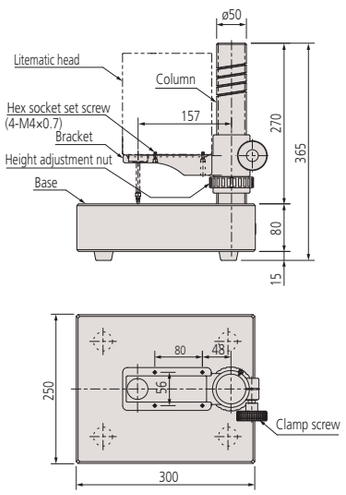
Optional Stand for VL-50S-B

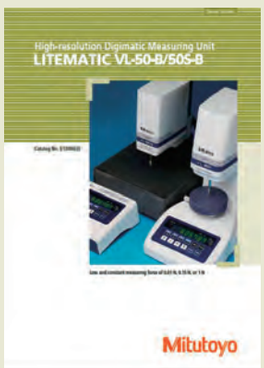
957460 Unit: mm



Optional Accessories

- Foot switch: **937179T**
- Dedicated stand: **957460***1
- SPC cable (1 m): **936937***2
- SPC cable (2 m): **965014***2
- VL weight part: **02AZE375***3
- Recommended spare contact points:
  Shell type: **101118** (Approx. 0.02 N)*4
  Carbide tipped spherical contact point, ø7.5: **120059** (Approx. 0.03 N)*4
  Carbide tipped spherical contact point, ø10.5: **120060** (Approx. 0.06 N)*4
  Carbide tipped needle contact point, ø0.45: **120066** (Approx. 0.01 N)*4

*1 Only **VL-50S** is available.
*2 Refer to page G-18 for details of the RS link.
*3 Not applicable to **VL-50-100-B** and **VL-50S-100-B**
*4 Values in parentheses indicate the measuring force of a 0.01 N model fitted with the respective optional points



Refer to the Litematic Brochure (**E13006**) for more details.

VL-50-B/50S-B Litematic
SERIES 318 — High-accuracy/resolution Measuring Machine

- With a measuring force of only 0.01 N, the Litematic is ideal for measuring easily deformed workpieces or high-accuracy components.
- For workpieces for which 0.01 N is insufficient, either the 0.15 N or 1 N model is recommended.
- The motor-driven spindle moves up/down and stops when the contact point touches the workpiece. Then the maximum, minimum and runout values are measured under a constant force.
- High resolution of 0.01 µm, and wide measuring range of 50 mm.
- Measuring system **VL-50-B**, integrated display type, and **VL-50S-B**, a separate display type, are available.
- The measuring table supplied with **VL-50-B** is ceramic, which is corrosion free, for easier maintenance and storage.
- The spindle is made of low thermal expansion material.

318-221

318-226

SPECIFICATIONS

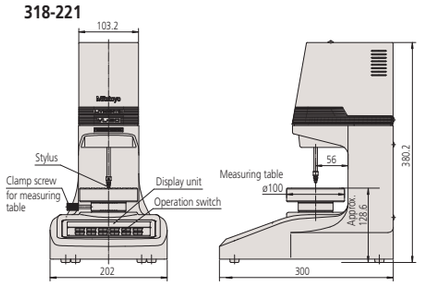
Order No.		318-221*4	318-222*4	318-223*4	318-226*4	318-227*4	318-228*4
Model		VL-50-B	VL-50-15-B	VL-50-100-B	VL-50S-B	VL-50S-15-B	VL-50S-100-B
Measuring range		0 to 50 mm (0 to 2 in)					
Resolution		0.01/0.1/1.0 µm (0.0000005 in/0.000005 in/0.00005 in)					
Display unit		8 digits/14 mm (0.6 in) character height (without signs)					
Scale type		Reflection type linear encoder					
Stroke		51.5 mm (2 in) (when using a standard contact point)					
Measuring accuracy (20 °C)*1		(0.5 + L/100) µm L=arbitrary measuring length (mm)					
Accuracy guaranteed temperature*2		20±1 °C					
Repeatability*1		σ=0.05 µm					
Measuring force*1		0.01 N	0.15 N*3	1 N*3	0.01 N	0.15 N*3	1 N*3
Feed speed	Measurement	Approx. 2 mm/s (0.08 in/s) or 4 mm/s (0.16 in/s) (changeable by parameter)					
	Fast feed	Approx. 8 mm/s (0.3 in/s)					
Contact point		ø3 mm carbide tipped (fixing screw: M2.5 (P=0.45) ×5), standard contact point: **901312**					
Measuring table		ø100 (ceramic, grooved, removable)			—		
Input		Foot switch input (when optional foot switch is used) External Control					
Output		Digimatic output/RS-232C output (changeable by parameter)					
Rating	Power supply	85 to 264 V AC (depends on AC adapter)					
	Power consumption	Max. 12 W (12 V, 1 A)					
Standard Accessories		AC adapter: **357651**, Grounding wire: **09CAA985**, AC cable (Japan): **02ZAA000**, AC cable (USA): **02ZAA010**, AC cable (EU): **02ZAA020**, AC cable (UK): **02ZAA030**, AC cable (China): **02ZAA040**, AC cable (Korea): **02ZAA050** Hex wrench (2 pcs. for fixing contact point and for removing fixing bracket)					

*1 Normal measurement using standard contact point.
*2 Under less temperature change, and hot or cold direct air flow should be avoided.
*3 0.15 N, 1 N types are factory-installed option.
*4 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE.
Note: Motor life is approximately 100,000 operations, after which replacement is advisable.
This maintenance factor is particularly important to bear in mind when the machine is used frequently, such as on a production line.

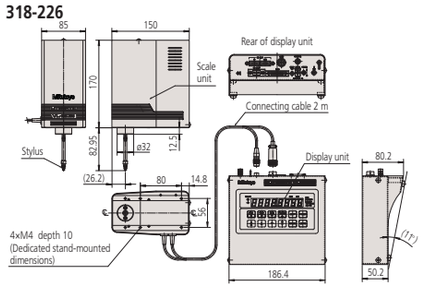
DIMENSIONS

Unit: mm

318-221



318-226



Lever/Cartridge Probe Heads
SERIES 519 — Electronic micrometer

SPECIFICATIONS

Lever heads

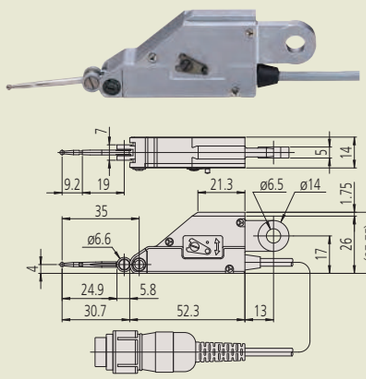
Order No.	519-521	519-522	519-326	519-327
Model	MLH-521	MLH-522	MLH-326	MLH-327
Measuring range (mm)	±0.5			
Stroke (mm)	±0.6			±0.65
Measuring force (N)	Approx. 0.2	Approx. 0.02	Approx. 0.15	
Linearity (%)	±0.3			±0.5
Stylus support	Pivot bearing	Pivot bearing	Parallel-leaf spring	Pivot bearing

Note: A ø2 mm ball-ended stylus is supplied as standard with all probes.

Common specifications

- Connection: Half-bridge
- Cable length: 2 m
- Connector type: MAS-5100 (DIN5P) or equivalent

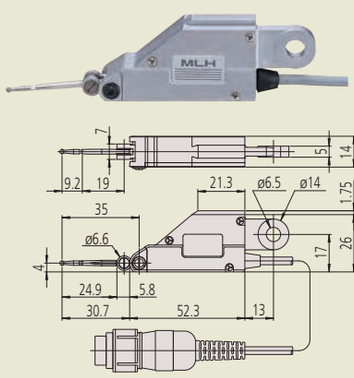
519-521
MLH-521



- Interchangeable styli:
  ø1: **520940** (Standard accessory)
  ø2: **520939** (Standard equipment)
  ø3: **520938** (Standard accessory)

Unit: mm

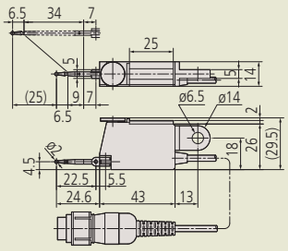
519-522
MLH-522



- Interchangeable styli:
  ø1: **520940** (Standard accessory)
  ø2: **520939** (Standard equipment)
  ø3: **520938** (Standard accessory)

Unit: mm

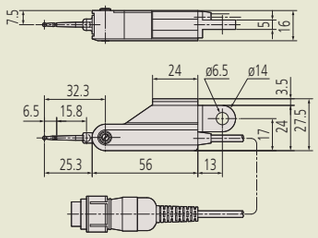
519-326
MLH-326



- Interchangeable styli:
  ø1: **102824** (Optional)
  ø2: **102825** (Standard equipment)
  ø3: **102826** (Optional)
- Extension bar
  L=9 mm (Standard equipment)
  L=34 mm (When a bar for extending the distance to the stylus tip is supplied)

Unit: mm

519-327
MLH-327



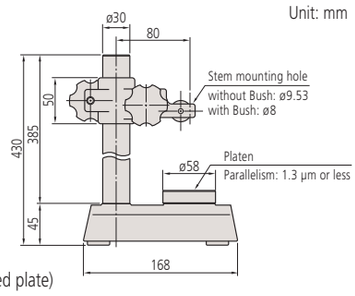
- Interchangeable styli:
  ø1: **102824** (Optional)
  ø2: **102825** (Standard equipment)
  ø3: **102826** (Optional)

Unit: mm

Transfer Stand

519-109-10
(with a serrated plate)

Unit: mm



Main Specifications

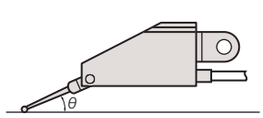
Order No.	Effective transfer range (mm)	Fine adjustment range (mm)	Mounting hole (mm)
519-109-10	0 - 320	1	Without Bush: ø9.53 With Bush: ø8

Note on stylus angle

If the stylus of a pivot bearing type probe makes an angle with a workpiece surface, as in the figure, calibration should be performed for accurate measurement. Alternatively, the displayed value may be corrected by multiplying it by the appropriate correction factor as given in the table.

Model **519-326** does not need correction.

Angle (θ)	Correction factor
0°	1.00
10°	0.98
20°	0.94
30°	0.87
40°	0.77
50°	0.64
60°	0.50

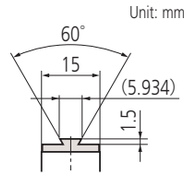


Display value × Correction factor = Corrected value

Dimensions of dovetail plate on probe body

Enables mounting on a lever head mounting bracket or stem.

Unit: mm



Lever-head mounting brackets (optional)

Optional accessories for Mitutoyo test indicators can be used.

Stems

ø4 dovetail-grooved stem
21CZB131

ø6 dovetail-grooved stem
21CZB128

ø8 dovetail-grooved stem
21CZB129

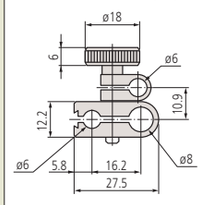
ø9.5 dovetail-grooved stem
21CZB130

Clamp

Clamp for ø6/8 dovetail-grooved stem
902053

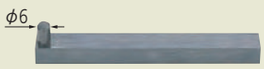
Clamp for ø6/9.5 dovetail-grooved stem
900320

Unit: mm



902053

Holder



Holding arm A (Square 9×9, Length 100)
900209

Holding arm B (ø8, Length 115)
900211

SPECIFICATIONS

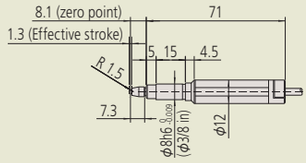
Cartridge heads (special order only)

Order No.	519-331	519-332	519-346	519-347	519-385	519-341	519-348
Model	MCH-331	MCH-332	MCHS-346	MCHS-347	MCH-385	MCHP-341	MCHS-348
Measuring range (mm)	±0.5	±0.5	±0.25	±0.5	±1.5	±2.5	±1.0
Stroke (mm)	±0.65	±0.65	+0.34 −0.26	+0.85 −0.65	+2.35 −1.65	+3.2 −2.8	+1.35 −1.15
Measuring force (N)	Approx. 0.25	Approx. 0.25	Approx. 0.7	Approx. 0.7	Approx. 0.7	Approx. 0.9	Approx. 0.7
Stem Dia. (mm)	ø8	ø3/8 in	ø8	ø8	ø8	ø8	ø8
Linearity (%)	±0.5	±0.5	±0.3	±0.3	±0.3	±0.5	±0.3
Plunger support	Plain bearing		Linear ball-bearing				

519-331 / (519-332)
MCH-331 / (MCH-332)

- M2.5×5 (4-48 UNF) interchangeable contact points for dial indicators can be used.

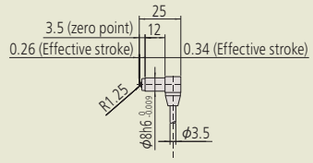
Unit: mm



519-346
MCHS-346

- Dedicated contact point only that cannot be replaced.

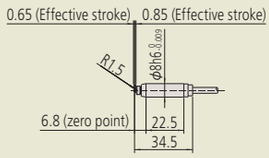
Unit: mm



519-347
MCHS-347

- Dedicated contact point only that cannot be replaced.

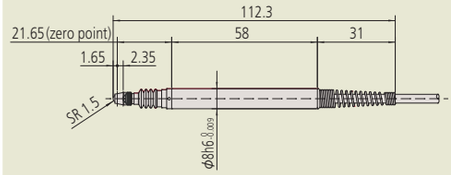
Unit: mm



519-385
MCH-385

- M2.5×5 interchangeable contact points for dial indicators can be used.

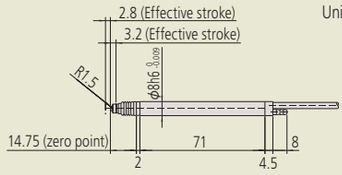
Unit: mm



519-341
MCHP-341

- M2.5×5 interchangeable contact points for dial indicators can be used.
- Recommended air pressure 0.05 MPa

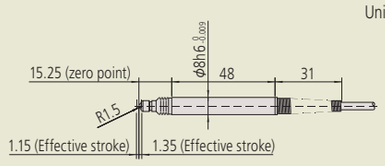
Unit: mm



519-348
MCHS-348

- M2.5×5 interchangeable contact points for dial indicators can be used.

Unit: mm



G

Mitutoyo

Display unit for Mu-checker (analog/digital)
SERIES 519 — Electronic micrometer

- Single touch zero-set function is standard.
- Switchable measurement ranges make the Mu-checker suitable for a range of applications, especially those that involve moderately fast-changing measurement values which suit the use of analog readout.
- Two types of analog display are available and one digital type.

Analog Mu-checker

Standard type
519-551
M-551

Differential type
519-553
M-553

SPECIFICATIONS

	Metric		Inch	
Order No.	**519-551***	**519-553***	**519-552***	**519-554***
Model	**M-551**	**M-553**	**M-552**	**M-554**
Type	Standard type (one probe required)	Differential type (one/two probes required)	Standard type (one probe required)	Differential type (one/two probes required)
Display range	±5 µm/±15 µm/±50 µm/±150 µm/±500 µm/±1500 µm		±5 µm/±15 µm/±50 µm/±150 µm/±500 µm/±1500 µm ±0.00015 in/±0.0005 in/±0.0015 in/±0.005 in/±0.015 in/±0.05 in	
Graduation	0.1 µm/0.5 µm/1 µm/5 µm/10 µm/50 µm		0.1 µm/0.5 µm/1 µm/5 µm/10 µm/50 µm 0.000005 in/0.00001 in/0.00005 in/0.0001 in/0.0005 in/0.001 in	
Differential mode	±A	±A, ±B, ±A±B	±A	±A, ±B, ±A±B
Display accuracy (linearity)	±1% of full-scale reading			
Analog output	±1.0 V at full-scale reading			
Analog output accuracy	Within ±0.1% of full-scale reading (excluding probe)			
Zero-setting adjustment range	±15%/FS (error: ±0.2%/FS)			
External dimensions	134 (W) ×183 (D) ×208 (H) mm			
Mass	2.4 kg			
Power input	AC adapter 100, 120, 220, 240 V AC 50/60 Hz			
Probe	Various probes (refer to pages G-21 and G-22)			

* To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix are required for PSE.

Digital Mu-checker

Digital Mu-checker
519-561
M-561

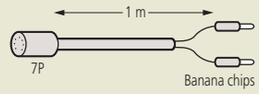
SPECIFICATIONS

	Metric	Inch
Order No.	**519-561***	**519-562***
Model	**M-561**	**M-562**
Type	Differential type digital Mu-Checker (2 connecting heads)	
Display range	±2.000 mm/±0.2000 mm	±2.000 mm/±0.2000 mm/±0.08 in/±0.008 in
Resolution	0.001 mm/0.0001 mm	0.001 mm/0.0001 mm/0.00005 in/0.000005 in
Differential mode	±A, ±B, ±A±B	
Measurement mode	ABS/CMP	
Analog output	±1 V at full-scale reading	
Digital output	Digimatic code out	
External dimensions	134 (W) ×183 (D) ×208 (H) mm	
Mass	Approx. 2.6 kg	
Power input	AC adapter 100, 120, 220, 240 V AC 50/60 Hz	
Probe	Various probes (refer to pages G-21 and G-22)	

* To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix are required for PSE.

Optional Accessories

- SPC Cable for connecting digital Mu-checker (**936937**)
  Used for connecting to the Digimatic mini-processor. (Not suitable for analog Mu-checkers)
- Output cable A (**934795**)
  Used for connecting to external devices, such as data recorders, etc.



- Analog, limit out (7P) connector (**529035**)
  Used for output to external data recorders, sequencers, etc.

Main features

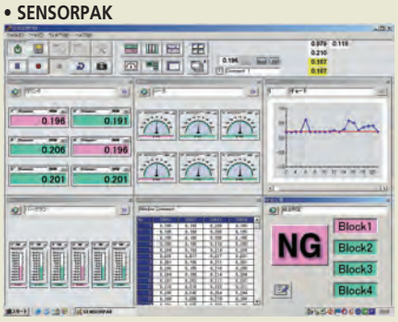
- External control (Zero-set, Preset etc.)
- Direction switching
- Error messaging
- Tolerance judgment output
- Each data output (RS-232C, BCD, segment)
- Peak measurement (maximum value, minimum value, runout) and arithmetic operation (addition, average, maximum value, minimum value, maximum width) between axes

Optional Accessories

- Output connector: **02ADB440**
- D-EV External display unit*1: **02ADD400**
- SPC cable (0.5 m): **02ADD950**
- SPC cable (1 m): **936937**
- SPC cable (2 m): **965014**
- AC adapter: **357651**
- AC cable (Japan): **02ZAA000***2
- AC cable (USA): **02ZAA010***2
- AC cable (EU): **02ZAA020***2
- AC cable (UK): **02ZAA030***2
- AC cable (China): **02ZAA040***2
- AC cable (Korea): **02ZAA050***2
- Terminal connecting cable: **02ADD930***2

*1 Refer to page G-25 for details of **D-EV**.
*2 Required when using AC adapter.

- **SENSORPAK**



Note: Refer to page G-16 for more details.

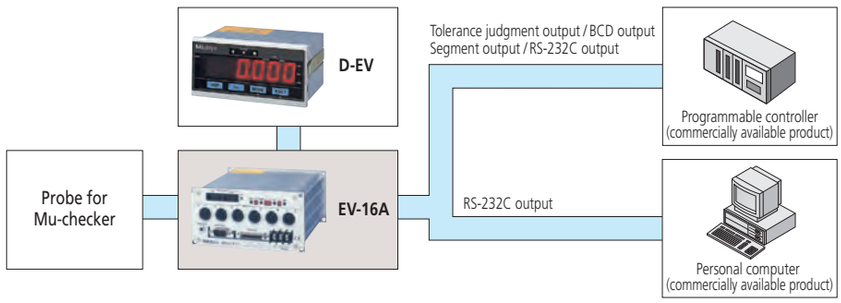
EV-16A Counter
SERIES 519 — 6-channel, No-display Type

519-355
EV-16A

- Up to six probes can be connected to one unit. Up to ten counters can be connected to one personal computer using the RS Link function to enable the configuration of a multi-point measurement system comprising a maximum of 60 gages.
- I/O outputs for RS-232C, BCD, tolerance judgment and segment output are available.
- Maximum, minimum and runout measurement between channels (in the same unit) is possible in addition to normal measurement on individual channels.

