip detection in different scenarios.

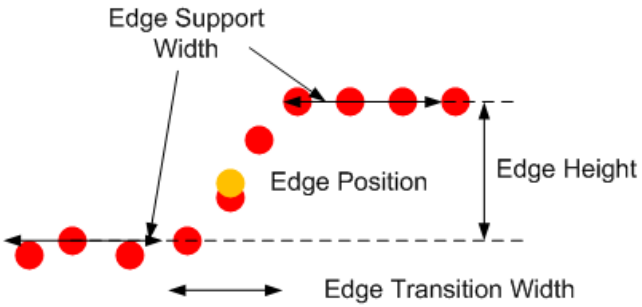
Left and Right Edge conditions

Condition	Example
Left: Rising, data end, void Right: Falling, data end, void	
Left: Rising, void Right: Falling, void	
Left: Rising Right: Data end, void	
Left: Data end, void Right: Falling	
Left: Falling Right: Rising	

Strip Step Edge Definitions

The Strip tool detects step edges based on the parameters Base Type, Edge Transition Width, Edge Support Width, and Minimum Edge Height.

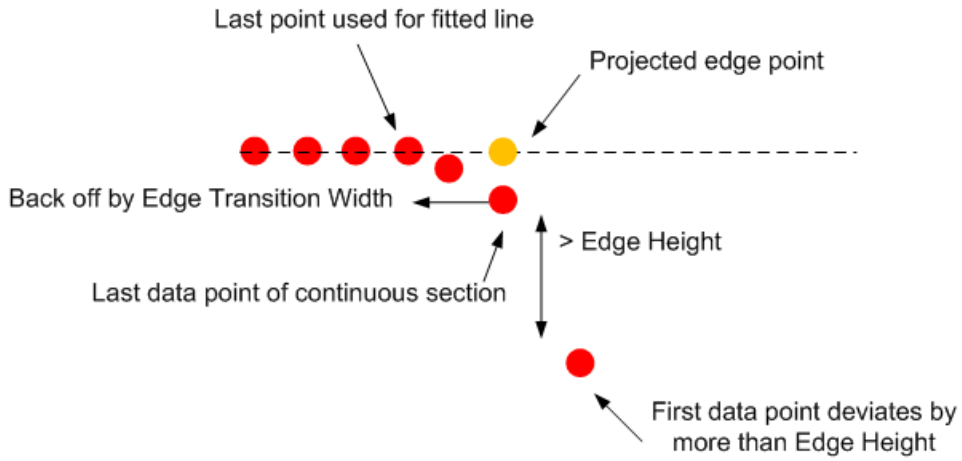
When Base Type is set to Flat, the regions around the edges are visible and the edge positions are between the base and the strip surface.



The Minimum Edge Height parameter defines the size of the step edge. The Edge Transition Width parameter specifies the nominal width of the transition, from the base to the strip surface.

The Edge Support Width parameter defines the width of the region around the edges from which the data is used to measure the step change. To improve noise immunity, the height level of the Edge Support Width parameter is calculated by averaging the data within the region.

When the base is set to None, the tool looks for continuous sections that are wider than the Edge Support Width parameter and have no data points that deviate positively or negatively more than the value of the Minimum Edge Height parameter. The data in the strip support region (the raised area) must be smooth. The height level of the continuous region is calculated based on the fitted line as shown below.



The algorithm then backs off by the value of the Edge Transition Width parameter and uses the data up to the back-off point to create the fitted line and projects the edge point on the line. This step prevents the points near the end of a rounded strip from affecting the height of the strip.

Surface Tools

Hole Algorithm

The Hole tool processes the data in three phases: Search, Measure, and Filter. The algorithm can separate out background information that appears inside the hole. It can also detect holes that only partially appear in the data.