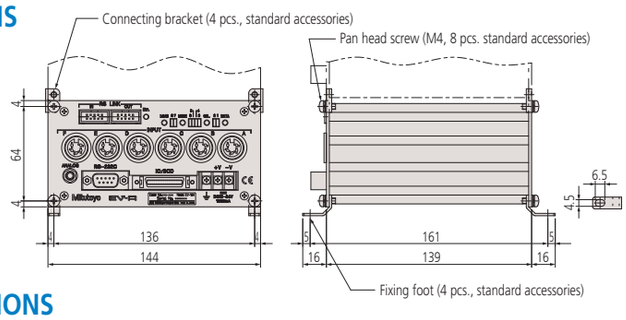
SYSTEM CONFIGURATION

Mitutoyo probes, **EV-16A** counters and **D-EV** display units combined with commercial controllers and personal computers enable construction of a powerful, multi-channel system that can be built to meet the needs of almost any measurement application.



DIMENSIONS

Unit: mm



SPECIFICATIONS

Order No.		519-355
Model		EV-16A
Number of gage inputs		6
Display range (mm)		±2.000, ±0.200
Resolution (mm)		0.001, 0.0001
Display processing		8 digits for parameters (display setting), 1 for error display
Error messaging		Power supply voltage error, Gage error, etc.
External display		Dedicated external display unit **D-EV** (optional) can be connected
Number of input switches		4
Input switch function		Measurement mode switching, Parameter settings
I/O	Tolerance judgment output	1 to 6 gages (L1, L2, L3), open-collector
	BCD output	Parallel BCD output (positive/negative-true logic), open-collector
	Segment output	A function to enable only output from the terminal corresponding to the counting values, open-collector
	Control output	Normal operation signal (NOM), open-collector
	Control input	Output channel designation (segment, in BCD mode), presetting, peak value clear, range changeover (at segment output), holding counting value, open-collector or no-voltage contact signal (with/without contact point)
Interface	RS-232C	Measurement data output and control input, EIA RS-232C-compatible Use cross cables for home position DTE (terminal definition)
	RS link	Max. connected units: 10 Connecting cable length: Max. 10 m (sum of link cable length) Data transfer time: 1.1 sec./60 ch (when transmission rate is 19200 bps)
Power supply	Voltage	12 to 24 V DC (Terminal block: M3)
	Consumption	1 A
Operating temperature (humidity) ranges		0 to 40 °C (RH 20 to 80%, non-condensing)
Storage temperature (humidity) ranges		-10 to 50 °C (RH 20 to 80%, non-condensing)
External dimensions		144 (W) ×72 (H) ×139 (D) mm
Mass		Approx. 1000 g
Standard accessories		Fixing foot (4), connecting bracket (4), fixing screw M4×8 (8)
Applicable probes		For probes, refer to pages G-21 and G-22.

D-EV
Display unit for the EV counter

- Display unit for the **EV** counter.
- Connecting this display unit helps configuration of the **EV** counter.
- Able to display each gage measurement value and GO/NG judgment result, total GO/NG judgment result for all gages, setting details, and errors.

02ADD400

Optional Accessories

- AC adapter: **357651**
- AC cable (Japan): **02ZAA000***
- AC cable (USA): **02ZAA010***
- AC cable (EU): **02ZAA020***
- AC cable (UK): **02ZAA030***
- AC cable (China): **02ZAA040***
- AC cable (Korea): **02ZAA050***
- Terminal connecting cable: **02ADD930***

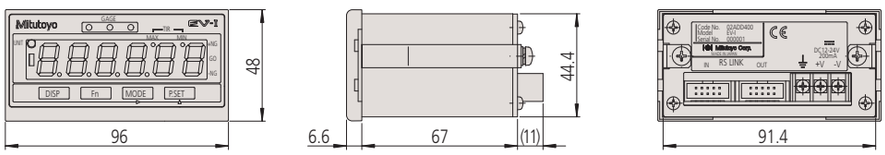
* Required when using AC adapter.

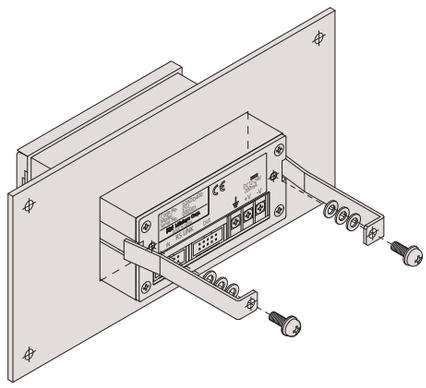
SPECIFICATIONS

Order No.	**02ADD400**
Model	**D-EV**
Number of connections	1 **EV** counter per unit
Number of digits	Sign plus 6 digits (8 digits internal to **EV** counter)
LED display	Channel display (also for judgment result display): 3 (3-color LED) Measurement mode display (current data, maximum value, minimum value, runout): 2 Status display: 1 (2 colors)
Operation switches	4
Function of operation switch	Channel switching, measurement mode switching (current data, maximum value, minimum value, runout), parameter setting, presetting, tolerance setting
Input/output	RS Link connectors: 1 each for IN, OUT
Error message	Overspeed, gage error etc.
Power supply	12 to 24 V DC, 200 mA (Terminal block: M3)
Operating temperature (humidity) ranges	0 to 40 °C (RH 20 to 80%, non-condensing)
Storage temperature (humidity) ranges	–10 to 50 °C (RH 20 to 80%, non-condensing)
External dimensions	96 (W) ×48 (H) ×84.6 (D) mm
Mass	150 g

DIMENSIONS

Unit: mm



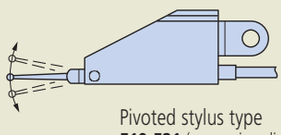


Quick Guide to Precision Measuring Instruments

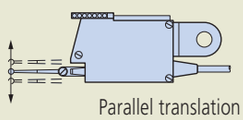
Mu-checker

Probe
A sensor that converts movement of a contact point, on a stylus or plunger, into an electrical signal.

Lever probes
Lever probes are available in two types. The most common type uses a pivoted stylus so the contact point moves in a circular arc; this type is subject to cosine effect and, therefore, measurements may require linearity correction if the direction of measurement is much different to the direction of movement of the contact point. The less common type uses a parallel translation leaf-spring mechanism so contact point movement is linear; this type requires no correction.

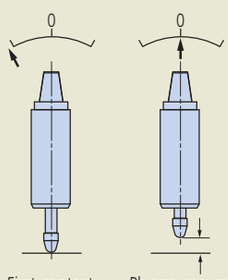


Pivoted stylus type
519-521 (measuring direction can be switched with the up/down lever)
519-522 (measuring direction is not switchable)



Parallel translation type
519-326 (measuring direction can be switched with the upper dial)

Pre-travel
The distance from first contact with a workpiece until the measurement indicator reads zero.



First contact. Plunger moves until the indicator reads zero.

Measuring force
The force applied to the workpiece by the probe when the indicator registers zero. It is indicated in newtons (N).

Digimatic code
A communication protocol for connecting the output of measuring tools with various Mitutoyo data processing units. This allows output connection to a Digimatic Mini Processor **DP-1VA LOGGER** for performing various statistical calculations and creating histograms, etc.

Open-collector output
A direct connection to the collector of a driving transistor.

Comparative measurement
A measurement method where a workpiece dimension is found by measuring the difference in size between the workpiece and a master gage that represents the nominal dimension.
This method is usually applied when the measurement to be made is greater than the measuring range of the instrument.

Linearity
The ratio of proportionality between measuring system output and measured distance.
If this is not constant within acceptable limits then correction is required.

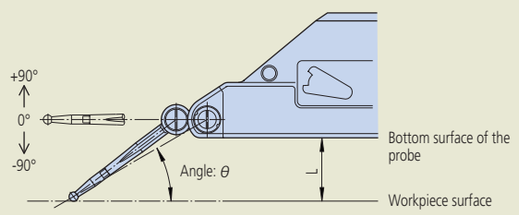
0 (zero) point
A reference point on the master gage in a comparative measurement.

Sensitivity
The ratio of the electric micrometer output signal to the input signal to the amplifier. The sensitivity is normal if a value as expected from the given displacement is displayed.

Tolerance setting
Tolerance limits can be set on the electronic micrometer to provide an automatic judgment as to whether a measured value falls within the tolerance.

Lever-head angle
Before measurement, be sure to confirm that probe sensitivity adjustment has been completed.
Changing the probe angle will cause variation in the measured values. Adjust the probe angle to obtain an optimum sensitivity before starting measurement. If it is difficult, adjust the sensitivity with the probe angle set to 0°, and after measurement, correct the measured values according to the actual probe angle (by multiplying the measured value by a correction factor).

Tips Correction using a correction factor may result in lower accuracy than when adjusting sensitivity with the actual probe angle.



Angle: θ	Distance from the workpiece surface: L *	Correction factor
0°	—	1.00
10°	Approx. 3.1 mm	Approx. 0.98
20°	Approx. 8.8 mm	Approx. 0.94
30°	Approx. 13.9 mm	Approx. 0.87
40°	Approx. 18.3 mm	Approx. 0.77
50°	Approx. 21.6 mm	Approx. 0.64
60°	Approx. 23.8 mm	Approx. 0.50

* Value when using a carbide probe with spherical diameter of ø2 that is installed before shipment. When using a ø1 (or ø3) carbide probe, subtract (or add) 1/2 of the difference in spherical diameter.

LSM-500S Measuring Unit
SERIES 544 — 5 µm to 2 mm Measuring Unit

- Capable of measuring down to 5 µm outside diameter.
- Provides ultra-high accuracy of ±0.3 µm over the entire measuring range (5 µm to 2 mm).

With signal cable (5 m)
02AGN770A

SPECIFICATIONS

Order No.		**544-531**	**544-532**
Model		**LSM-500S**	
Applicable laser standards		JIS	IEC, FDA
User's Manual		Japanese version	English version
Measuring range		0.005 to 2 mm*1	
Resolution		0.01 to 10 µm (selectable)	
Repeatability*2		±0.03 µm	
Linearity*3 (20 °C)		±0.3 µm	
Positional error*4		±0.4 µm	
Measuring region*5		1×2 mm (0.005 to 2 mm)	
Scanning rate		3200 scans/s	
Laser wavelength		650 nm (Visible)	
Laser scanning speed		76 m/s	
Operating environment	Temperature	0 to 40 °C	
	Humidity	RH 35 to 85% (non-condensing)	
Protection Level		IP64*6	

*1 The measuring range for a transparent object is 0.05 mm to 2 mm. Please consult your local Mitutoyo office for objects smaller than 0.05 mm.
The measuring range is 0.1 mm to 2 mm in the 1 to 255 edge measurement mode or when activating automatic workpiece detection.
*2 Determined at the level of ±2σ (σ: standard deviation) when measuring ø2 mm at the interval of 0.32 sec. (average 1024 times).
*3 Applies at the center of the measuring range when measuring outside diameters.
*4 An error in outside diameter measurement due to variation in workpiece position either in the optical axis direction or in the scanning direction.
*5 The area defined by [optical axis depth]×[scanning width].
*6 The protection level provided for the interior. If the workpiece or glass of the measuring unit window is soiled by water or dust, the unit may malfunction.
Note 1: If using the optional dual connection unit for **LSM-6200**, the measuring range will be 0.05 mm to 2 mm.
Note 2: When using the extra-fine line measurement function (FINE), guide messages for setting the following will not be displayed: dual-measurement, segment designation, automatic workpiece detection, and group judgment.

LSM-501S Measuring Unit
SERIES 544 — 50 µm to 10 mm Measuring Unit

- Provides ultra-high accuracy of ±0.5 µm over the entire measuring range (0.05 to 10 mm).
- The industry's first narrow-range accuracy performance in this measuring range of ±(0.3+0.1ΔD) µm is available for high-accuracy measurement.

With signal cable (5 m)
02AGN770A

SPECIFICATIONS

Order No.		**544-533**	**544-534**
Model		**LSM-501S**	
Applicable laser standards		JIS	IEC, FDA
User's Manual		Japanese version	English version
Measuring range		0.05 to 10 mm	
Resolution		0.01 to 10 µm (selectable)	
Repeatability*1		±0.04 µm	
Linearity*2 (20 °C)	Whole range	±0.5 µm	
	Narrow range	±(0.3+0.1ΔD) µm*3	
Positional error*4		±0.5 µm	
Measuring region*5		2×10 mm (0.05 to 0.1 mm) 4×10 mm (0.1 to 10 mm)	
Scanning rate		3200 scans/s	
Laser wavelength		650 nm (Visible)	
Laser scanning speed		113 m/s	
Operating environment	Temperature	0 to 40 °C	
	Humidity	RH 35 to 85% (non-condensing)	
Protection Level		IP64*6	

*1 Determined at the level of ±2σ (σ: standard deviation) when measuring ø10 mm at the interval of 0.32 sec. (average 1024 times).
*2 Applies at the center of the measuring range when measuring outside diameters.
*3 ΔD=Difference in diameter between the master gage and workpiece. (Unit: mm)
*4 An error in outside diameter measurement due to variation in workpiece position either in the optical axis direction or in the scanning direction.
*5 The area defined by [optical axis depth]×[scanning width].
*6 The protection level provided for the interior. If the workpiece or glass of the measuring unit window is soiled by water or dust, the unit may malfunction.

Optional Accessories

• Multifunctional display unit, **LSM-6200**:

Order No.	Display type	Remarks
544-071	Japanese mm/E	Japanese user's manual
544-071*	English mm/E	English user's manual
544-072*	English mm/in	

* To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE."

• Panel-mount type display unit, **LSM-5200**:

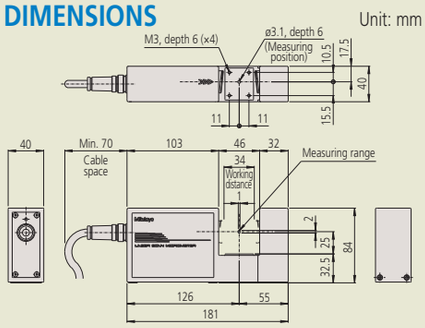
Order No.	Remarks
544-046	Japanese user's manual
544-047	English user's manual

• Standard calibration gage set (ø0.1, ø2.0) : **02AGD110**
• Guide pulley : **02AGD200**
• Air blower : **02AGD220**
• Extension signal cable (max. 15 m)

Order No.	Cable length
02AGN780A	5 m
02AGN780B	10 m
02AGN780C	15 m

DIMENSIONS

Unit: mm



Optional Accessories

• Multifunctional display unit, **LSM-6200**:

Order No.	Display type	Remarks
544-071	Japanese mm/E	Japanese user's manual
544-071*	English mm/E	English user's manual
544-072*	English mm/in	

* To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE."

• Panel-mount type display unit, **LSM-5200**:

Order No.	Remarks
544-046	Japanese user's manual
544-047	English user's manual

• Standard calibration gage set (ø0.1, ø10.0): **02AGD120**
• Wire guiding pulley : **02AGD210**
• Adjustable workstage : **02AGD400**
• Air blower : **02AGD230**
• Workstage : **02AGD270**
• Extension signal cable (max. 15 m)

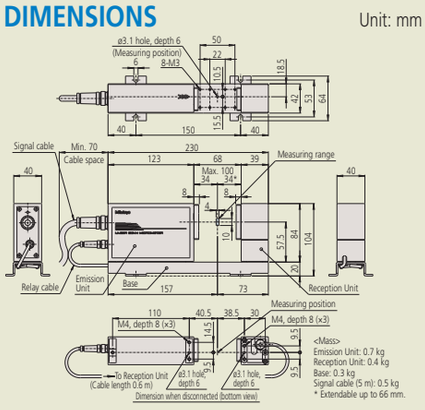
Order No.	Cable length
02AGN780A	5 m
02AGN780B	10 m
02AGN780C	15 m

• Extension relay cable

Order No.	Cable length
02AGC150A	1 m

DIMENSIONS

Unit: mm



Optional Accessories

• Multifunctional display unit, **LSM-6200**:

Order No.	Display type	Remarks
544-071	Japanese mm/E	Japanese user's manual
544-071*	English mm/E	English user's manual
544-072*	English mm/in	

* To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE."

• Panel-mount type display unit, **LSM-5200**:

Order No.	Remarks
544-046	Japanese user's manual
544-047	English user's manual

• Standard calibration gage set (ø1.0, ø30.0) : **02AGD130**
• Adjustable workstage : **02AGD490**
• Air blower : **02AGD240**
• Workstage : **02AGD270**
• Extension signal cable (max. 25 m)

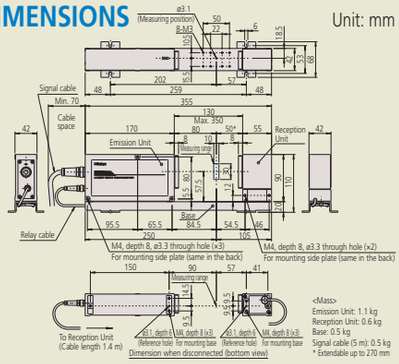
Order No.	Cable length
02AGN780A	5 m
02AGN780B	10 m
02AGN780C	15 m
02AGN780D	20 m

• Extension relay cable (max. 5 m)

02AGC150A	1 m
02AGC150B	3 m
02AGC150C	5 m

DIMENSIONS

Unit: mm



Optional Accessories

• Multifunctional display unit, **LSM-6200**:

Order No.	Display type	Remarks
544-071	Japanese mm/E	Japanese user's manual
544-071*	English mm/E	English user's manual
544-072*	English mm/in	

* To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE. "

• Panel-mount type display unit, **LSM-5200**:

Order No.	Remarks
544-046	Japanese user's manual
544-047	English user's manual

• Standard calibration gage set (ø0.1, ø60.0) : **02AGD140**
• Adjustable workstage : **02AGD520**
• Air blower : **02AGD250**
• Extension signal cable (max. 25 m)

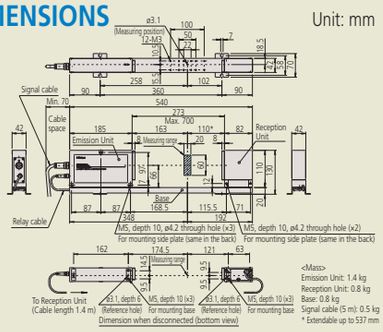
Order No.	Cable length
02AGN780A	5 m
02AGN780B	10 m
02AGN780C	15 m
02AGN780D	20 m

• Extension relay cable (max. 5 m)

02AGC150A	1 m
02AGC150B	3 m
02AGC150C	5 m

DIMENSIONS

Unit: mm



LSM-503S Measuring Unit
SERIES 544 — 0.3 mm to 30 mm Measuring Unit

• Ensures ±1.0 µm accuracy over the entire measuring range (0.3 to 30 mm).
• The industry's first narrow-range accuracy performance in this measuring range of ±(0.6+0.1ΔD) µm is available for high-accuracy measurement.

With signal cable (5 m)
02AGN770A

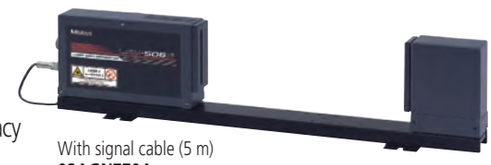
SPECIFICATIONS

Order No.		**544-535**	**544-536**
Model		**LSM-503S**	
Applicable laser standards		JIS	IEC, FDA
User's Manual		Japanese version	English version
Measuring range		0.3 to 30 mm	
Resolution		0.02 to 100 µm (selectable)	
Repeatability*1		±0.11 µm	
Linearity*2 (20 °C)	Whole range	±1.0 µm	
	Narrow range	±(0.6+0.1ΔD) µm*3	
Positional error*4		±1.5 µm	
Measuring region*5		10×30 mm (0.3 to 30 mm)	
Scanning rate		3200 scans/s	
Laser wavelength		650 nm (Visible)	
Laser scanning speed		226 m/s	
Operating environment	Temperature	0 to 40 °C	
	Humidity	RH 35 to 85% (non-condensing)	
Protection Level		IP64*6	

*1 Determined at the level of ±2σ (σ: standard deviation) when measuring ø30 mm at the interval of 0.32 sec. (average 1024 times).
*2 Applies at the center of the measuring range when measuring outside diameters.
*3 ΔD=Difference in diameter between the master gage and workpiece (Unit: mm)
*4 An error in outside diameter measurement due to variation in workpiece position either in the optical axis direction or in the scanning direction.
*5 The area defined by [optical axis depth]×[scanning width].
*6 The protection level provided for the interior. If the workpiece or glass of the measuring unit window is soiled by water or dust, the unit may malfunction.

LSM-506S Measuring Unit
SERIES 544 — 1 mm to 60 mm Measuring Unit

• Ensures ±3 µm accuracy over the entire measuring range (1 to 60 mm).
• The industry's first narrow-range accuracy performance in this measuring range of ±(1.5+0.5ΔD) µm is available for high-accuracy measurement.



With signal cable (5 m)
02AGN770A

SPECIFICATIONS

Order No.		**544-537**	**544-538**
Model		**LSM-506S**	
Applicable laser standards		JIS	IEC, FDA
User's Manual		Japanese version	English version
Measuring range		1 to 60 mm	
Resolution		0.05 to 100 µm (selectable)	
Repeatability*1		±0.36 µm	
Linearity*2 (20 °C)	Whole range	±3 µm	
	Narrow range	±(1.5+0.5ΔD) µm*3	
Positional error*4		±4 µm	
Measuring region*5		20×60 mm (1 to 60 mm)	
Scanning rate		3200 scans/s	
Laser wavelength		650 nm (Visible)	
Laser scanning speed		452 m/s	
Operating environment	Temperature	0 to 40 °C	
	Humidity	RH 35 to 85% (non-condensing)	
Protection Level		IP64*6	

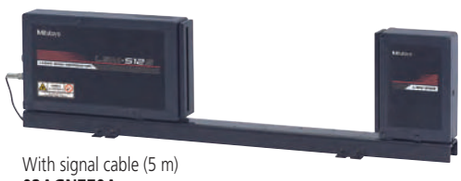
*1 Determined at the level of ±2σ (σ: standard deviation) when measuring ø60 mm at the interval of 0.32 sec. (average 1024 times).
*2 Applies at the center of the measuring range when measuring outside diameters.
*3 ΔD=Difference in diameter between the master gage and workpiece (Unit: mm)
*4 An error in outside diameter measurement due to variation in workpiece position either in the optical axis direction or in the scanning direction.
*5 The area defined by [optical axis depth]×[scanning width].
*6 The protection level provided for the interior. If the workpiece or glass of the measuring unit window is soiled by water or dust, the unit may malfunction.

G

Mitutoyo

LSM-512S Measuring Unit
SERIES 544 — 1 mm to 120 mm Measuring Unit

- Ensures ±6 µm accuracy over the entire measuring range (1 to 120 mm).
- The industry's first narrow-range accuracy performance in this measuring range of ±(4.0+0.5ΔD) µm is available for high-accuracy measurement.



With signal cable (5 m)
02AGN770A

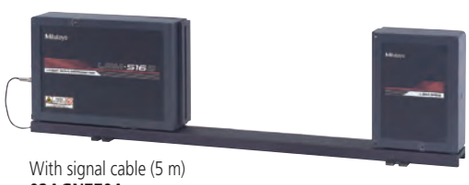
SPECIFICATIONS

Order No.		544-539	544-540
Model		LSM-512S	
Applicable laser standards		JIS	IEC, FDA
User's Manual		Japanese version	English version
Measuring range		1 to 120 mm	
Resolution		0.1 to 100 µm (selectable)	
Repeatability*1		±0.85 µm	
Linearity*2 (20 °C)	Whole range	±6 µm	
	Narrow range	±(4.0+0.5ΔD) µm*3	
Positional error*4		±8 µm	
Measuring region*5		30×120 mm (1 to 120 mm)	
Scanning rate		3200 scans/s	
Laser wavelength		650 nm (Visible)	
Laser scanning speed		904 m/s	
Operating environment	Temperature	0 to 40 °C	
	Humidity	RH 35 to 85% (non-condensing)	
Protection Level		IP64*6	

*1 Determined at the level of ±2σ (σ: standard deviation) when measuring ø120 mm at the interval of 0.32 sec. (average 1024 times).
*2 Applies at the center of the measuring range when measuring outside diameters.
*3 ΔD=Difference in diameter between the master gage and workpiece (Unit: mm)
*4 An error in outside diameter measurement due to variation in workpiece position either in the optical axis direction or in the scanning direction.
*5 The area defined by (optical axis depth)×(scanning width).
*6 The protection level provided for the interior. If the workpiece or glass of the measuring unit window is soiled by water or dust, the unit may malfunction.

LSM-516S Measuring Unit
SERIES 544 — 1 mm to 160 mm Measuring Unit

- Ensures ±7 µm accuracy over the entire measuring range (1 to 160 mm).
- The industry's first narrow-range accuracy performance in this measuring range of ±(4.0+2.0ΔD) µm is available for high-accuracy measurement.



With signal cable (5 m)
02AGN770A

SPECIFICATIONS

Order No.		544-541	544-542
Model		LSM-516S	
Applicable laser standards		JIS	IEC, FDA
User's Manual		Japanese version	English version
Measuring range		1 to 160 mm	
Resolution		0.1 to 100 µm (selectable)	
Repeatability*1		±1.4 µm	
Linearity*2 (20 °C)	Whole range	±7 µm	
	Narrow range	±(4.0+2.0ΔD) µm*3	
Positional error*4		±8 µm	
Measuring region*5		40×160 mm (1 to 160 mm)	
Scanning rate		3200 scans/s	
Laser wavelength		650 nm (Visible)	
Laser scanning speed		1206 m/s	
Operating environment	Temperature	0 to 40 °C	
	Humidity	RH 35 to 85% (non-condensing)	
Protection Level		IP64*6	

*1 Determined at the level of ±2σ (σ: standard deviation) when measuring ø160 mm at the interval of 0.32 sec. (average 1024 times).
*2 Applies at the center of the measuring range when measuring outside diameters.
*3 ΔD=Difference in diameter between the master gage and workpiece (Unit: mm)
*4 An error in outside diameter measurement due to variation in workpiece position either in the optical axis direction or in the scanning direction.
*5 The area defined by (optical axis depth)×(scanning width).
*6 The protection level provided for the interior. If the workpiece or glass of the measuring unit window is soiled by water or dust, the unit may malfunction.

Optional Accessories

• Multifunctional display unit, **LSM-6200**:

Order No.	Display type	Remarks
544-071	Japanese mm/E	Japanese user's manual
544-071*	English mm/E	English user's manual
544-072*	English mm/in	

* To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE."

• Panel-mount type display unit, **LSM-5200**:

Order No.	Remarks
544-046	Japanese user's manual
544-047	English user's manual

• Standard calibration gage set (ø20.0, ø120.0): **02AGD150**
• Air blower : **02AGD260**
• Extension signal cable (max. 25 m)

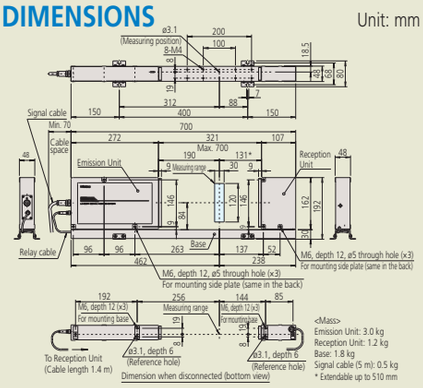
Order No.	Cable length
02AGN780A	5 m
02AGN780B	10 m
02AGN780C	15 m
02AGN780D	20 m

• Extension relay cable (max. 5 m)

02AGC150A	1 m
02AGC150B	3 m
02AGC150C	5 m

DIMENSIONS

Unit: mm



Optional Accessories

• Multifunctional display unit, **LSM-6200**:

Order No.	Display type	Remarks
544-071	Japanese mm/E	Japanese user's manual
544-071*	English mm/E	English user's manual
544-072*	English mm/in	

* To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE."

• Panel-mount type display unit, **LSM-5200**:

Order No.	Remarks
544-046	Japanese user's manual
544-047	English user's manual

• Standard calibration gage set (ø20.0, ø160.0): **02AGM300**
• Extension signal cable (max. 25 m)

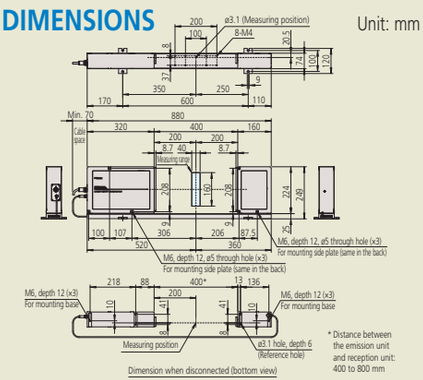
Order No.	Cable length
02AGN780A	5 m
02AGN780B	10 m
02AGN780C	15 m
02AGN780D	20 m

• Extension relay cable (max. 5 m)

02AGC150A	1 m
02AGC150B	3 m
02AGC150C	5 m

DIMENSIONS

Unit: mm



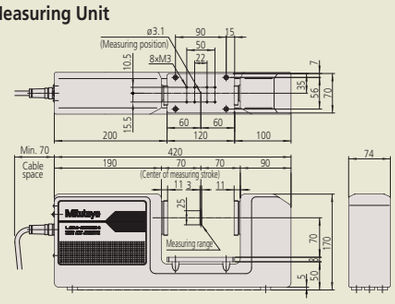
Optional Accessories

- Standard calibration gage set (ø1.0, ø25.0) : **02AGD180**
- Workstage : **02AGD270**
- Adjustable workstage : **02AGD280**

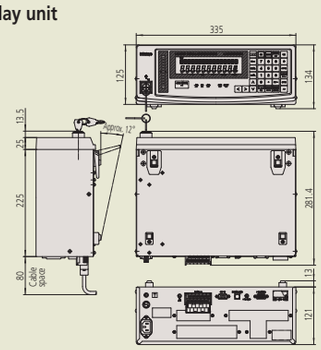
External Dimensions

Unit: mm

Measuring Unit



Display unit

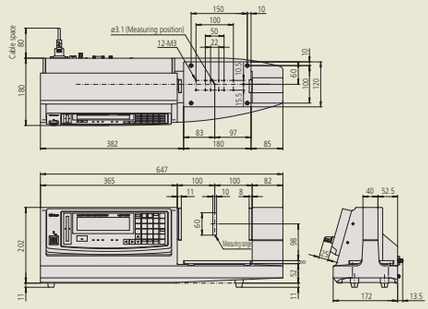


Optional Accessories

- Standard calibration gage set (ø1.0, ø60.0): **02AGD170**
- Adjustable workstage
  Horizontal stroke 200 mm : **02AGD370**
  Horizontal stroke 300 mm : **02AGD680**

DIMENSIONS

Unit: mm



LSM-6902H Measuring Unit and 6900 Display
SERIES 544 — 0.1 mm to 25 mm High Accuracy

- Demonstrates the best repeatability available in the 25 mm class.
- The ultra-precise scanning motor enables the highest measurement accuracy to be realized.
- Thanks to excellent linearity, an accuracy of ±0.5 µm over the entire measuring range and a higher accuracy of ±(0.3+0.1ΔD) µm over a narrow range are guaranteed.
- The optimal solution for measuring the outside diameter of pin gages or plug gages.

LSM-6902H

SPECIFICATIONS

Set Order No.		**544-497-1**	**544-498-1***6	**544-499-1***6
Model		**LSM-6902H**		
Measuring unit				
Type		mm	mm	inch/mm
Applicable standards		JIS	IEC, FDA	
Measuring range		0.1 to 25 mm (0.004 to 1.0 in)		
Resolution		0.01 to 10 µm (selectable) (0.000001 to 0.0005 in)		
Repeatability*1	Whole range	±0.045 µm (±0.0000018 in) (ø25 mm)		
	Narrow range	±0.03 µm (±0.0000012 in) (ø10 mm)		
Linearity*2 (20 °C)	Whole range	±0.5 µm (±0.000020 in)		
	Narrow range	±(0.3+0.1ΔD) µm ±(0.000012+0.01ΔD) inch*5		
Positional error*3		±0.5 µm (±0.000020 in)		
Measuring region*4		±1.5 mm×25 mm (±0.006×1.0 in)		
Scanning rate		3200 scans/s		
Laser wavelength		650 nm (Visible)		
Laser scanning speed		226 m/s		
Operating environment	Temperature	0 to 40 °C		
	Humidity	RH 35 to 85% (non-condensing)		

*1 ±2σ values (σ being the standard deviation) for when ø25 mm and ø10 mm samples are measured for 1.28 seconds (2048 scans on average, 2 samples).
*2 The value at the center of the measuring range.
*3 An error in outside diameter measurement due to variation in workpiece position either in the optical axis direction or in the scanning direction.
*4 The region defined by [optical axis depth]×[scanning width].
*5 ΔD=Difference in diameter between the master gage and workpiece (Unit: mm).
*6 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE.

Display unit

Display	16-digit plus 11-digit fluorescent display, and guide message LED
Segment	1 to 7 (1 to 3, transparent) or 1 to 255 edges
Averaging times	Arithmetic average: 2 to 2048 scans. Moving average: 32 to 2048 scans.
Judgment	Selection from "target value + tolerance", "lower tolerance + upper tolerance", or "7 classes multilimit tolerance zone".
Measurement mode	Standby, Single measurement, Continuous measurement
External dimensions	335 (W) ×134 (H) ×250 (D) mm
Power supply	100 to 240 VAC ±10% 30 W 50/60 Hz
Standard I/F	RS-232C, Analog I/O
Optional I/F	Digimatic code output unit (2-ch), 2nd I/O analog I/F, BCD I/F
Operating environment	0 to 40 °C, RH 35 to 85% (non-condensing)
Others	Nominal setting, sample setting, suppression of unnecessary digits, transparent object measurement, automatic measurement in edge mode, output timer, abnormal data elimination, SHL change, group judgment, simultaneous measurement, statistical processing, mastering, buzzer function, automatic workpiece detection (dimension/position), zero-set/offset Note: In the case of dual measuring-unit connection, extra-fine line measurement and some of the communication commands are not available

LSM-9506 Integrated Display/Measuring Unit
SERIES 544 — 0.5 mm to 60 mm High Accuracy

- High accuracy of ±2.5 µm, integrated display unit with many functions equivalent to the multi-function display unit. (Some functions may be unavailable.)

SPECIFICATIONS

Order No.		**544-115***5	**544-116***6
Model		**LSM-9506**	
Type		mm	inch/mm
Measuring range		0.5 to 60 mm	0.02 to 2.36 in/0.5 to 60 mm
Resolution		0.05 to 100 µm (selectable)	0.000002 to 0.005 in/0.00005 to 0.1 mm
Repeatability*1		±0.6 µm (±0.00003 in)	
Linearity*2 (20 °C)		±2.5 µm (±0.0001 in)	
Positional error*3	Optical axis direction	±2.5 µm (±0.0001 in)	
	Scanning direction	± (2.0+L/10) µm L: Displacement between workpiece center and optical axis center	
Measuring region*3		±5×60 mm (±0.2×2.36 in)	
Scanning rate		1600 scans/s	
Laser wavelength		650 nm (Visible)*4	
Laser scanning speed		226 m/s (8900 in/s)	
Display unit		16-digit dot matrix (upper column) +7 segment 11-digit (lower column), guidance LEDs	
Standard interface		RS-232C, Digimatic code output unit (1-ch)	
Optional interface		No	
Power supply		AC100 V to 240 V±10%, 25 W, 50/60 Hz	
Operating environment		0 to 40 °C, RH 35 to 85% (non-condensing)	

*1 Determined at the level of ±2σ (σ: standard deviation) when measuring ø60 mm in the interval of 0.32 sec. (average 512 times).
*2 Applies at the center of the measuring range when measuring outside diameters.
*3 An error in outside diameter measurement due to variation in workpiece position either in the optical axis direction or in the scanning direction.
*4 FDA Class II (**544-116-1A**)/IEC Class 2 (All models except **544-116-1A**) semiconductor laser for scanning (Maximum power: 1.0 mW)
*5 To denote your AC power cable add the following suffixes to the order No.: D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE.
*6 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC and No suffix are required for PSE.

LSM-5200 Display Unit
SERIES 544 — Panel-mount Type

- A compact controller which could be used for multi-unit system configurations.
- A panel-mount type display unit designed for the **LSM-S** Series.
- Analog I/O and RS-232C is standard.

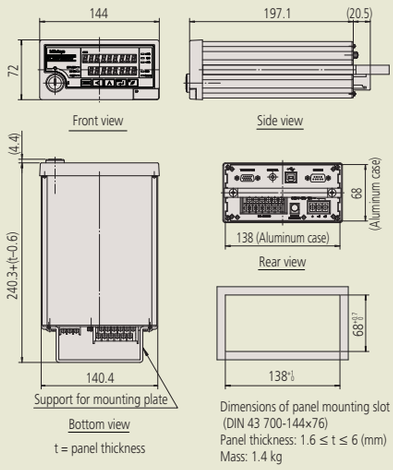
SPECIFICATIONS

Order No.	**544-047**
Model	**LSM-5200**
Display	9-digit (upper) and 8-digit (lower) 7-segment
Segment	1 to 7 (1 to 3, transparent) or 1 to 255 edges*1
Averaging method	Arithmetic average: from 4 to 2048; Moving average: from 32 to 2048 (Arithmetic average is from 16 to 2048 when using **LSM-500S**.)
Judgment	Selecting from "target value±tolerance value" or "lower limit/upper limit".
Measurement mode	Standby, Single measurement, Continuous measurement
Statistical analysis	Calculation result is output via USB or RS-232C.
External dimensions	144 (W) ×72 (H) ×197.1 (D) mm
Power supply	24 V DC±10%, 1.3 A or more
Standard I/F	USB2.0, RS-232C, I/O analog
Operating temperature (humidity) ranges	0 to 40 °C, RH 35 to 85% (non-condensing)
Storage temperature (humidity) ranges	–20 to 70 °C, RH 35 to 85% (non-condensing)
Other functions	Measurement of odd fluted parts, simultaneous measurement, nominal setting, sample setting, selection of unnecessary digits, transparent object measurement*2 Automatic workpiece detection (dimension/position detected)*1, abnormal data elimination, mastering, statistical processing (when using USB, RS-232C), output timer, automatic measurement in edge mode, presetting Note that every function is limited in its combination possibilities. See the user manual for details.
Mass	1.4 kg

*1 The measuring range will be 0.1 mm to 2 mm in the 1 to 255 edge measurement mode or when activating the automatic workpiece detection with **544-531**, **544-532**. Each function has its combination limit.
*2 The measuring range is 50 µm to 2 mm when using **544-531**, **544-532**. For smaller ranges, contact your local Mitutoyo sales office.
Note 1: Cannot be connected to **544-495**, **544-496**.
Note 2: Previous models such as **544-451** cannot be connected.
Note 3: For USB communication with a PC, a dedicated device driver is required. For details, contact your local Mitutoyo sales office.

DIMENSIONS

Unit: mm



LSM-6200 Display Unit
SERIES 544 — Multi-function Type

- 2-axis display unit enables 2 items be displayed simultaneously.
- Statistical operation is supported.
- Capable of statistical analysis such as: average, maximum value, minimum value, range (max. to min.).
- Segment measurement (7 points) or edge measurement (1 to 255 edges) can be selected.
- A function to eliminate abnormal values is standard.
- 100 tolerance values, preset values, or settings can be stored.