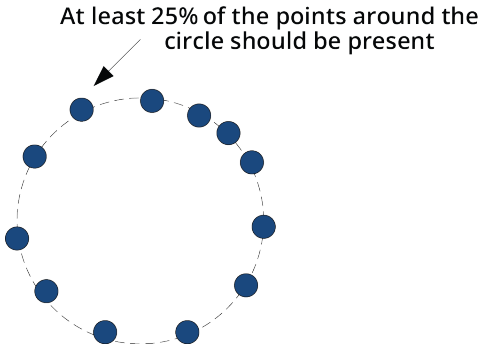
See the tables below for the parameters used by the algorithm.

Search phase - The tool searches for coarse data transitions (edge data) and performs a coarse fitting of the hole model (specified by the orientation angles and the nominal value) to determine the most likely candidate. If **Tilt Correction** is set to **Autoset**, the algorithm uses the data within the measurement region to estimate the orientation of the part.

Measure phase - A more rigorous edge detection algorithm is applied to precisely determine the edges around the feature. Edge detection at this stage will reject outliers and noise. The algorithm requires at least 25% of the data around the hole for the candidate to remain valid.

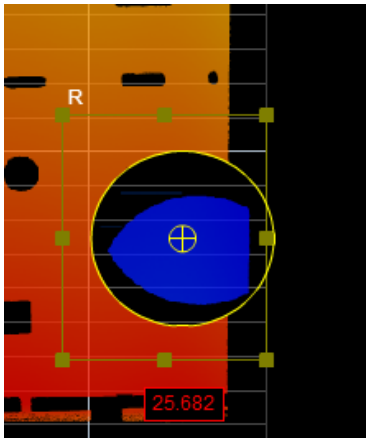
The accuracy of the algorithm improves when the points are spread more evenly along the hole's circumference.

The set of refined edges is then used to locate and inspect the feature. If the Reference Regions option is enabled and set to AutoSet, the edges are also used to calculate the location of the reference regions.

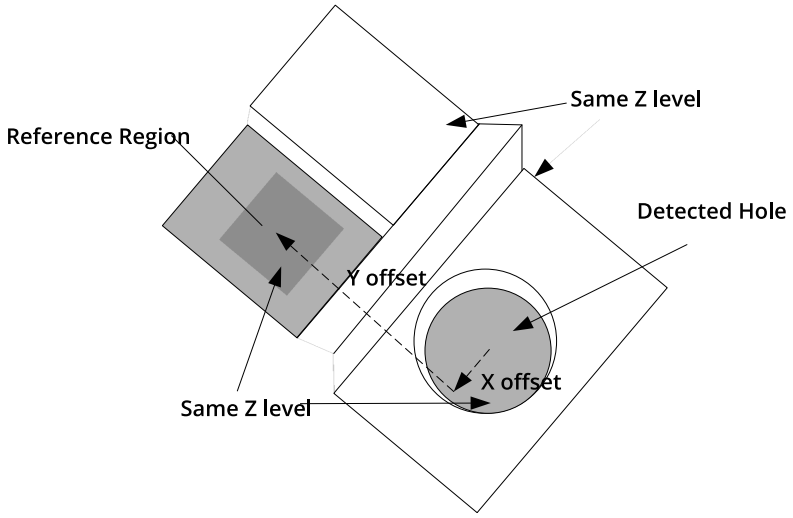


Filter phase - The detected location and dimensions are then compared to the nominal and tolerance settings. If the refined feature falls within the measurement region and its measurements fit within the specified tolerance, the results are reported. If not, an invalid result is returned.

Parameters

Parameter	Description
Source	The sensor, or combination of sensors, that provides data for the tool's measurements.
Nominal Radius	Expected radius of the hole.
Radius Tolerance	The maximum variation from the nominal radius (+/- from the nominal radius).
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 opening calculations.
Region	The region to which the tool's measurements will apply. For more information, see *Regions* on page 31.

Parameter	Description
Reference Region	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.

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 30.
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 28.