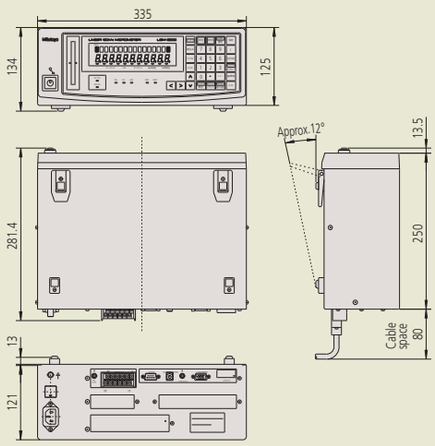
SPECIFICATIONS

Order No.	**544-071**	**544-072**
Model	**LSM-6200**	
Type	mm	inch/mm
Display	16-digit dot matrix (upper) and 11-digit 7-segment (lower)	
Segment	1 to 7 (1 to 3, transparent) or 1 to 255 edges*1	
Averaging times	Arithmetic average: per 2 to 2048/Moving average: per 32 to 2048 (Arithmetic average is per 16 to 2048 when using **544-531**, **544-532**)	
Judgment	Selection from "target value+tolerance", "lower tolerance + upper tolerance", or "7 classes multi-limit tolerance zone".	
Measurement mode	Standby, Single measurement, Continuous measurement	
Statistical analysis	Maximum, Minimum, Average, Dispersion, σ (S.D)	
Size	335 (W) ×134 (H) ×250 (D) mm	
Power supply	100 to 240 V AC ±10%, 45 W, 50/60 Hz	
Standard I/F	RS-232C, Analog I/O	
Optional I/F	Digimatic code output unit (2-ch), 2nd I/O analog I/F, BCD I/F	
Operating environment	0 to +40 °C, RH 35 to 85% (non-condensing)	
Other functions	Nominal setting, sample setting, selection of unnecessary digits, transparent object measurement*2, measurement of odd fluted parts, automatic measurement in edge mode, output timer, abnormal data elimination, SHL change, group judgment, simultaneous measurement, statistical processing, mastering, buzzer function, automatic workpiece detection (dimension/position)*1, zero-set/offset, dual measurement (optional)	

*1 The measuring range will be 0.1 mm to 2 mm in the 1 to 255 edge measurement mode or when activating automatic workpiece detection with **544-531**, **544-532**. Each function has its combination limit.
*2 The measuring range is 50 µm to 2 mm when using **544-531**, **544-532**. For smaller ranges, contact your local Mitutoyo sales office.
Note 1: To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, F for SAA, K for KC, C and No suffix are required for PSE.
Note 2: Cannot be connected to **544-495**, **544-496**.
Note 3: Previous models such as **544-451** cannot be connected.

DIMENSIONS

Unit: mm



Optional Accessories
SERIES 544 — Laser Scan Micrometer (Measuring Unit)

Standard calibration gage set

- Standard gage set suitable for calibration of Laser Scan Micrometers.
- Nominal gage diameters (1 to 160 mm) are as given in Specifications.

SPECIFICATIONS

For calibrating models		LSM-6902H	LSM-500S	LSM-501S	LSM-503S	LSM-506S	LSM-512S	LSM-516S	LSM-9506
Set No.		02AGD180	02AGD110	02AGD120	02AGD130	02AGD140	02AGD150	02AGM300	02AGD170
Configuration (Order No.)	Stand	02AGD181	02AGD111	02AGD121	02AGD131	02AGD141	02AGD151	02AGM320	02AGD171
	Gages	ø1: 02AGD920 ø25: 02AGD963	ø0.1: 958200 ø2 : 958202	ø0.1: 958200 ø10: 229317	ø1: 02AGD920 ø30: 02AGD961	ø1: 02AGD920 ø60: 02AGD962	ø20: 229730 ø120: 234072	ø20: 229730 ø160: 02AGM303	ø1: 02AGD920 ø60: 02AGD962
	Carrying case	02AGD190	958203	958203	02AGD980	02AGD980	02AGD990	02AGM310	02AGD970

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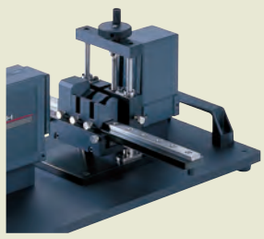
Workstage

- Easy set-up and height adjustment enables high-precision measurement.

SPECIFICATIONS

Model	LSM-501S LSM-503S LSM-6902H
Order No.	02AGD270

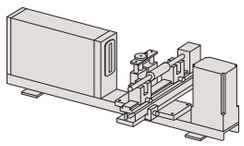


Adjustable workstage

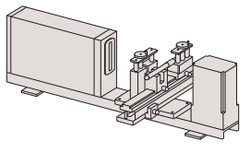
- Vertical/horizontal slide mechanism enables easy measurement of various workpiece diameters.
- Suitable for quality control of high-precision shafts, rollers, pin gages and similar.

Measurement Examples

- Roller of copying machine



- Pin gage or plug gage



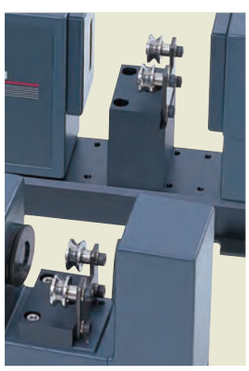
Basic configuration

Basic set	Order No.	Model	Standard Accessories	Measuring range (mm)	Horizontal stroke (mm)	Vertical stroke (mm)
1) Main unit 2) V-block 3) Stop	02AGD280	LSM-6902H	V-block (02AGD420), 2 pcs. Stopper (02AGD430), 1 pc.	0.1 - 25	130	47
	02AGD400	LSM-501S		0.05 - 10	130	32
	02AGD490	LSM-503S		0.3 - 30	200	35
	02AGD520	LSM-506S*	V-block A (02AGD550), 2 pcs.	1 - 60	300	45
	02AGD370	LSM-9506*	V-block B (02AGD560), 1 pc.	0.5 - 60	200	45
	02AGD680		V-block C (02AGD570), 1 pc.	0.5 - 60	300	45

* The stop is not included in the basic set for these models.
Note: Optional part for the adjustable workstage, such as center support, adjustable V-block (up/down) etc., are available.

Guide pulley

- Used for supporting measurement of outside diameter of fine wirelike materials such as magnetic wire or fiber.



SPECIFICATIONS

Model	LSM-500S	LSM-501S
Order No.	02AGD200	02AGD210

Note 1: Each measurement range is as follows:
LSM-500S: ø5 µm to ø1.6 mm
LSM-501S: ø50 µm to ø2 mm

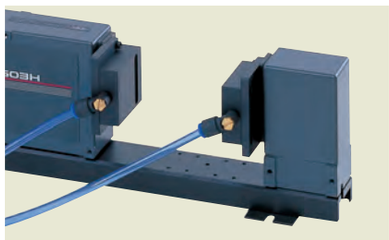
Note 2: For calibration, the calibration gage set for **LSM-500S** (**02AGD110**) is required.

Mitutoyo

Optional Accessories
SERIES 544 — Laser Scan Micrometer (Measuring Unit)

Air shield

- Air blows from the air outlet installed on the laser section to clear dust adhering to the laser window.



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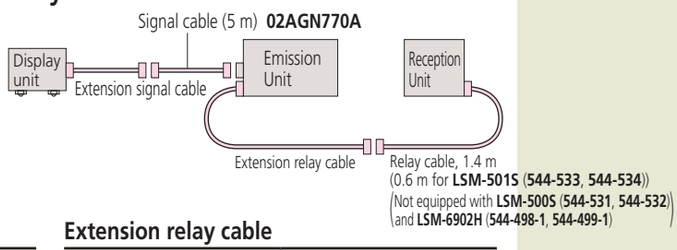
SPECIFICATIONS

Air supply unit	Air shield	Applicable models
957608	**02AGD220**	**LSM-500S** (**544-531**, **544-532**)
	02AGD230	**LSM-501S** (**544-533**, **544-534**)
	02AGD240	**LSM-503S** (**544-535**, **544-536**)
	02AGD250	**LSM-506S** (**544-537**, **544-538**)
	02AGD260	**LSM-512S** (**544-539**, **544-540**)

Note: Air shield is supplied with 5 m air tube (Outside Diameter: 6 mm).

Extension signal cable / Extension relay cable

- Extension signal cables are necessary when the measuring unit and display unit are separated in operation; Extension relay cables are necessary when the optical section is separated in operation.



SPECIFICATIONS

Extension signal cable

Order No.	Cable length
02AGN780A	5 m
02AGN780B	10 m
02AGN780C	15 m
02AGN780D	20 m

Extension relay cable

Order No.	Cable length
02AGC150A	1 m
02AGC150B	3 m
02AGC150C	5 m

Note 1: For **544-531**, **544-532**, **544-533**, **544-534**, the overall length of the signal cable and the extension signal cable is 20 m at a maximum.
Note 2: For **544-535**, **544-536**, **544-537**, **544-538**, **544-539**, **544-540**, **544-541**, **544-542** the overall length of the signal cable and the extension signal cable is 30 m at a maximum.
Note 3: The length of the relay extension cable is 5 m at a maximum.
Note 4: The maximum extension length of the signal cable and relay cable is 32 m in total.
Note 5: Cannot be used with **544-498-1** and **544-499-1**.

Optional Accessories
SERIES 544 — Laser Scan Micrometer (Display Unit)

Foot switch

- For **LSM-6200** (**544-071**, **544-072**), **LSM-6902H** (**544-498-1**, **544-499-1**) and **LSM-9506** (**544-115**, **544-116**).

937179T

Optional Accessories
Interface for LSM6200, 6902H

BCD Interface

- Outputs measurement data in BCD output (7-digit) or HEX output.
- Data logic can be switched.
- Isolated I/O circuitry
- Available for **LSM-6200** (**544-071**, **544-072**) and **LSM-6902H** (**544-498-1**, **544-499-1**).

SPECIFICATIONS

Order No.	**02AGC910**
Standard Accessories	Connector (DDK) **57-30360** (**214188**)

Optional Accessories
SERIES 544 — Laser Scan Micrometer (Display Unit)

Digimatic code output unit

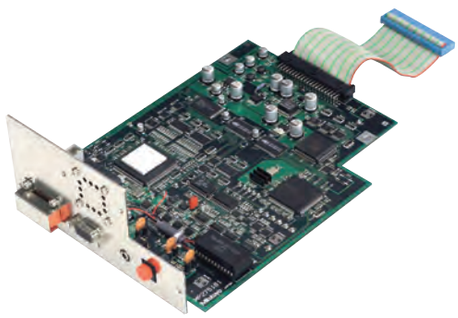
- 2-channel Digimatic code output
- In simultaneous measurement, measurement data are output as follows:
  Program No. 0 to No. 4 in OUTPUT-1
  Program No. 5 to No. 9 in OUTPUT-2
  (10 programs operated)
- 10 pin MIL type connector.
- Output cable is not supplied.
  Connecting cable (optional) 1 m (**936937**)
- Available for **LSM-6200** (**544-071**, **544-072**) and **LSM-6902H** (**544-498-1**, **544-499-1**).

Note 1: Output is 6 digits of measurement data.
Note 2: Displaying 6th and 7th digit after the decimal point is not supported.

SPECIFICATIONS

Order No.	**02AGC840**

Dual connection unit



- Enables second unit connection to **LSM-6200** (**544-071**, **544-072**). (both units must be the same model)

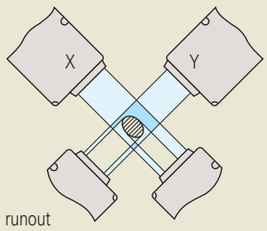
Note: Cannot be used for **LSM-6902H** (**544-498-1**, **544-499-1**).

- Depending on the layout of the two measuring units, large-diameter measurement, XY measurement, and parallel measurement are possible.
- Both of the measuring units and display units can be simultaneously operated.

SPECIFICATIONS

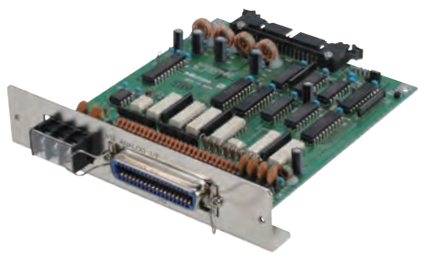
Order No.	**02AGP150**

XY Measurement



(X–Y): runout
(X+Y)/2: average
Note: XY requires 10 mm-interval.

2nd I/O analog I/F

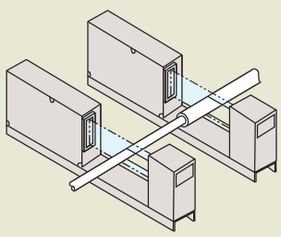


- I/O, analog output.
- Simultaneous measurement is supported by two pairs of GO/NG judgment outputs.
- Available for **LSM-6200** (**544-071**, **544-072**) and **LSM-6902H** (**544-498-1**, **544-499-1**).

SPECIFICATIONS

Order No.	**02AGC880**
Standard Accessories	Connector (DDK) **57-30360** (**214188**)

Parallel Measurement



Cable for BCD and 2nd I/O simultaneous mount

- Both BCD (**02AGC910**) and 2nd I/O analog I/F (**02AGC880**) can be mounted on **LSM-6200** (**544-071**, **544-072**) and **LSM-6902H** (**544-498-1**, **544-499-1**) using this cable.

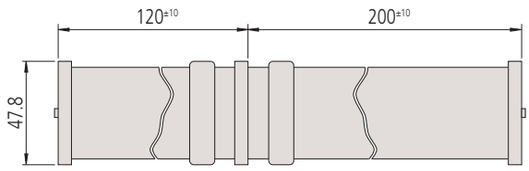
Note: If using this cable, the dual connection unit (**02AGP150**) cannot be used.

SPECIFICATIONS

Order No.	**02AGE060**

DIMENSIONS

Unit: mm



Compatibility

Your Laser Scan Micrometer has been adjusted together with the ID Unit, which is supplied with the measuring unit. The ID Unit, which has the same code number and the same serial number as the measuring unit, must be installed in the display unit. This means that if the ID Unit is replaced the measuring unit can be connected to another corresponding display unit.

The workpiece and measuring conditions

Depending on whether the laser is visible or invisible, the workpiece shape, and the surface roughness, measurement errors may result. If this is the case, perform calibration with a master workpiece which has dimensions, shape, and surface roughness similar to the actual workpiece to be measured.
If measurement values show a large degree of dispersion due to the measuring conditions, increase the number of scans for averaging to improve the measurement accuracy.

Electrical interference

To avoid operational errors, do not route the signal cable and relay cable of the Laser Scan Micrometer alongside a high voltage line or other cables capable of inducing noise current in nearby conductors. Ground all appropriate units and cable shields.

Connection to a computer

If the Laser Scan Micrometer is to be connected to an external personal computer via the RS-232C interface, ensure that the cable connections conform to the specification.

Laser safety

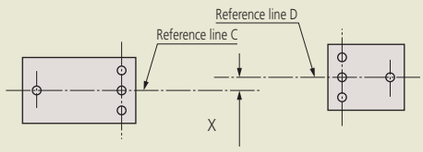
Mitutoyo Laser Scan Micrometers use a low-power visible laser for measurement. The laser is a CLASS 2 EN/IEC60825-1 device.
Warning and explanation labels, as shown below, are attached to the Laser Scan Micrometers as is appropriate.

Re-assembly after removal from the base

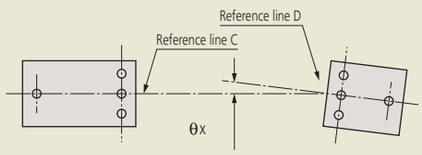
Observe the following limits when re-assembling the emission unit and reception unit to minimize measurement errors due to misalignment of the laser's optical axis with the reception unit.

• Alignment within the horizontal plane

a. Parallel deviation between reference lines C and D: X (in the transverse direction)

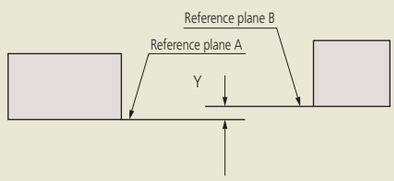


b. Angle between reference lines C and D: θx (angle)

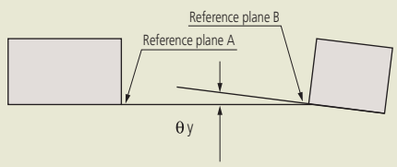


• Alignment within the vertical plane

c. Parallel deviation between reference planes A and B: Y (in height)



d. Angle between reference planes A and B: θy (angle)

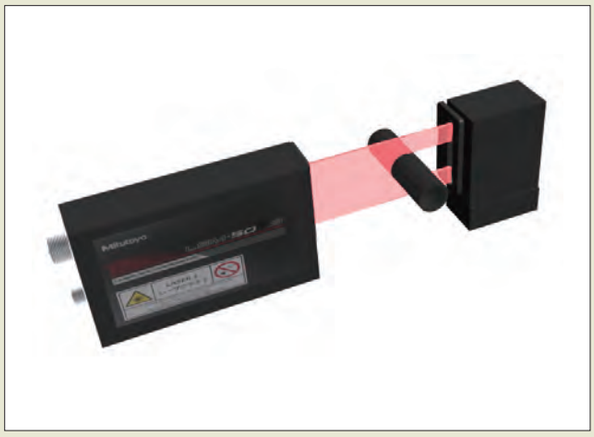


• Allowable limits of optical axis misalignment

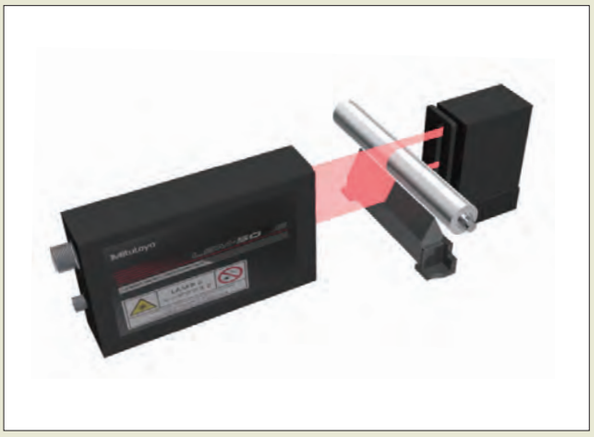
Model	Distance between Emission Unit and Reception Unit	X and Y	θx and θy
LSM-501S	68 mm (2.68 in) or less	within 0.5 mm (0.02 in)	within 0.4° (7 mrad)
	100 mm (3.94 in) or less	within 0.5 mm (0.02 in)	within 0.3° (5.2 mrad)
LSM-503S	130 mm (5.12 in) or less	within 1 mm (0.04 in)	within 0.4° (7 mrad)
	350 mm (13.78 in) or less	within 1 mm (0.04 in)	within 0.16° (2.8 mrad)
LSM-506S	273 mm (10.75 in) or less	within 1 mm (0.04 in)	within 0.2° (3.5 mrad)
	700 mm (27.56 in) or less	within 1 mm (0.04 in)	within 0.08° (1.4 mrad)
LSM-512S	321 mm (12.64 in) or less	within 1 mm (0.04 in)	within 0.18° (3.1 mrad)
	700 mm (27.56 in) or less	within 1 mm (0.04 in)	within 0.08° (1.4 mrad)
LSM-516S	800 mm (31.50 in) or less	within 1 mm (0.04 in)	within 0.09° (1.6 mrad)

Measurement Examples

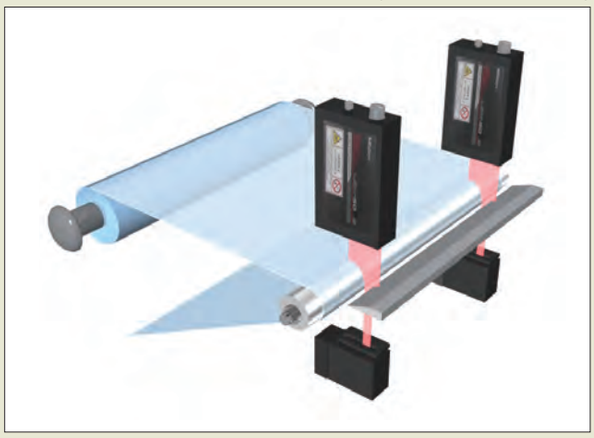
Measurement of outside diameter of rubber roll



Simultaneous measurement of roller outside diameter and deflection

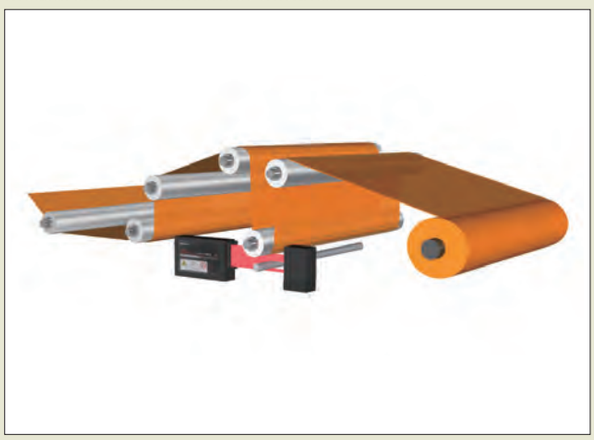


Measurement of uneven thickness of film or sheet (simultaneous measurement)

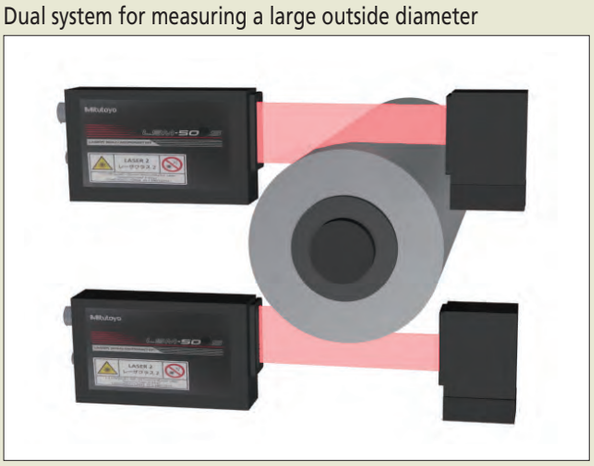


Measurement of gap between rollers

Measurement of film sheet thickness



Dual system for measuring a large outside diameter



ABS AT1300 Series

Assembly Type Scale Unit for Absolute Systems
ABS AT1300 Series

Refer to page H-11 for details.

ABS AT1100 Series

Assembly Type Scale Unit for Absolute Systems
ABS AT1100 Series

Refer to page H-12 for details.

H

Digimatic Scale Units Linear Scales

IP Codes

These are codes that indicate the degree of protection provided (by an enclosure) for the electrical function of a product against the ingress of foreign bodies, dust and water as defined in IEC standards (IEC 60529: 2001) and JIS C 0920: 2003.
(Refer to page IX)

Measuring Instruments Shipped with Inspection Certificate

Mitutoyo guarantees product quality as a leading precision measuring instrument manufacturer and ships measuring instruments with an inspection certificate that includes inspection data so that customers can use them with confidence.

ABSOLUTE™

ABSOLUTE Linear Encoder

Mitutoyo developed the unique absolute method to retain position information after the power is turned off.
The origin is set once - thereafter the live position is displayed when the power is turned on.

INDEX

ABSOLUTE Digimatic Scale Units

Linear Scales

Mitutoyo

SD ABSOLUTE Digimatic Scale Units SERIES 572

Horizontal single-function type (Water-proof type)
572-602 SD-20G

Horizontal single-function type
572-202-30 SD-20AX
572-203-10 SD-30D

Horizontal multi-function type
572-461 SD-15E

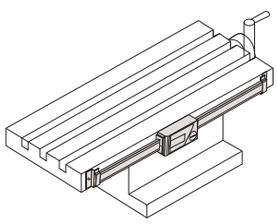
Vertical single-function type
572-303-10 SDV-30D

Vertical multi-function type
572-561 SDV-15E

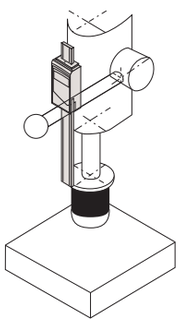
H

Typical applications

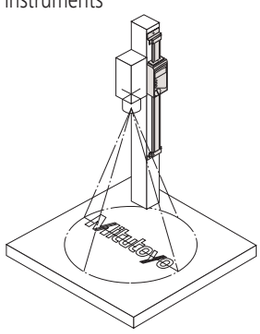
Machine table position



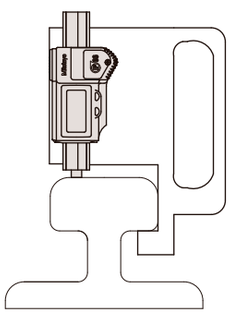
Drilling machine stroke position



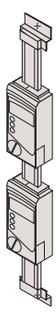
Focus setting on optical instruments



Special applications



As a measurement jig for outdoor use (**SD-G**)



Detector head mechanism

Please contact Mitutoyo for special applications.

IP66 ABSOLUTE™

Applicable models: **SD-G**

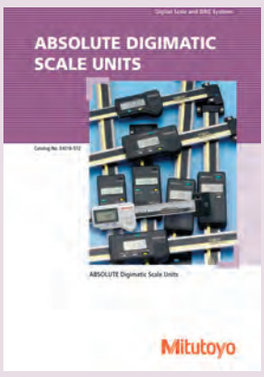
- **SD** Series facilitates mounting on jigs, tools, and small machine tools to enable accurate positioning.
- Built-in absolute scale including the ABS point does not require a zero-set every time the power is turned on. In addition, reliability has improved thanks to elimination of overspeed errors.
- Horizontal or vertical display according to the scale mounting direction.
- The dust resistance and the environmental resistance of the display has improved. The **SD-G** Series offers dust/water protection level IP66.
- Long battery life.
- **EC** counters are available as external display units.
- Equipped with an output port to transfer measurement data, allowing implementation in control systems and gaging systems.

Functions

- ABS (Absolute) measurement function
- INC (Incremental) measurement function
- Zero-setting function
- Presetting function (2 preset values can be set. Not available for **SD-G**, **SD-AX**, **SD-D**, **SDV-D**)
- Double reading function (Available only for **SD-F** or **SDV-F**)
- Direction switch function (Available only for **SD-E**, **SDV-E**)
- Hold function*
- Measurement value composition error alarm
- Low battery alarm
- Output function

* To activate the hold function when using **SD-AX**, **SD-D** or **SDV-D** models, an optional hold unit is required. Simultaneous activation with the output function is not available.

Note: These units use 1.5 V silver oxide cells for the power supply. Therefore, when the units are directly fixed to the frame of a machine tool that requires a high voltage, malfunctions such as display digit fluctuations and errors may occur. Countermeasure examples are described in the user manuals provided.



Refer to the ABSOLUTE DIGIMATIC SCALE UNITS Brochure (**E4316**) for more details.

System Diagram

[Scale units]

Single-function type with high dust / water resistance

SD-G (Horizontal)

*2

Single-function type

SD-AX (Horizontal)

Note 1: **SD-30D** for the measuring range of 300 mm.

SDV-D (Vertical)

Multi-function type

SD-E (Horizontal)

SDV-E (Vertical)

Multi-function type

SD-F (Horizontal)

SDV-F (Vertical)

[Display units]

EC Counter*3

Refer to page G-11 for details.

→ Tolerance judgment output*1

*3

Digimatic mini-processor
DP-1VA LOGGER
264-505

Palm-sized printer for printing and statistical analysis

*3

Multiplexer
MUX-10F
264-002

Interface unit for the **RS-232C** conversion and output **RS-232C** output

→ RS-232C output

*3

USB Input Tool Direct
USB-ITN-D
06AFM380D

An interface that easily transfers data to widely used software such as Excel. Slim, with integrated cable.

→ USB keyboard signal conversion

*3

Input Tool (USB keyboard signal conversion model)
IT-020U
264-020

USB Interface unit that converts and transfers data into spreadsheets

→ USB keyboard signal conversion

Note 2: May also be connected to an RS-232C conversion type (**IT-007R**) input tool.

USB Input Tool Direct
USB-ITN-A **06AFM380A**
USB-ITN-C **06AFM380C**
USB-ITN-F **06AFM380F**

→ USB keyboard signal conversion

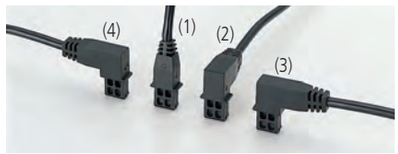
Measurement Data Wireless Communication System
U-WAVE
The data output from the **SD** Series can be sent to the computer by wireless communication without using the **EC** counter. Refer to pages A-9 to A-14 for details.

→ USB keyboard signal conversion

Connecting cable with the water-proof type output switch*2 1 m: **05CZA624** 2 m: **05CZA625**

Connecting cable with the output switch 1 m: **959149** 2 m: **959150**

Connecting cable with the output switch



(1) 1 m: **905338** 2 m: **905409**
(2) 1 m: **905689** 2 m: **905690**
(3) 1 m: **905691** 2 m: **905692**
(4) 1 m: **905693** 2 m: **905694**

Connecting cable 1 m: **936937** 2 m: **965014**

*1 Select the tolerance judgment output or Digimatic output when setting the parameters.
*2 Connecting cable with the water-proof type output switch can be used only for **SD-G** or Water-proof Digital Caliper equipped with the external output function.
*3 Connecting of **SD** Series and **DP-1VA LOGGER**/**MUX-10F**/**IT-020U** is also available without passing through the **EC** counter. In this case, connect these units and **SD** Series with the cables used for connection with the **EC** counter.

H

Mitutoyo

ABSOLUTE Digimatic Scale Units
SERIES 572
SPECIFICATIONS

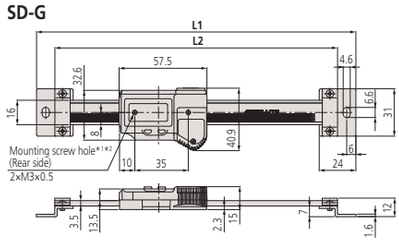
Type	Unit spec.	Order No.	Model	Range	Resolution	Accuracy	Repeatability	Response speed*2	Battery life
Horizontal single-function type (Water-proof type)	Metric	**572-600**	**SD-10G**	100 mm	0.01 mm	0.03 mm	0.01 mm	Unlimited	Approx. 13,000 hours
		572-601	**SD-15G**	150 mm					
		572-602	**SD-20G**	200 mm					
	Metric/Inch	**572-613**	**SD-4" /10G**	100 mm/4 in	0.0005 in/0.01 mm	0.03 mm/0.001 in	0.01 mm/0.0005 in		
		572-614	**SD-6" /15G**	150 mm/6 in					
		572-615	**SD-8" /20G**	200 mm/8 in					
Horizontal single-function type	Metric	**572-200-30**	**SD-10AX**	100 mm	0.01 mm	0.03 mm	0.01 mm		Approx. 18,000 hours
		572-201-30	**SD-15AX**	150 mm					
		572-202-30	**SD-20AX**	200 mm					
		572-203-10	**SD-30D**	300 mm		0.04 mm			Approx. 20,000 hours
	Metric/Inch	**572-210-30**	**SD-4" AX**	100 mm/4 in	0.0005 in/0.01 mm	0.03 mm/0.001 in	0.01 mm/0.0005 in		Approx. 18,000 hours
		572-211-30	**SD-6" AX**	150 mm/6 in					
		572-212-30	**SD-8" AX**	200 mm/8 in					
		572-213-10	**SD-12" D**	300 mm/12 in		0.04 mm/0.002 in			Approx. 20,000 hours
Horizontal multi-function type	Metric	**572-460**	**SD-10E**	100 mm	0.01 mm	0.03 mm	0.01 mm		Approx. 5,000 hours
		572-461	**SD-15E**	150 mm					
		572-462	**SD-20E**	200 mm					
		572-463	**SD-30E**	300 mm		0.04 mm			
		572-464	**SD-45E**	450 mm					
		572-465	**SD-60E**	600 mm		0.05 mm			
		572-466	**SD-80E**	800 mm		0.06 mm			
		572-467	**SD-100E**	1000 mm		0.07 mm			
	Metric/Inch	**572-470**	**SD-4" E**	100 mm/4 in	0.0005 in/0.01 mm	0.03 mm/0.001 in	0.01 mm/0.0005 in		
		572-471	**SD-6" E**	150 mm/6 in					
		572-472	**SD-8" E**	200 mm/8 in					
		572-473	**SD-12" E**	300 mm/12 in		0.04 mm/0.002 in			
		572-474	**SD-18" E**	450 mm/18 in					
		572-475	**SD-24" E**	600 mm/24 in		0.05 mm/0.002 in			
		572-476	**SD-32" E**	800 mm/32 in		0.06 mm/0.0025 in			
		572-477	**SD-40" E**	1000 mm/40 in		0.07 mm/0.003 in			
Horizontal multi-function type (equipped with double reading function)	Metric	**572-480-10***1	**SD-10F**	100 mm	0.01 mm	0.03 mm	0.01 mm (Radius indication, not diameter)		Approx. 5,000 hours
		572-481-10*1	**SD-15F**	150 mm					
		572-482-10*1	**SD-20F**	200 mm					
		572-483-10*1	**SD-30F**	300 mm		0.04 mm			
		572-484-10*1	**SD-45F**	450 mm					
		572-485-10*1	**SD-60F**	600 mm		0.05 mm			
		572-486-10*1	**SD-80F**	800 mm		0.06 mm			
		572-487-10*1	**SD-100F**	1000 mm		0.07 mm			
	Metric/Inch	**572-490-10***1	**SD-4" F**	100 mm/4 in	0.0005 in/0.01 mm	0.03 mm/0.001 in	0.01 mm/0.0005 in (Radius indication, not diameter)		
		572-491-10*1	**SD-6" F**	150 mm/6 in					
		572-492-10*1	**SD-8" F**	200 mm/8 in					
		572-493-10*1	**SD-12" F**	300 mm/12 in		0.04 mm/0.002 in			
		572-494-10*1	**SD-18" F**	450 mm/18 in					
		572-495-10*1	**SD-24" F**	600 mm/24 in		0.05 mm/0.002 in			
		572-496-10*1	**SD-32" F**	800 mm/32 in		0.06 mm/0.0025 in			
		572-497-10*1	**SD-40" F**	1000 mm/40 in		0.07 mm/0.003 in			
Vertical single-function type	Metric	**572-300-10**	**SDV-10D**	100 mm	0.01 mm	0.03 mm	0.01 mm		Approx. 20,000 hours
		572-301-10	**SDV-15D**	150 mm					
		572-302-10	**SDV-20D**	200 mm					
		572-303-10	**SDV-30D**	300 mm		0.04 mm			
	Metric/Inch	**572-310-10**	**SD-4" D**	100 mm/4 in	0.0005 in/0.01 mm	0.03 mm/0.001 in	0.01 mm/0.0005 in		
		572-311-10	**SD-6" D**	150 mm/6 in					
		572-312-10	**SD-8" D**	200 mm/8 in					
		572-313-10	**SD-12" D**	300 mm/12 in		0.04 mm/0.002 in			
Vertical multi-function type	Metric	**572-560**	**SDV-10E**	100 mm	0.01 mm	0.03 mm	0.01 mm		Approx. 5,000 hours
		572-561	**SDV-15E**	150 mm					
		572-562	**SDV-20E**	200 mm					
		572-563	**SDV-30E**	300 mm		0.04 mm			
		572-564	**SDV-45E**	450 mm					
		572-565	**SDV-60E**	600 mm		0.05 mm			
		572-566	**SDV-80E**	800 mm		0.06 mm			
		572-567	**SDV-100E**	1000 mm		0.07 mm			
	Metric/Inch	**572-570**	**SDV-4" E**	100 mm/4 in	0.0005 in/0.01 mm	0.03 mm/0.001 in	0.01 mm/0.0005 in		
		572-571	**SDV-6" E**	150 mm/6 in					
		572-572	**SDV-8" E**	200 mm/8 in					
		572-573	**SDV-12" E**	300 mm/12 in		0.04 mm/0.002 in			
		572-574	**SDV-18" E**	450 mm/18 in					
		572-575	**SDV-24" E**	600 mm/24 in		0.05 mm/0.002 in			
		572-576	**SDV-32" E**	800 mm/32 in		0.06 mm/0.0025 in			
		572-577	**SDV-40" E**	1000 mm/40 in		0.07 mm/0.003 in			
Vertical multi-function type (equipped with double reading function)	Metric	**572-580-10***1	**SDV-10F**	100 mm	0.01 mm	0.03 mm	0.01 mm (Radius indication, not diameter)		Approx. 5,000 hours
		572-581-10*1	**SDV-15F**	150 mm					
		572-582-10*1	**SDV-20F**	200 mm					
		572-583-10*1	**SDV-30F**	300 mm		0.04 mm			
		572-584-10*1	**SDV-45F**	450 mm					
		572-585-10*1	**SDV-60F**	600 mm		0.05 mm			
		572-586-10*1	**SDV-80F**	800 mm		0.06 mm			
		572-587-10*1	**SDV-100F**	1000 mm		0.07 mm			
	Metric/Inch	**572-590-10***1	**SDV-4" F**	100 mm/4 in	0.0005 in/0.01 mm	0.03 mm/0.001 in	0.01 mm/0.0005 in (Radius indication, not diameter)		
		572-591-10*1	**SDV-6" F**	150 mm/6 in					
		572-592-10*1	**SDV-8" F**	200 mm/8 in					
		572-593-10*1	**SDV-12" F**	300 mm/12 in		0.04 mm/0.002 in			
		572-594-10*1	**SDV-18" F**	450 mm/18 in					
		572-595-10*1	**SDV-24" F**	600 mm/24 in		0.05 mm/0.002 in			
		572-596-10*1	**SDV-32" F**	800 mm/32 in		0.06 mm/0.0025 in			
		572-597-10*1	**SDV-40" F**	1000 mm/40 in		0.07 mm/0.003 in			

*1 Available to special order
*2 High slider speed does not cause data errors. Position feedback and output data may not be used while the slider is moving.

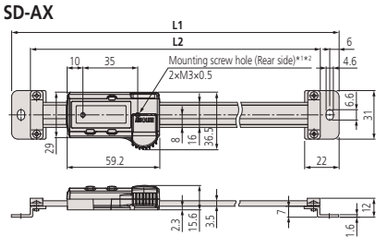
DIMENSIONS

Unit: mm

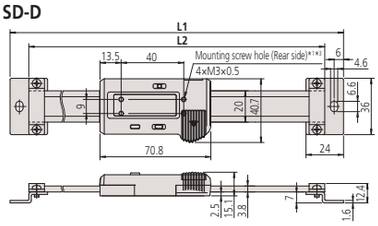
SD-G



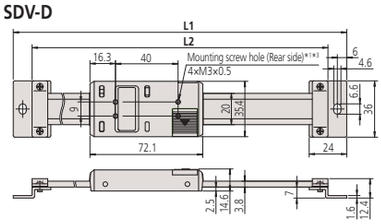
SD-AX



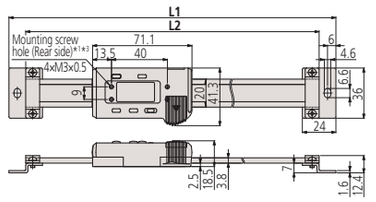
SD-D



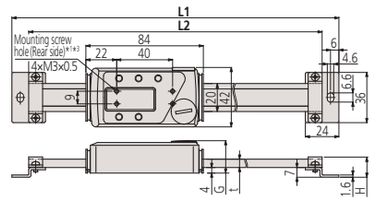
SDV-D



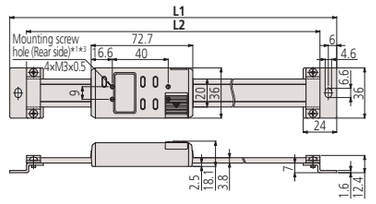
SD-E (to 300 mm)/**SD-F** (to 300 mm)



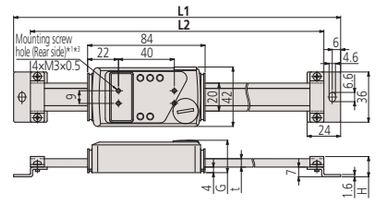
SD-E (450 to 1000 mm)/**SD-F** (450 to 1000 mm)



SDV-E (to 300 mm)/**SDV-F** (to 300 mm)



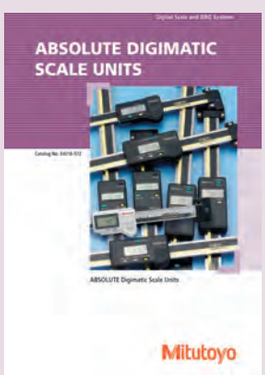
SDV-E (450 to 1000 mm)/**SDV-F** (450 to 1000 mm)



*1 Refer to the dimension table for details of the depth including the screw on the rear of the display.
*2 Mounting screw hole: 2×No.5-40 UNC (Inch type, Inch/Metric switching type)/2×M3×0.5 (Metric type) Screwed depth on the rear side of display unit: under 2 mm
*3 Mounting screw hole: 4×No.5-40 UNC (Inch type, Inch/Metric switching type)/4×M3×0.5 (Metric type) Screwed depth on the rear side of display unit: under 2 mm