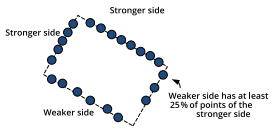
Opening Algorithm

The Opening tool processes the data in three phases: Search, Measure, and Filter.

See the tables below for the parameters used by the algorithm.

Search phase - The tool searches for coarse data transitions (edge data) and performs a coarse fitting of the opening shape (specified by the orientation angles and the nominal dimensions) to determine the most likely candidate. If **Tilt Correction** is enabled, the algorithm uses the flat surface in the measurement region to estimate the orientation of the part.

Measure phase - A more rigorous edge detection algorithm is applied to precisely determine the edges around the feature. Edge detection at this stage will reject outliers and noise. The algorithm requires opposite sides and ends to be associated with a comparable number of edge pixels, with the weaker side or end having at least 25% of the stronger.

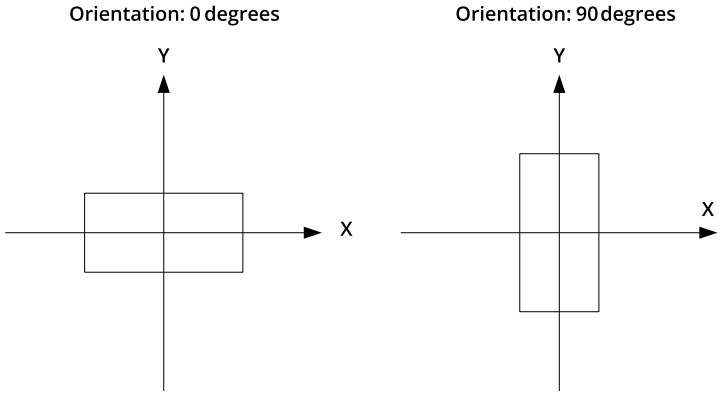
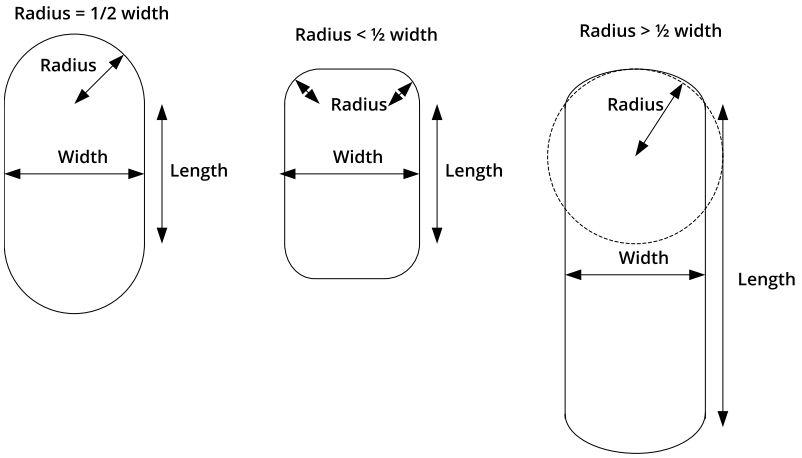