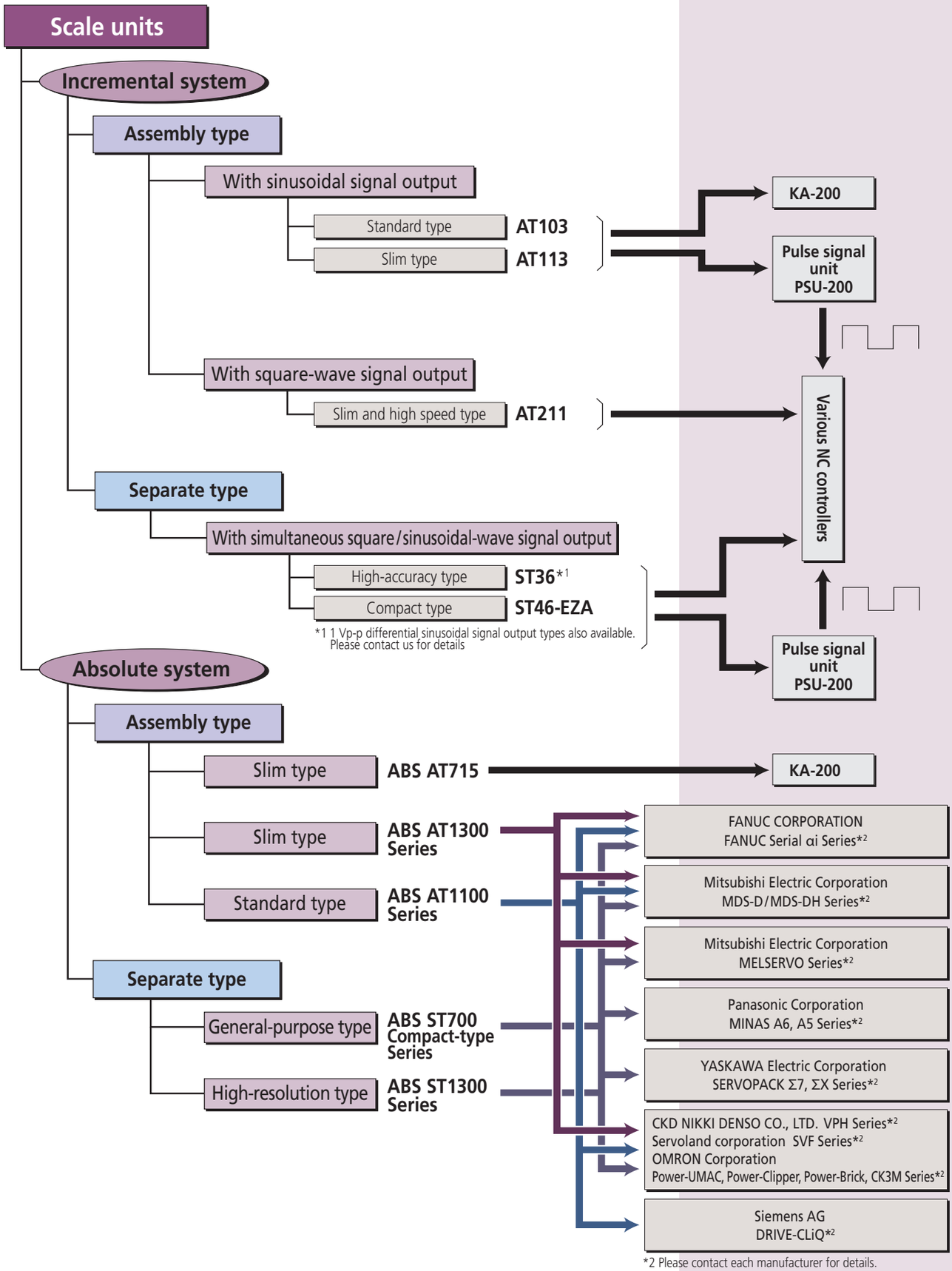
SPECIFICATIONS

Model	Range (mm)	Dimensions (mm)					Depth including the screw on the rear of the display	Mass (g)
		L1	**L2**	t	G	H		
SD-G	100	209	185	—	—	—	Less than 2 mm	390
	150	259	235	—	—	—		410
	200	311	287	—	—	—		430
SD-AX	100	209	185	—	—	—		235
	150	259	235	—	—	—		255
	200	311	287	—	—	—		275
SD-30D	300	444	420	—	—	—		370
SD-E **SD-F**	100	244	220	—	—	—		250
	150	294	270	—	—	—		280
	200	344	320	—	—	—		310
	300	444	420	—	—	—		370
	450	594	570	6	23.2	14.6	Less than 3 mm	760
	600	774	750					900
	800	974	950	10	27.2	18.6		1710
	1000	1174	1150					2040
SDV-D	100	244	220	—	—	—	Less than 2 mm	250
	150	294	270	—	—	—		280
	200	344	320	—	—	—		310
	300	444	420	—	—	—		370
SDV-E **SDV-F**	100	244	220	—	—	—		250
	150	294	270	—	—	—		280
	200	344	320	—	—	—		310
	300	444	420	—	—	—		370
	450	594	570	6	23.2	14.6	Less than 3 mm	760
	600	774	750					900
	800	974	950	10	27.2	18.6		1710
	1000	1174	1150					2040



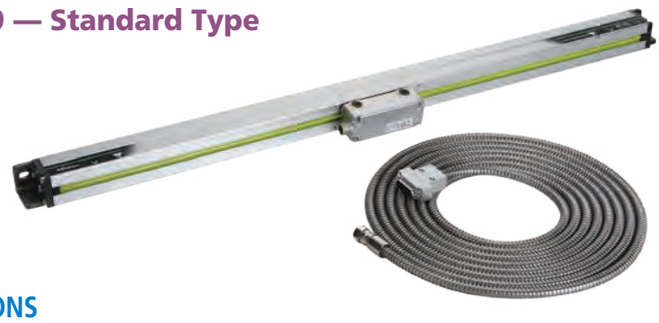
Refer to the ABSOLUTE DIGIMATIC SCALE UNITS Brochure (**E4316**) for more details.

Linear Scale System Diagram



- A wide choice of measuring range is available in this standard type scale unit.
- Connectable to the **KA-200** counter or **PSU-200**.

Linear Scales AT103
SERIES 539 — Standard Type



SPECIFICATIONS

Model	AT103
Effective range	100 to 6000 mm
Accuracy (20 °C)	Effective range 100 to 3000 mm: (5 + 5L0/1000) µm Effective range 3250 to 6000 mm: (5 + 8L0/1000) µm
Output signal	Two 90° phase-shifted sinusoidal signals
Maximum response speed	120 m/min (50 m/min when the effective measuring length is 3250 to 6000 mm)
Signal output pitch	20 µm
Scale reference point	Output in 50 mm pitch
Operating temperature	0 to 45 °C

Note 1: High precision model **AT103F** (JIS Class 0, (3 + 3L0/1000) µm) is also available to special order for the effective range of 100 to 2000 mm.
Note 2: Ultra-high precision model **AT103S** (2 + 2L0/1000) µm is also available to special order for the effective range of 100 to 500 mm.
Note 3: The indication accuracy does not include quantizing error. L0=Effective range (mm)

AT103		Effective range* L0 (mm)	Signal cable length (m)
Order No.	Model		
539-111-30	**AT103-100**	100 (4 in)	3
539-112-30	**AT103-150**	150 (6 in)	
539-113-30	**AT103-200**	200 (8 in)	
539-114-30	**AT103-250**	250 (10 in)	
539-115-30	**AT103-300**	300 (12 in)	
539-116-30	**AT103-350**	350 (14 in)	
539-117-30	**AT103-400**	400 (16 in)	
539-118-30	**AT103-450**	450 (18 in)	
539-119-30	**AT103-500**	500 (20 in)	
539-121-30	**AT103-600**	600 (24 in)	
539-123-30	**AT103-700**	700 (28 in)	
539-124-30	**AT103-750**	750 (30 in)	
539-125-30	**AT103-800**	800 (32 in)	
539-126-30	**AT103-900**	900 (36 in)	
539-127-30	**AT103-1000**	1000 (40 in)	5
539-128-30	**AT103-1100**	1100 (44 in)	
539-129-30	**AT103-1200**	1200 (48 in)	
539-130-30	**AT103-1300**	1300 (52 in)	
539-131-30	**AT103-1400**	1400 (56 in)	
539-132-30	**AT103-1500**	1500 (60 in)	
539-133-30	**AT103-1600**	1600 (64 in)	
539-134-30	**AT103-1700**	1700 (68 in)	
539-135-30	**AT103-1800**	1800 (72 in)	
539-136-30	**AT103-2000**	2000 (80 in)	
539-137-30	**AT103-2200**	2200 (88 in)	
539-138-30	**AT103-2400**	2400 (96 in)	7
539-139-30	**AT103-2500**	2500 (100 in)	
539-140-30	**AT103-2600**	2600 (104 in)	
539-141-30	**AT103-2800**	2800 (112 in)	
539-142-30	**AT103-3000**	3000 (120 in)	
539-143-30	**AT103-3250**	3250 (130 in)	10
539-144-30	**AT103-3500**	3500 (140 in)	
539-145-30	**AT103-3750**	3750 (150 in)	
539-146-30	**AT103-4000**	4000 (160 in)	
539-147-30	**AT103-4250**	4250 (170 in)	
539-148-30	**AT103-4500**	4500 (180 in)	
539-149-30	**AT103-4750**	4750 (190 in)	15
539-150-30	**AT103-5000**	5000 (200 in)	
539-151-30	**AT103-5250**	5250 (210 in)	
539-152-30	**AT103-5500**	5500 (220 in)	
539-153-30	**AT103-5750**	5750 (230 in)	
539-154-30	**AT103-6000**	6000 (240 in)	

* Models for the effective range 3250 mm or more are made-to-order.

Refer to the Linear Scale DRO Systems Brochure (**E13000**) for more details.

Linear Scales AT113
SERIES 539 — Slim Type

- Slim type with unit sectional dimensions of 22×35 mm.
- Connectable to the **KA-200** counter or **PSU-200**.

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SPECIFICATIONS

Model	AT113
Effective range	100 to 1500 mm
Accuracy (20 °C)	(5 + 5L0/1000) µm
Output signal	Two 90° phase-shifted sinusoidal signals
Maximum response speed	120 m/min
Signal output pitch	20 µm
Scale reference point	Output in 50 mm pitch
Operating temperature	0 to 45 °C

Note 1: High precision model **AT113F** (JIS Class 0, 3 + 3L0/1000) µm is also available to special order.
Note 2: Ultra-high precision model **AT113S** (2 + 2L0/1000) µm is also available to special order for the effective range 100 to 500 mm.
Note 3: The indication accuracy does not include quantizing error. L0=Effective range (mm)

AT113		Effective range L0 (mm)	Signal cable length (m)
Order No.	Model		
539-201-30	**AT113-100**	100 (4 in)	3
539-202-30	**AT113-150**	150 (6 in)	
539-203-30	**AT113-200**	200 (8 in)	
539-204-30	**AT113-250**	250 (10 in)	
539-205-30	**AT113-300**	300 (12 in)	
539-206-30	**AT113-350**	350 (14 in)	
539-207-30	**AT113-400**	400 (16 in)	
539-208-30	**AT113-450**	450 (18 in)	
539-209-30	**AT113-500**	500 (20 in)	
539-211-30	**AT113-600**	600 (24 in)	
539-213-30	**AT113-700**	700 (28 in)	
539-214-30	**AT113-750**	750 (30 in)	
539-215-30	**AT113-800**	800 (32 in)	
539-216-30	**AT113-900**	900 (36 in)	
539-217-30	**AT113-1000**	1000 (40 in)	5
539-218-30	**AT113-1100**	1100 (44 in)	
539-219-30	**AT113-1200**	1200 (48 in)	
539-220-30	**AT113-1300**	1300 (52 in)	
539-221-30	**AT113-1400**	1400 (56 in)	
539-222-30	**AT113-1500**	1500 (60 in)	

Refer to the Linear Scale DRO Systems Brochure (**E13000**) for more details.

- This is a slim, sealed, 2-phase, square-wave scale that can be directly connected to a control unit.
- Scale alarm LED enables easy maintenance.
- A wide range of specifications to best suit your application.
- Suitable for the control (positioning and speed) of semiconductor manufacturing systems and NC machine tools.

Linear Scales AT211-A (Multipoint mounting) AT211-B (Double-end mounting) SERIES 539 — Slim and high speed Type

H

Common specification

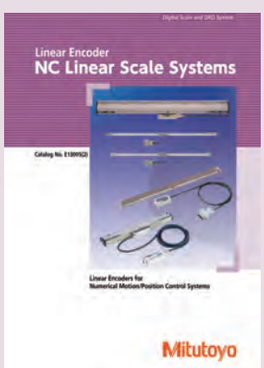
Model	AT211
Effective range*	100 to 1500 mm
Accuracy (20 °C)*	(3 + 3L0/1000) µm L0=effective range (mm)
	(2 + 2L0/1000) µm (L0≤500 mm)
Output signal	2-phase square-wave signals (RS-422A compatible)
Maximum response speed*	5.4 to 120 m/min (varies depending on the resolution or minimum edge interval)
Resolution*	0.1/0.2/0.5/1.0/2.5/5.0 µm
Scale reference point*	50 mm pitch/Center point/Left-edge point/Right-edge point
Operating temperature	0 to 45 °C

* Desired specification is selectable.

Meaning of Model No.

AT211 - 0100 A 1 S - P 1 - A B

- Effective range: 100 to 1500 mm
- Mounting method: Multipoint mounting/Double-end mounting
- Scale reference point: 50 mm pitch/Center point/Left edge point/Right edge point
- Indication accuracy: (3 + 3L0/1000) µm/(2 + 2L0/1000) µm
- Resolution/Minimum edge-to-edge interval: 0.1 to 5 µm/125 to 1000 ns, 22 types
- Direction: PA/PB phase
- Head cable: 0.3 to 9 m, 9 types
- Signal cable: 3 to 7 m/None, 10 types



Refer to the NC Linear Scale Systems Brochure (**E13005**) for more details.

Linear Scales ABS AT1300 — Slim Type
Assembly Type Scale Unit for Absolute Systems

ABS AT1300-S

ABS AT1300-H

SPECIFICATIONS

	High rigidity type	High accuracy type
Model	**ABS AT13□□(A)-S**	**ABS AT13□□(A)-H**
Detection method	Optical	
Resolution	0.001/0.01/0.05 µm	
Maximum response speed	3 m/s	
Maximum effective measuring length	2.2 m	1 m
Accuracy (20 °C)*1	(3 + 3L0/1000) µm	(2 + 2L0/1000) µm
Reference point*2	Center of the effective measuring length	
Operating temperature (humidity) range	0 to 50 °C (RH 20 to 80%, non-condensing)	
Storage temperature (humidity) range	–20 to 70 °C (RH 20 to 80%, non-condensing)	

*1 The indication accuracy does not include quantizing error. L0=Effective range (mm)
*2 Scale is mechanically fixed at this point, therefore expansion caused by temperature fluctuations are relative to this point.

Meaning of Model No.

ABS AT13□□□ - □□□□ - □

- ABS AT13□□□: Interface specifications
- □□□□: Effective range
- □: Type of the scale unit
  - **S**: High rigidity type
  - **H**: High accuracy type

Model	Applicable system
ABS AT135□	FANUC CORPORATION Serial αi Interface
ABS AT134□	Mitsubishi Electric Corporation MDS-D/MDS-DH Series
ABS AT134□A	Mitsubishi Electric Corporation MELSERVO servo amplifier MR-J5 Series, MR-J4 Series
ABS AT138□A	YASKAWA Electric Corporation SERVOPACK Σ7, ΣX Series
ABS AT130□A	Mitutoyo ENSIS

Note 1: Be sure to contact each manufacturer for details of the applicable systems.

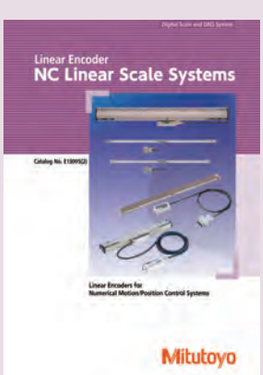
Note 2: **ABS AT13□□□**
- □□: Resolution
  - **7**: 0.001 µm
  - **4**: 0.01 µm
  - **3**: 0.05 µm
- □: Transmission method
  - Nothing: Full duplex communication
  - **A**: Half-duplex communication

Signal cable specifications (optional)

Items	Specifications
Cable length	1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7 m, 8 m, 9 m, 12 m
Cable material	PVC sheath (ø6.5 mm), High-flex connecting cable (No metal conduit)
I/O output connector	Flying lead specifications FANUC specifications Mitsubishi specifications D-sub specifications (Alarm display LED mounted)

ABSOLUTE™

- Outstanding resistance to contamination compared to conventional optical types by using a new detection principle (in-house testing result).
- Features a new coolant-proof design incorporating a high-performance rubber seal to provide higher reliability in the harsh factory environment.
- Delivers high accuracy and the outstanding resolution of 0.001 µm, the best-in-class in absolute scales.
- Allows space-saving design thanks to a slim form. (**AT500-S** and **AT500-H** are compatible with each other in installation.)
- Supports the interfaces of various manufacturers allowing a variety of system configurations.



Refer to the NC Linear Scale Systems Brochure (**E13005**) for more details.

ABSOLUTE™

Linear Scales ABS AT1100
Assembly Type Scale Unit for Absolute Systems

- Features a new coolant-proof design incorporating a high-performance rubber seal to provide higher reliability in the harsh factory environment.
- The 0.4 mm air gap between the sensors is approximately four times wider than the conventional optical or magnetic sensors. Therefore, the chance of foreign objects lodging in this gap is lower. This air gap is the world's largest in this class of scale used on machine tools.
- The de facto standard multi-point fixing method for the frame is adopted, resulting in high vibration/shock-resistance.
- Due to an improvement in the signal processing technique for the electromagnetic induction ABSOLUTE linear encoder, the repeatability is six times better than our conventional model.
- Being compatible with the high-speed serial interface of each company, a direct connection to the NC controller is possible.

ABS AT1100

H

SPECIFICATIONS

Model	**ABS AT11□3(A)**
Detection method	Electromagnetic induction
Mounting method	Frame multipoint
Effective range	140 to 3040 mm
Resolution	0.05 µm
Maximum response speed	3 m/s
Accuracy (20 °C)	Effective range L_0=140 to 2040 mm: 3 + 5L_0/1000 (µm) Effective range L_0=2240 to 3040 mm: 5 + 5L_0/1000 (µm)
Expansion coefficient	≈8×10^{-6}/K
Vibration resistance	≤196 m/s^2 (20 G) (55 to 2000 Hz)
Shock resistance	Effective range L_0=140 to 2040 mm: ≤ 343 m/s^2 (35 G) Effective range L_0=2240 to 3040 mm: ≤ 294 m/s^2 (30 G) (1/2 sin 11 ms)
Power supply voltage	**ABS AT1153/1143/1103A**: 5 VDC ± 10% **ABS AT1123**: DC24 V (Conforming to DRIVE-CLiQ)
Maximum current consumption	**AT1153**: 300 mA (Max.) **AT1143**: 290 mA (Max.) **AT1123**: 140 mA (Max.) **AT1103A**: 300 mA (Max.)
Operational temperature (humidity) ranges	0 to 50 °C (RH 20 to 80%, non-condensing)
Storage temperature (humidity) ranges	–20 to 70 °C (RH 20 to 80%, non-condensing)

Meaning of Model No.

ABS AT11□3 - □□□□
- **ABS AT11□3**: Interface specifications
- **□□□□**: Effective range

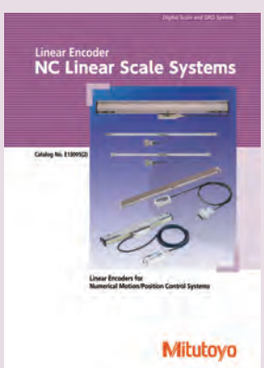
Model	Applicable system
ABS AT1153	FANUC CORPORATION Serial αi Interface
ABS AT1143	Mitsubishi Electric Corporation MDS-D/MDS-DH Series
ABS AT1123	Siemens AG DRIVE-CLiQ
ABS AT1103A	Mitutoyo ENSIS

Note 1: Please contact each manufacturer for details of the applicable systems.

Note 2: **ABS AT11□3□**
- **□**: Transmission method
  - Nothing: Full duplex communication
  - **A**: Half-duplex communication

Signal cable specifications (optional)

Items	Specifications
Cable length	1 m, 3 m, 6 m, 9 m, 12 m
Cable material	PVC sheath ø6.5 Without conduit, High-flex specification with conduit PUR sheath ø6.5 Without conduit
I/O output connector	Flying lead specifications FANUC specifications Mitsubishi specifications Mitutoyo standard specifications Siemens specifications M12 connector specifications



Refer to the NC Linear Scale Systems Brochure (**E13005**) for more details.