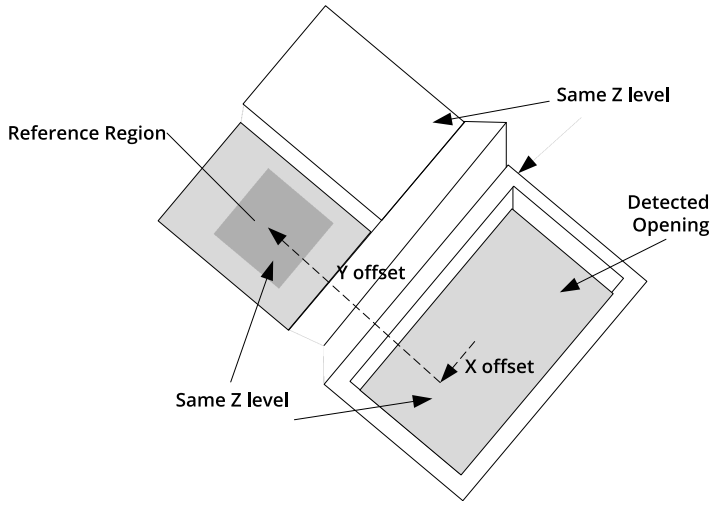
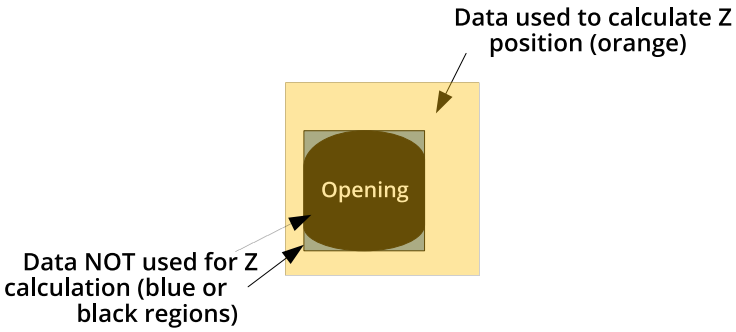
The set of refined edges is then used to locate and inspect the feature. If the **Reference Regions** setting is enabled, the edges are also used to calculate the location of the reference regions.

Filter phase - The detected location and dimensions are compared to the nominal and tolerance settings. If the refined feature falls within the measurement region and its measurements fit within the specified tolerance, the results are reported. If not, an invalid result is returned.

Parameters

Parameter	Description
Source	The sensor, or combination of sensors, that provides data for the tool's measurements.
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 hole opening calculations.
Region	The region to which the tool's measurements will apply. For more information, see *Regions* on page 31.

Parameter	Description
Reference Regions	The tool uses the reference regions to calculate the Z position of the hole 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 hole's 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.
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).

Parameter	Description
X Angle	The X and Y angles you must specify when **Tilt Correction** is set to **Custom**.
Y Angle	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 30.
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 the next page.

Stud Algorithm

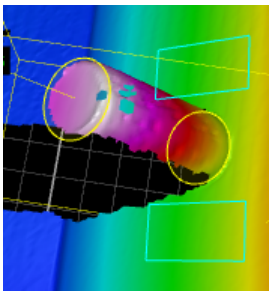
The Stud algorithm measures the stud in three steps: searching for the tip, finding the reference plane, and shaft fitting.

See the tables below for the parameters used by the algorithm.

Searching for the tip - The algorithm looks for the approximate location of the tip. If Auto-Tilt is enabled, the algorithm uses the flat surface around the tip to estimate the orientations of the part. The approximate tip is the location of the highest (maximum Z) pixel after correction for the nominal tilt angle.

Finding the reference plane - The reference regions are positioned using the approximate tip, the nominal angle values, and the nominal stud length. Compared to the hole/opening, misplaced stud reference regions are more likely to cause a failure to produce any measurement.

Shaft fitting - The shaft region is determined based on the approximate tip position, the nominal angles, the reference plane position, and the stud nominal size parameters. Shaft fitting is successful if the algorithm can fit at least three circles with the stud diameter along the shaft. Fitting each circle requires sufficient data along the top portion the shaft. Because of occlusions, the bottom of the shaft is often not visible to the sensor and the algorithm is designed to handle this situation.



Parameters

Parameter	Description
Source	The sensor, or combination of sensors, that provides data for the tool's measurements.
Stud Radius	Expected radius of the stud.
Stud Height	Expected height/length of the stud.

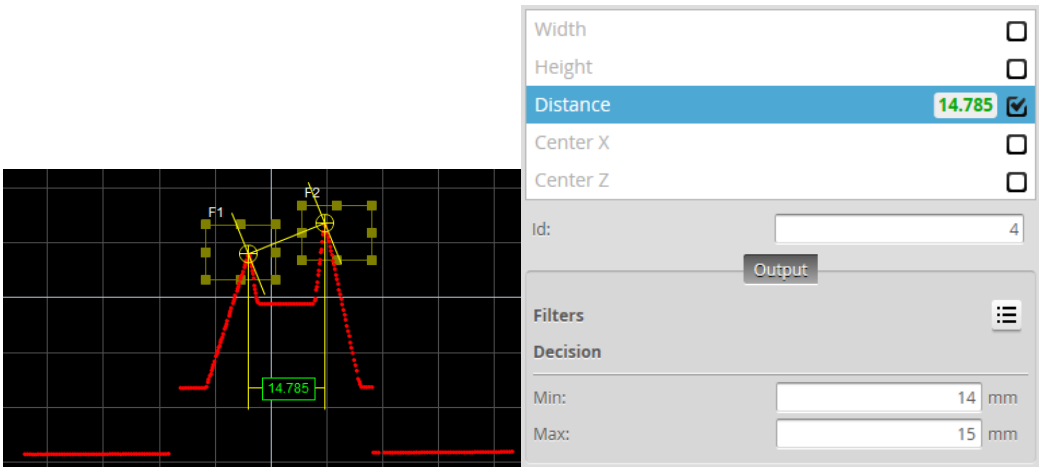
Parameter	Description
Base Height	The height above the base surface that will be ignored when the (truncated) cone is fit to the stud data.
Tip Height	The height from the top of the surface that will be ignored when the (truncated) cone is fit to the stud data.
Region	The region to which the tool's measurements will apply. For more information, see *Regions* on page 31.
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.
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 30.
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* below.

Common Parameters

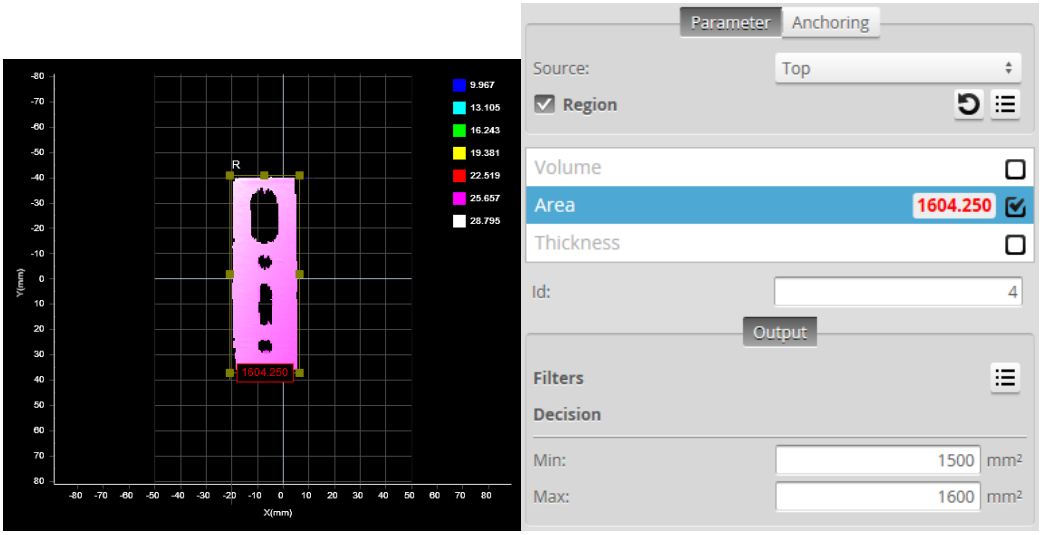
Decisions

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.

To configure decisions:

1. Go to the **Measure** page by clicking on the **Measure** icon.

   > 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.