Mitutoyo

Linear Scales ABS AT715
SERIES 539 — Slim Type

ABSOLUTE™

IP67

- The electromagnetic induction principle adopted means Absolute system-type linear scales are highly resistant to environmental contamination.
- Absolute scales have eliminated the need for origin restoration, also drastically reducing power consumption.

H

SPECIFICATIONS

Model	ABS AT715	
Detection method	Electromagnetic induction	
Minimum resolution	0.001 mm to 0.01 mm (Changeable by parameter on the **KA-200** counter)	
Effective range	100 to 3000 mm	
Accuracy (20 °C)	±5 µm (L0: 100 to 500 mm), ±7 µm (L0: 600 to 1800 mm), ±10 µm (L0: 2000 to 3000 mm) L0=Effective range (mm)	
Maximum response speed	50 m/min	
Protection level	IP67	
Sliding force	5 N or less	
Signal cable	Standard Accessories Refer to the dimension table shown below for the length.	
Extension cable (optional)	Length	Order No.
	2 m 5 m 7 m	**09AAB674A** **09AAB674B** **09AAB674C**
Connectable counter	**KA-200** Counter	

AT715		Effective range L0 (mm)	Signal cable length (m)
Order No.	Model		
539-801R	**ABS AT715-100**	100 (4 in)	3.5
539-802R	**ABS AT715-150**	150 (6 in)	
539-803R	**ABS AT715-200**	200 (8 in)	
539-804R	**ABS AT715-250**	250 (10 in)	
539-805R	**ABS AT715-300**	300 (12 in)	
539-806R	**ABS AT715-350**	350 (14 in)	
539-807R	**ABS AT715-400**	400 (16 in)	
539-808R	**ABS AT715-450**	450 (18 in)	
539-809R	**ABS AT715-500**	500 (20 in)	
539-811R	**ABS AT715-600**	600 (24 in)	
539-813R	**ABS AT715-700**	700 (28 in)	
539-814R	**ABS AT715-750**	750 (30 in)	
539-815R	**ABS AT715-800**	800 (32 in)	
539-816R	**ABS AT715-900**	900 (36 in)	
539-817R	**ABS AT715-1000**	1000 (40 in)	5
539-818R	**ABS AT715-1100**	1100 (44 in)	
539-819R	**ABS AT715-1200**	1200 (48 in)	
539-820R	**ABS AT715-1300**	1300 (52 in)	
539-821R	**ABS AT715-1400**	1400 (56 in)	
539-822R	**ABS AT715-1500**	1500 (60 in)	
539-823R	**ABS AT715-1600**	1600 (64 in)	
539-824R	**ABS AT715-1700**	1700 (68 in)	
539-825R	**ABS AT715-1800**	1800 (72 in)	
539-860R	**ABS AT715-2000**	2000 (80 in)	
539-861R	**ABS AT715-2200**	2200 (88 in)	
539-862R	**ABS AT715-2400**	2400 (96 in)	7*
539-863R	**ABS AT715-2500**	2500 (100 in)	
539-864R	**ABS AT715-2600**	2600 (104 in)	
539-865R	**ABS AT715-2800**	2800 (112 in)	
539-866R	**ABS AT715-3000**	3000 (120 in)	

* Combination of a 5 m signal cable and a 2 m extension cable

Refer to the Linear Scale DRO Systems Brochure (**E13000**) for more details.

KA-200 Counter
SERIES 174 — Standard Type

- **KA-200** counter is high-performance unit that can be used as "standard counter" or "lathe counter".
- Downsizing and weight saving have been realized.
- The RS-232C interface enables connection to a PC or printer.

Optional Accessory
- Code out unit: **06AET993**

174-183
KA-212

H

SPECIFICATIONS

Order No.	**174-183**☐	**174-185**☐
Model	**KA-212**	**KA-213**
Number of axes to be displayed	2	3
Resolution	(Changeable according to the parameter) When **AT100** is connected: 0.05 to 0.0001 mm When **AT715** is connected: 0.01 to 0.001 mm	
Display/digit	Main display: 9 digits including sign Sub display: 8 digits	
Power supply voltage	AC100 to 240 V, 50/60 Hz	
Dimensions	300 (W) ×70 (D) ×167 (H) mm	
Output (optional)	RS-232C	
Mass	1.25 kg	1.3 kg

☐: To denote your AC power cable add the following suffixes to the order No. :
A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix are required for PSE.

Refer to the Linear Scale DRO Systems Brochure (**E13000**) for more details.

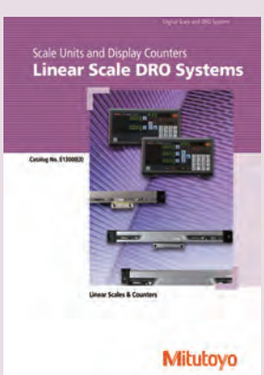
Mitutoyo

Linear scale counter

FUNCTIONS

Function \ Type		High performance  **KA-200 Counter**
Zero-setting	ZERO	●
Preset	P.SET	●
Resolution setting	0.0005 / 0.1	●
Measurement direction setting		●
mm/inch conversion	mm/E	●
Diameter display	DIA	●
Scale reference point setting*1	SET	●
1/2 calculation	1/2	●
Coordinate system switching	N	●
Bolt-hole circle machining		●*2
Pitch machining		●
Zero approach machining (INC mode)		●
Addition of 2-axis data	Z1+Z2	●*3
Linearity error compensation		●
Pitch error compensation		●*1
Smoothing	1234	●
Memory backup		●
Expansion/contraction coefficient setting		—
Lower digit blanking out	123	●
External zero-setting	ZERO SET IN PUT	▲*4
RS-232C output	RS-232C OUTPUT	▲*4
USB output	USB	▲*5
Limit signal output	LIMIT OUTPUT	—
Error message	Error	●

●: Standard function, ▲: Optional function, —: Not available
*1 Only available when connecting with **AT100** Series.
*2 Not available in single-axis use
*3 Only available for 3-axis model (**KA-213**)
*4 Code out unit (**06AET993**) is required.
*5 Text can be output by code out unit and foot switch



Refer to the Linear Scale DRO Systems Brochure (**E13000**) for more details.

- Outputs 2-phase sinusoidal wave signals at 4 µm pitch.
- The maximum effective measuring length is 3000 mm when the resolution is 0.01/0.02/0.05/0.1 µm (2-phase square-wave is output).
- Compact detector head enables space saving design.
- Along with the output specifications of 2-phase sinusoidal wave and 2-phase square-wave, the output specification of 1 Vp-p wave is also available.
- Equipped with the function to display signal errors on the LED.

Linear Scales ST36
SERIES 579 — High Accuracy Type

H

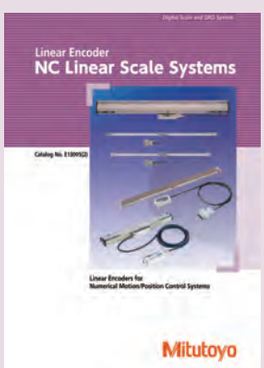
SPECIFICATIONS

Model	ST36
Detection method	Optical
Output signal	**ST36A**: 2 Vp-p sinusoidal signals **ST36B**: 2-phase square-wave signals (RS-422A compatible), Alarm reset input **ST36C**: 2-phase square-wave signals (RS-422A compatible), 2-phase sinusoidal signals **ST36D**: 1 Vp-p differential sinusoidal signals
Main scale grating pitch	8 µm
Signal output pitch	4 µm
Effective range	10 to 3000 mm
Accuracy (20 °C)*1	±0.5 µm, ±1 µm, ±2 µm/m
Maximum response speed*2	1200 mm/s
Scale reference point	10 to 80 mm: 1 center point; 100 to 300 mm: 50 mm pitch
Power supply voltage	5 VDC ± 5%
Operating temperature (humidity) range	0 to 40 °C (20 to 80% RH, non-condensing)
Storage temperature (humidity) range	–20 to 60 °C (20 to 80% RH, non-condensing)
Head cable length	1 m (high-flex connecting cable)

*1

Effective range	Accuracy
300 mm or less	±0.5 µm
500 mm or less	±1 µm
1000 mm or less	±2 µm
3000 mm or less	±2 µm/m

*2 Maximum response speed when sinusoidal signals are output



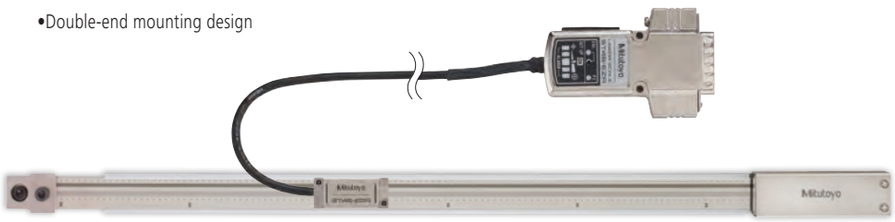
Refer to the NC Linear Scale Systems Brochure (**E13005**) for more details.

Linear Scales ST46-EZA
SERIES 579 — Compact Type

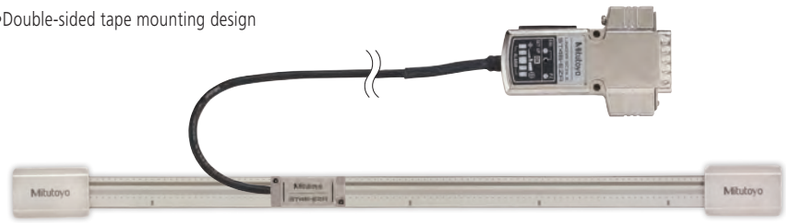
Glass Scale Type

Metal Tape Scale Type

•Double-end mounting design



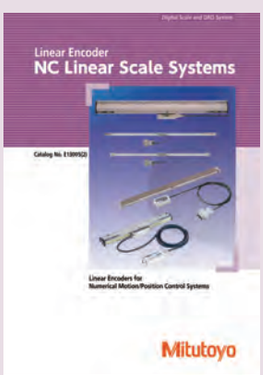
•Double-sided tape mounting design



- Includes an automatic adjusting function for the signal (EZA function) at the push of a button.
- Detector head mounting and signal adjustment possible without oscilloscope or PC.
- A setup indicator for checking signal strength is included.
- When connected with a PC it is possible to check signal strength and set parameter (Optional application program required).
- I/F circuit integrated in connector shell reduces volume to compared to conventional interface.
- The thickness of the detector head is only 7.5 mm. The metal tape scale type has a mounting surface area of 12.5 by 9.325 mm, allowing use in applications where a space-saving design is important.
- Glass and metal tape versions are available.

SPECIFICATIONS

Model	ST46-EZA	
Detection method	Optical	
Scale type	Glass	Metal tape
Main scale grating pitch	20 µm	
Output signal	Type B: 2-phase square-wave signals (RS-422A compatible), reference point pulse, external reset input. Type C: 2-phase square-wave signals (RS-422A compatible), reference point pulse, 2-phase sinusoidal signals.	
Effective range	10 to 3000 mm	
Accuracy (20 °C)	Effective range 10 to 300 mm: ±1 µm Effective range 350 to 500 mm: ±2 µm Effective range 600 to 1000 mm: ±3 µm Effective range 1100 to 3000 mm: ±3 µm/m	Effective range 10 to 1000 mm: ±5 µm Effective range 1100 to 3000 mm: ±5 µm/m (The above accuracy applies to individual scales. For double-end mounting designs, perform point-to-point correction after ensuring the metal tape is tensioned correctly.)
Maximum response speed	2.6 m/s (at the point where the sinusoidal signal amplitude has decreased by 3 dB)	
Scale reference point	10 to 80 mm: 1 center point; 100 to 300 mm: 50 mm pitch	
Power supply voltage	5 VDC ± 5%	
Operating temperature (humidity) range	0 to 40 °C (RH 20 to 80%, non-condensing)	
Storage temperature (humidity) range	–20 to 60 °C (RH 20 to 80%, non-condensing)	
Head cable length	1 m (high-flex connecting cable)	



Refer to the NC Linear Scale Systems Brochure (**E13005**) for more details.

ABSOLUTE™

Linear Scales ABS ST700
SERIES 579 — General-purpose Type

- Absolute measurement with separate type scales
- Non-contact detection is optimal for high speed and high acceleration devices such as linear motors
- Electromagnetic induction principle means scales are unaffected by water and oil contamination
- The detector head is approximately 1/3 the previous model size: 50 mm (W) × 28 mm (D) ×11 mm (H)
- Cable outlets can be in four directions, with mounting holes on the top and sides
- Compatible with servo amplifiers from a range of companies (high-speed serial interfaces)

SPECIFICATIONS

Model	ABS ST700	
Scale type	Scale base	
Resolution	0.1 µm	
Detection method	Electromagnetic induction	
Max. effective range	100 to 3000 mm	3200 to 6000 mm
Accuracy (20 °C)	5 + (5L/1000) µm L=Effective range (mm)	5 + (5L/1000) µm L=Effective range (mm)
Maximum response speed	5 m/s	
Power supply voltage	5 VDC ± 10% (at the detection head) (Ripple+spike noise component should be less than 100 mV)	
Maximum current consumption	270 mA	
Head cable length	1 m (high-flex connecting cable)	
Maximum cable length	29 m (including the head cable length)	
Operating temperature (humidity) range	0 to 50 °C (RH 20 to 80%, non-condensing)	0 to 50 °C (RH 20 to 70%, non-condensing)
Storage temperature (humidity) range	–20 to 70 °C (RH 20 to 80%, non-condensing)	–20 to 60 °C (RH 20 to 70%, non-condensing)

Meaning of Model No.

ABS ST7 0 8 A L - 100 A - R

Absolute type

Series name
Separate Type ABSOLUTE Linear Scale
ABS ST700 Compact-type Series (Effective range ≤ 3 m)
ABS ST700 Compact-type Series (3.2 m ≤ Effective range ≤ 6 m)

Interface specification[*1]
0: Supports Mitutoyo ENSIS high-speed serial interface
ABS ST708A
4: Supports Mitsubishi Electric Corporation, high-speed serial interface
ABS ST748A, **ST748AL**, **ABS ST748**
5: Supports FANUC CORPORATION, high-speed serial interface
ABS ST758, **ST758L**
7: Supports Panasonic Corporation, high-speed serial interface
ABS ST778A
8: Supports YASKAWA Electric Corporation, high-speed serial interface
ABS ST788A, **ST788AL**

Detection head form and resolution
8: Form: 50 (W)×28 (D)×11 (H) mm
Resolution: 0.1 µm
9: 0.05 µm resolution (to special order)

Transmission method
A: 2-wire system
Nothing: 4-wire system

Nothing: 100 to 3000 mm
L: 3200 to 6000 mm

Effective range: 100 to 6000 mm

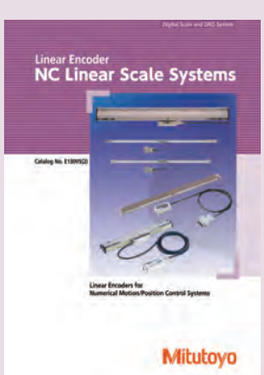
A: Scale base type

Head cable outlet direction
R: Right side
L: Left side
U: Upper side
D: Lower side

Available Interfaces[*1]

FANUC CORPORATION, FANUC Serial αi Series
Mitsubishi Electric Corporation, MDS-D/MDS-DH Series
Mitsubishi Electric Corporation, MELSERVO Series Servo Amplifier MR-J5 Series, MR-J4 Series, MR-J3 Series
YASKAWA Electric Corporation, SERVOPACK Σ7, ΣX Series
Panasonic Corporation, MINAS A6, A5 Series
Mitutoyo ENSIS[*2] CKD NIKKI DENSO CO., LTD. VPH Series Servoland Corporation SVF Series OMRON Corporation Power-UMAC, Power-Clipper, Power-Brick, CK3M Series

*1 Be sure to contact each manufacturer for details of the applicable systems (availability of connection).
*2 ENSIS is a registered trademark of Mitutoyo Corporation.



Refer to the NC Linear Scale Systems Brochure (**E13005**) for more details.

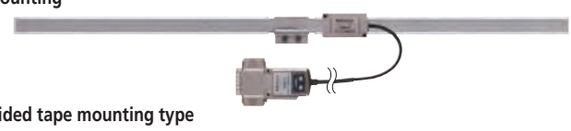
Mitutoyo

ABSOLUTE™

Linear Scales ABS ST1300 SERIES 579

Double-end mounting type

Center mounting



Double-sided tape mounting type

- Effective range: 12 m, Maximum response speed: 8 m/s, Resolution: 1 nm
- Various interfaces are supported.
- A new detection method has improved robustness in regards to contamination resistance and gap tolerance (in-house testing result).
- Can be mounted using double-sided tape or screws (on both sides or at the center of the unit).
- Signal check program enables integrity check and maintenance.

H

SPECIFICATIONS

Model	ABS ST1300			
Detection method	Optical			
Scale type	Double-end mounting	Center mounting	Double-sided tape mounting	
Maximum effective range	12000 mm	6000 mm	3000 mm	
Fixing part material	—	—	Equivalent to iron	Other than equivalent to iron
Accuracy (20 °C)	±5 µm (1 m or less), ±5 µm/m (1.1 m or more)*4	With system parameters: ±5 µm (1 m or less), ±5 µm/m (1.1 m or more) Without system parameters: ±10 µm (1 m or less), ±10 µm/m (1.1 m or more)	±5 µm (1 m or less), ±5 µm/m (1.1 m or more)	
Maximum response speed	8 m/s or less			
Expansion coefficient	≈10×10^{-6}/K*5	≈10×10^{-6}/K	≈10×10^{-6}/K*2	
Power supply	5 VDC ± 10%			
Maximum current consumption	270 mA or 250 mA (depends on interface)			
Cable length	1 m (high-flex connecting cable)			
Maximum cable length	29 m (including head cable)			
Usable temperature (humidity) range	0 to 50 °C (RH 20 to 70%, non-condensing)			0 to 50 °C*1 (RH 20 to 70%*3, non-condensing) When mounting: ±10 °C
Storage temperature (humidity) range	–20 to 70 °C (RH 20 to 70%, non-condensing)			

*1 Double-sided tape fixing type, careful for the condition of operating temperature range, in case that the sealing surface material is except for Fe equivalent.
*2 Thermal expansion coefficient occasionally change, as the difference between scale material's and sealing surface material's is excessive.
*3 Double-sided tape fixing type, the accuracy compensation occasionally change, in case that the sealing surface material is except for Fe equivalent and stored in environment over operating temperature range. Imaging these conditions, double-end fixing type is adopted.
*4 Tension fix is adopted to be stable the temperature property. Because scale tension is longer 250 µm/m, the accuracy compensation is needed over the system.
*5 Thermal expansion coefficient after mounted conform to expansion/contraction of mounted surface by changing outer temperature (Double-end fixing type).
Note: For details on specification, mounting procedure, and adjustments, refer to the corresponding brochure and operation manual.

Meaning of Model No.

ABS ST13 4 1 A - 1200 D

Absolute type

Series name
Separate Type ABSOLUTE Linear Scale

Interface specification*1
0:Supports Mitutoyo ENSIS high-speed serial interface
ABS ST130□A
4:Supports Mitsubishi Electric Corporation, high-speed serial interface
ABS ST134□A
5:Supports FANUC CORPORATION, high-speed serial interface
ABS ST135□
7:Supports Panasonic Corporation, high-speed serial interface
ABS ST137□A
8:Supports YASKAWA Electric Corporation, high-speed serial interface
ABS ST138□A

Resolution
1: Resolution 0.01 µm
2: Resolution 0.001 µm

Transmission method
A: Half-duplex method
Nothing: Full duplex method or Half-duplex method/Half-duplex method

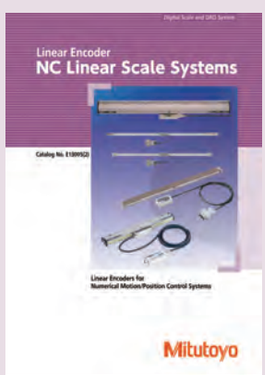
Effective range: 10 to 12000 mm

Scale mount
D: Double-end mounting
E: Double-sided tape mounting
F: Center mounting (With system parameters)
G: Center mounting (Without system parameters)

Available Interfaces*1

FANUC CORPORATION, FANUC Serial αi Series
Mitsubishi Electric Corporation, MELSERVO Series Servo Amplifier MR-J5 Series, MR-J4 Series
YASKAWA Electric Corporation, SERVOPACK Σ7, ΣX Series
Panasonic Corporation, MINAS A6, A5 Series
Mitutoyo ENSIS*2

*1 Be sure to contact each manufacturer for details of the applicable systems (availability of connection).
*2 ENSIS is a registered trademark of Mitutoyo Corporation.