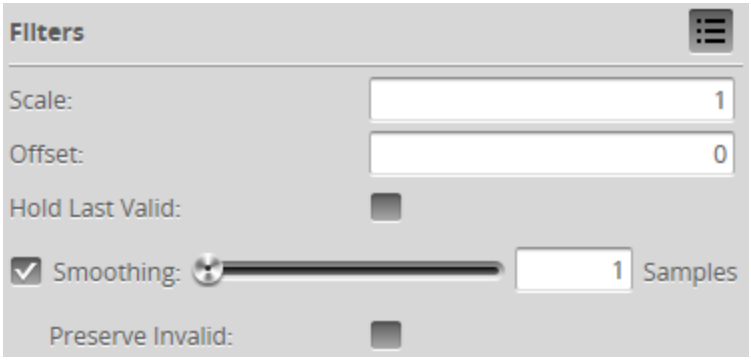
2. In the **Tools** panel, click on a tool in the tool list.
3. In the measurement list, select a measurement.
   To select a measurement, it must be enabled.
4. Click on the **Output** tab.

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 Gocator 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.
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.

> 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.
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.

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 5), a fit line (*Fit Lines* on page 7), or left or right side of the Panel tool (see *Panel (Gap and Flush) and Round Corner Algorithm* on page 7). Unlike reducing the active area, reducing the measurement region does not increase the maximum frame rate of the sensor.

> You can disable regions entirely and cause the measurement tool uses the entire active area by unchecking the checkbox next to the **Regions** setting.

All tools provide region settings under the upper **Parameters** tab. This region applies to all of a tool's measurements.

Region settings are often found within expandable feature sections in the tool's panel.

> 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.

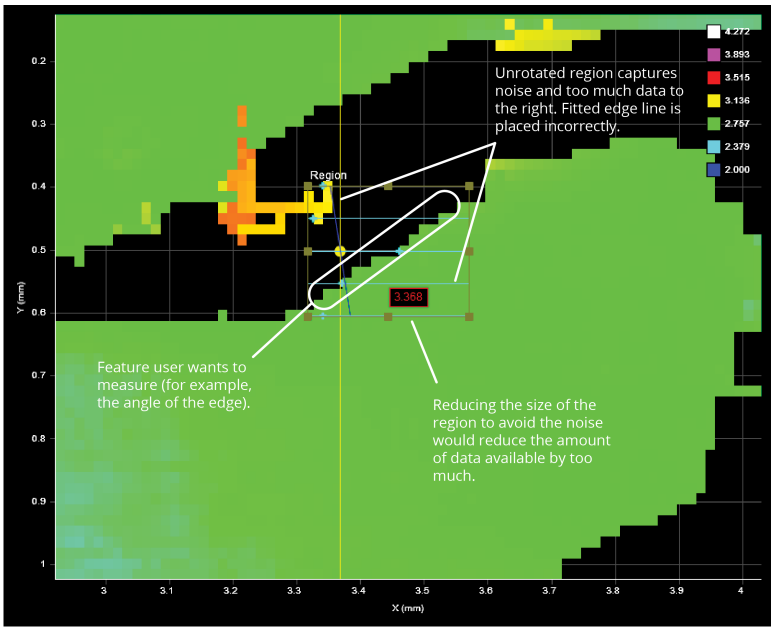
To configure regions:

1. Go to the **Measure** page by clicking on the **Measure** icon.

> 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.

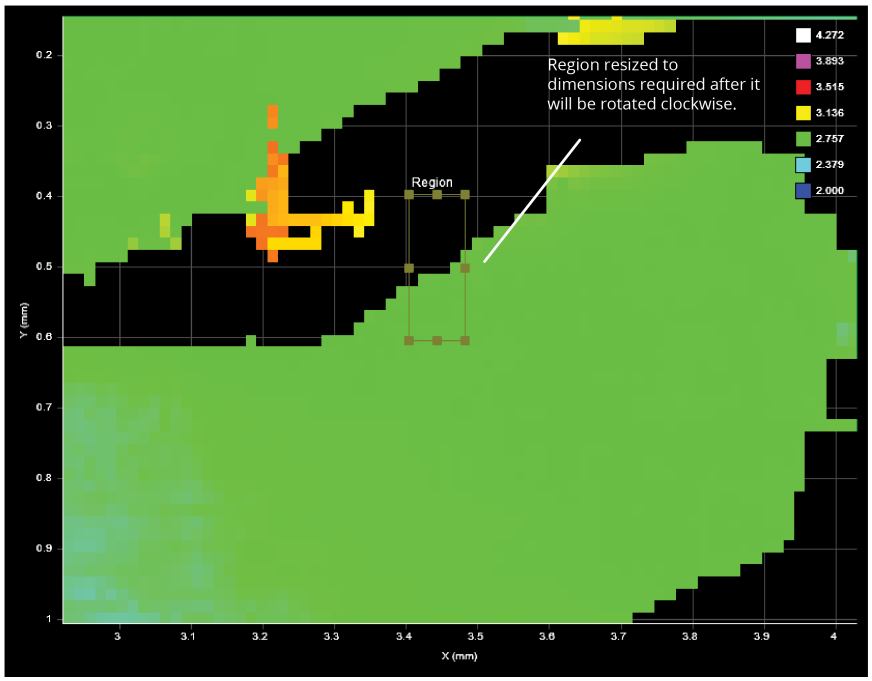
2. In the **Tools** panel, click on a tool in the tool list.
3. Configure the region using the mouse in the data viewer.
   You can also configure regions manually by clicking the expand button (☰) and entering values in the fields. This is useful if you need to set precise values.

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.



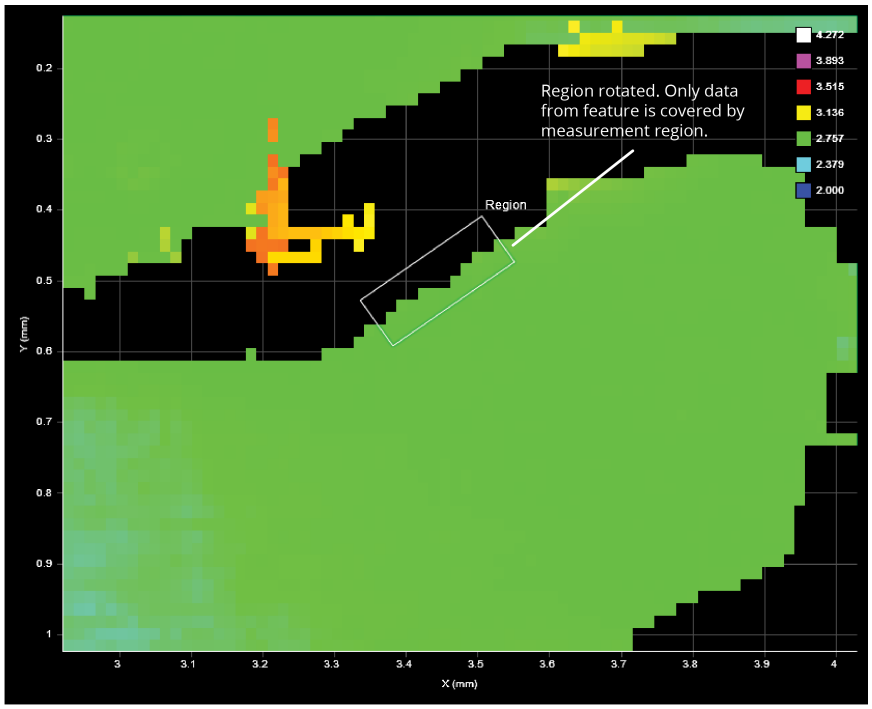
To rotate measurement regions:

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 cannot modify it in the data viewer using the mouse. You can however modify its dimensions and its location manually by changing the region's values in the **Region** setting.

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