Refer to the NC Linear Scale Systems Brochure (**E13005**) for more details.

Pulse signal interface unit PSU-200
SERIES 539

- The **PSU-200** splits the sinusoidal signal output by Mitutoyo linear scales into a minimum of four and a maximum of 200 divisions, and converts the signal to a square-wave signal so that NC feedback systems, measurement control devices, etc., can be used with linear scales in order to achieve highly accurate positioning.

SPECIFICATIONS

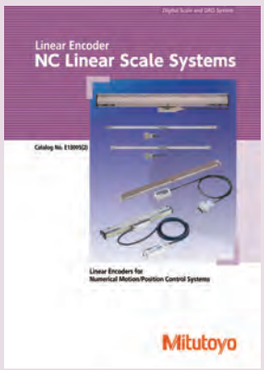
Order No.	**539-005**
Model	**PSU-200**
Number of axes	1
Input	Input connector DA-15S-N (JAE) or equivalent Input signal: 2-phase sinusoidal and the reference voltage, Reference point, Scale alarm
Output	Output connector: MR-20RMA (HONDA TSUSHIN KOGYO CO., LTD.) Output signal: 2-phase square-wave signals (PA, PB), reference point (PZ), Alarm, Alarm reset, Photo-coupler
Number of divisions	4, 8, 10, 20, 40, 80, 100, 200 (Selectable by switch)
Function	Setting the number of divisions, setting the minimum edge interval, and maximum response speed. Detection of broken wires or short circuits and abnormalities (alarm), detection of signal errors (alarm). Power supply voltage low alarm (warning light only), switching between high-impedance mode and alarm signal output mode. Reference position detection light, hysteresis width settings (directly linked to No. of divisions), external alarm reset input (Photo-coupler)
Power supply voltage	5 VDC ± 5%
Current consumption	200 mA
Operating temperature range	0 to 50 °C
Storage temperature range	–20 to 70 °C
Dimensions	160 (W) ×100 (D) ×28 (H) mm
Mass	Approx. 620 g

Serial signal interface unit PSU-251/252
SERIES 539

- **PSU-251** Series is a serial signal interface unit for incremental linear scales.

The interface outputs serial data equivalent to 400 divisions from the sinusoidal signal (according to EIA Standard RS-422-A)

- The **PSU-251** can be connected to Mitsubishi Electric Corporation's MR-J4/MR-J3 Series servo amplifier.
- Since this unit is connected to incremental linear scales, the reference point should be passed through to determine the absolute position.



Refer to the NC Linear Scale Systems Brochure (**E13005**) for more details.

SPECIFICATIONS

Order No.	**539-006**	**539-007**
Model	**PSU-251**	**PSU-252**
Number of axes	1	
Input	2-phase sinusoidal signals and standard voltage, reference signal, scale alarm signal. Maximum input frequency: 500 kHz	
Output	Mitsubishi Electric Corporation MR-J4/MR-J3 Series High-speed serial data*	Panasonic Corporation Motor Business Unit MINAS-A5, A5L, A5N, A5NL Series* MINAS-A4, A4P, A4N, A4NL Series*
Number of divisions	400	
Function	Alarm detection: Broken wires, short circuits in the scale and abnormalities. Alarm output: Status data is output through serial communication and the PWR light blinks. Also, the PWR light turns on.	
Power supply voltage	Power supply from the servo amplifier: 5 VDC ± 5% External power supply: 5 VDC ± 5% Power supply is selected with the shorting link for the terminal block used to supply external power. To choose a servo amplifier or external power supply, please refer to the servo amplifier power specifications (in particular, the maximum supplied current) and the power supply specifications of the scale that is used.	
Current consumption	150 mA (not including the scale)	
Operating temperature range	0 °C to 40 °C	
Storage temperature range	–20 °C to 70 °C	

* Please contact each manufacturer for details of the applicable systems.

Glossary

Absolute system
A measurement mode in which every point measurement is made relative to a fixed origin point.

Incremental system
A measurement mode in which every point measurement is made relative to a certain stored reference point.

Origin offset
A function that enables the origin point of a coordinate system to be translated to another point offset from the fixed origin point. For this function to work, a system needs a permanently stored origin point.

Restoring the origin point
A function that stops each axis of a machine accurately in position specific to the machine while slowing it with the aid of integrated limit switches.

Sequence control
A type of control that sequentially performs control steps according to a prescribed order.

Numerical control
A way of controlling the movements of a machine by encoded commands created and implemented with the aid of a computer (CNC). A sequence of commands typically forms a 'part program' that instructs a machine to perform a complete operation on a workpiece.

Binary output
Refers to output of data in binary form (ones and zeros) that represent numbers as integer powers of 2.

RS-232C
An interface standard that uses an asynchronous method of serial transmission of data over an unbalanced transmission line for data exchange between transmitters located relatively close to each other. It is a means of communication mainly used for connecting a personal computer with peripherals.

Line driver output
This output features fast operating speeds of several tens to several hundreds of nanoseconds and a relatively long transmission distance of several hundreds of meters. A differential-voltmeter line driver (RS-422A compatible) is used as an I/F to the NC controller in the linear scale system.

BCD
A notation of expressing the numerals 0 through 9 for each digit of a decimal number by means of four-bit binary sequence. Data transmission is one-way output by means of TTL or open collector.

RS-422
An interface standard that uses serial transmission of bits in differential form over a balanced transmission line. RS-422 is superior in its data transmission characteristics and in its capability of operating with only a single power supply of 5 VDC.

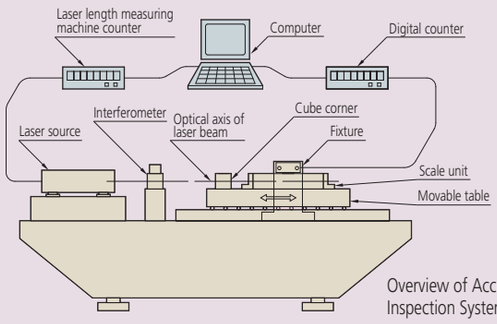
Accuracy
The accuracy specification of a scale is given in terms of the maximum error to be expected between the indicated and true positions at any point, within the range of that scale, at a temperature of 20 °C. Since there is no international standard defined for scale units, each manufacturer has a specific way of specifying accuracy. The accuracy specifications given in our catalog have been determined using laser interferometry.

Narrow range accuracy
Scale gratings on a scale unit normally adopt 20 µm pitch though it varies according to the kind of scale. The narrow range accuracy refers to the accuracy determined by measuring one pitch of each grating at the limit of resolution (1 µm for example).

Specifying Linear Scale Accuracy

Positional Indication accuracy

The accuracy of a linear scale is determined by comparing the positional value indicated by the linear scale with the corresponding value from a laser length measuring machine at regular intervals using the accuracy inspection system as shown in the figure below. As the temperature of the inspection environment is 20 °C, the accuracy of the scale applies only in an environment at this temperature. Other inspection temperatures may be used to comply with internal standards.



Overview of Accuracy Inspection System

The accuracy of the scale at each point is defined in terms of an error value that is calculated using the following formula:

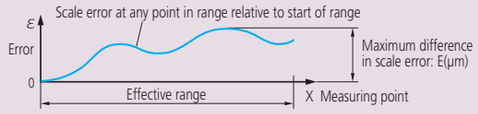
Error = Value indicated by Laser length measuring machine – Corresponding value indicated by the linear scale

A graph in which the error at each point in the effective positioning range is plotted is called an accuracy diagram.
There are two methods used to specify the accuracy of a scale, unbalanced or balanced, described the right.

(1) Unbalanced accuracy specification - maximum minus minimum error

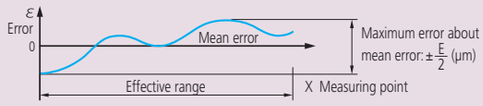
This method simply specifies the maximum error minus the minimum error from the accuracy graph, as shown below. It is of the form: $E = (\alpha + \beta L)$ µm. L is the effective range (mm), and α and β are factors specified for each model.

For example, if a particular type of scale has an accuracy specification of $(3 + \frac{3L}{1000})$ µm and an effective range of 1000 mm, E is 6 µm.



(2) Balanced accuracy specification - plus and minus about the mean error

This method specifies the maximum error relative to the mean error from the accuracy graph. It is of the form: $e = \pm \frac{E}{2}$ (µm). This is mainly used in separate-type (retrofit) scale unit specifications.



A linear scale detects displacement based on graduations of constant pitch. Two-phase sinusoidal signals with the same pitch as the graduations are obtained by detecting the graduations. Interpolating these signals in the electrical circuit makes it possible to read a value smaller than the graduations by generating pulse signals that correspond to the desired resolution. For example, if the graduation pitch is 20 µm, interpolated values can generate a resolution of 1 µm. The accuracy of this processing is not error-free and is called interpolation accuracy. The linear scale's overall positional accuracy specification depends both on the pitch error of the graduations and interpolation accuracy.

Profile Projectors
PJ-PLUS

Refer to page J-3 for details.

Motor-Driven Z-axis Measuring Microscopes
MF-J/MF-UJ/MF-UK

Refer to pages J-6, J-8 for details.

Varifocal Lens
TAGLENS

Refer to page J-15 for details.

J

Optical Measuring

MeasurLink® ENABLED
Data Management Software by Mitutoyo

Measurement Data Network System

MeasurLink® is a measurement data management system based on databases (SQL Server). You can build a network to manage the measurement results and measuring machines by simply combining the functions necessary for your purpose.

INDEX

Profile Projectors

Microscopes

Mitutoyo

MeasurLink® ENABLED
Data Management Software by Mitutoyo

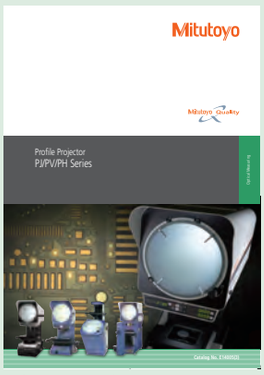
PJ-PLUS
SERIES 302 — Premium Benchtop Series

- The profile projector that "can be operated intuitively" even by inexperienced operators and also has excellent durability and energy saving performance thanks to adoption of an "LED illumination source" and "fan-less cooling system".
- Provides stable dimension and angle measurements in harsher environments, such as manufacturing and processing lines, than can be handled by conventional models.
- Stepless illumination has been adopted so as to allow precise adjustment of lighting to suit the surface texture and color of the workpiece.

PJ-P2010A

SPECIFICATIONS

Model No.		PJ-P1010A		PJ-P2010A	
Order No.		302-801-10	302-801-20	302-802-10	302-802-20
Unit system for the counter unit		mm/in	mm	mm/in	mm
Projected image		Inverted-reversed			
Protractor screen	Effective diameter	ø315 mm (12.4 in)			
	Screen rotation	±360° (±370° for display)			
	Angle display	Digital counter (ABS/INC mode switching, Zero Set)			
	Resolution	1′ or 0.01° (switchable)			
	Cross-hairs	90° (solid lines)			
Projection lens	Magnification	10X (standard accessory), 20X, 50X, 100X 10X, 20X (equipped with an external half-mirror for coaxial surface illumination)			
	Lens mount	Bayonet mount			
Illumination	Contour illumination	White LED light source, Telecentric, Variable brightness adjustment			
	Surface illumination	White LED light source, With an adjustable condenser lens, Variable brightness adjustment			
Resolution for X/Y counter		0.001 mm or 0.0001 in/0.001 mm			
Measuring unit		Digital scale			
Measuring range (X×Y)		100×100 mm		200×100 mm	



Refer to the Profile Projector Brochure (**E14005**) for more details.

MeasurLink® ENABLED
Data Management Software by Mitutoyo

PJ-H30
SERIES 303 — Premium Benchtop Series

- Conforms to JIS B 7184: 2021 "Profile projectors".
- High-end model that achieves accuracy of ±(3.0 + 0.02L) µm
- ø306 mm screen makes erect-unreversed images more visible.
- The largest measuring range in the class, up to 300×170 mm.
- Elevating shaft mechanism for the screen head reduces operator fatigue.

PJ-H30D3017B

SPECIFICATIONS

Protractor screen	Model No.	PJ-H30A1010B	PJ-H30A2010B	PJ-H30A2017B	PJ-H30A3017B
	Order No.	303-712-1*1	303-713-1*1	303-714-1*1	303-715-1*1
Projected image		Erect			
Protractor screen	Effective diameter	ø306 mm (12 in)			
	Screen rotation	±360° (±370° for display)			
	Angle display	Digital counter (ABS/INC mode switching, Zero Set)			
	Resolution	1′ or 0.01° (switchable)			
	Mechanism	Fine feed and clamp			
	Cross-hairs	90° (solid lines)			
Projection lens	Magnification	10X (standard accessory), 5X, 20X, 50X, 100X, All lens have the same focus. Half-mirror for the coaxial surface illumination are built-in and movable.			
	Lens mount	Bayonet mount, 3-lens mount turret type			
Illumination	Contour illumination	Halogen bulb (24 V, 150 W, 50 hours) (**515530**), Variable Illumination angle (Coaxial surface/Oblique reflected, Beam concentration and adjustment), Built-in heat-absorbing filter, Built-in cooling fan, Stepless brightness adjustment, Soft lighting (inrush current reduction)			
	Surface illumination	Halogen bulb (24 V, 150 W, 50 hours) (**515530**) Zoom Telecentric system, Heat absorbing filter, Built-in cooling fan, Stepless brightness adjustment, Soft lighting (inrush current reduction), Bulb sliding mechanism			
Resolution for X/Y counter *2		0.001 mm/0.0001 in			
Measuring unit		High-accuracy digital scale			
Measuring range (X×Y)		100×100 mm	200×100 mm	200×170 mm	300×170 mm
Measuring accuracy *3		±(3.0 + 0.02L) µm L=Measured length (mm)			

*1 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix is required for PSE.
*2 0.5 µm or 0.1 µm resolution is also available. Please contact Mitutoyo Techno Service Business Division.
*3 Measuring method complies with JIS B 7184.

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Data Management Software by Mitutoyo

PV-5110
SERIES 304 — Profile Projectors

- Floor-standing projector with a vertical axis and a unique forward-sloping screen.
- The large 500 mm diameter screen enables the whole of a 100 mm diameter workpiece to be inspected using a 5X projection lens without needing to move the workpiece.

- The sloping screen design enables the operator to maintain a comfortable operational posture for long periods of time while making comparative measurements or tracing a projected image.

PV-5110

SPECIFICATIONS

Model No.		PV-5110
Order No.		304-919*1
Projected image		Inverted-reversed
Protractor screen	Effective diameter	ø508 mm (20 in)
	Screen rotation	±360° (±370° for display)
	Angle display	Digital counter (ABS/INC mode switching, Zero Set)
	Resolution	1′ or 0.01° (switchable)
	Mechanism	Fine feed and clamp
	Cross-hairs	90° (solid lines)
	Zero-base index	Built-in, With a LED back light
Projection lens	Magnification	10X (standard accessory), 5X, 20X, 50X, 100X
Illumination	Contour illumination	Halogen bulb (24 V, 150 W, 500 hours) (**512305**), 2-step (High/Low) brightness switch, Combination use with a color filter available
	Surface illumination	Double-lighting oblique surface illumination unit (optional), Halogen bulb (24 V, 150 W, 500 hours) (**512305**), 2-step (High/Low) brightness switch
Resolution for X/Y counter*2		—
Measuring unit		Digital scale
Measuring range (X×Y)		200×100 mm (164×68 mm*3)

*1 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix is required for PSE.
*2 X and Y counters are not built into the **PV-5110** main unit. If a counter display is required, it is recommended that a **QM-Data200** or **KA-212** is purchased separately.
*3 The range where no shading is observed using a 5X projection lens with contour illumination.

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PH-3515F
SERIES 172 — Profile Projector

- Standard models as used in the machine tool industry. Best for observation and measurement of cutting tools (end mills, lathe tools).
- The stage has a higher loading capacity (45 kg) than any other type of projector.

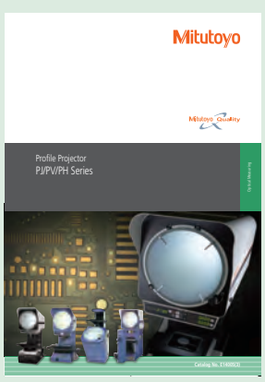
- Unique projector employing horizontal optical system. The optical axis and the stage are parallel, and the workpiece can be easily removed.

PH-3515F

SPECIFICATIONS

Model No.		PH-3515F
Order No.		172-868*1
Projected image		Erect-reversed
Protractor screen	Effective diameter	ø353 mm (13.9 in)
	Screen rotation	±360° (±370° for display)
	Angle display	Digital counter (ABS/INC mode switching), Zero Set
	Resolution	1′ or 0.01° (switchable)
	Mechanism	Fine feed and clamp
	Cross-hairs	90° (solid lines)
Projection lens	Magnification	10X (standard accessory), 5X, 20X, 50X, 100X
Illumination	Contour illumination	Halogen bulb (24 V, 150 W, 500 hours) (**515530**), 2-step (High/Low) brightness switch, Combination use with a color filter available
	Surface illumination (oblique)	Parabolic halogen bulb (24 V, 200 W, 50 hours) (**12BAA637**) Beam concentration and adjustment available, Heat-absorbing filter, Built-in cooling fan
Resolution for X/Y counter*2		—
Measuring unit		Digital scale
Measuring range (X×Y)		254×152 mm

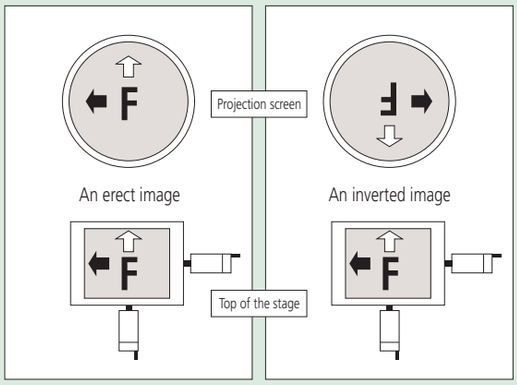
*1 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix is required for PSE.
*2 XY counter is not built in the main unit of the **PH-3515F**.
If a counter display is required, it is recommended to purchase the **QM-Data200** or a counter (**KA-212**) separately.
Note: Depending on the angle of illumination, measurement results may be smaller than actual values.



Refer to the Profile Projector Brochure (**E14005**) for more details.

Erect Image and Inverted Image

An image of an object projected onto a screen is erect if it is orientated the same way as the object on the stage. If the image is reversed top to bottom, left to right and by movement with respect to the object on the stage (as shown in the figure below) it is referred to as an inverted image (also known as a reversed image).



F Workpiece
⬅ X-axis movement
⇦ Y-axis movement

Magnification Accuracy

The magnification accuracy of a projector when using a certain lens is established by projecting an image of a reference object and comparing the size of the image of this object, as measured on the screen, with the expected size (calculated from the lens magnification, as marked) to produce a percentage magnification accuracy figure, as illustrated below. The reference object is often in the form of a small, graduated glass scale called a `stage micrometer' or `standard scale', and the projected image of this is measured with a larger glass scale known as a `reading scale'.

(Note: That magnification accuracy is not the same as measuring accuracy.)

$$\Delta M\,(\%) = \frac{L - \ell M}{\ell M} \times 100$$

ΔM (%): Magnification accuracy expressed as a percentage of the nominal lens magnification
L : Length of the projected image of the reference object measured on the screen
ℓ : Length of the reference object
M : Magnification of the projection lens

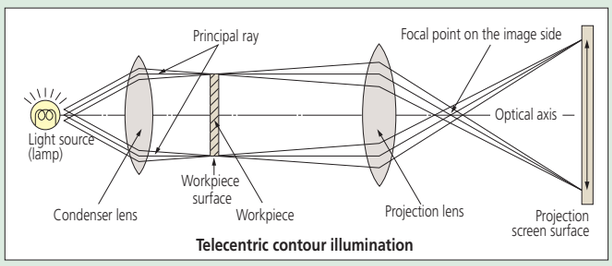
Type of Illumination

- Contour illumination: An illumination method to observe a workpiece by transmitted light and is used mainly for measuring the magnified contour image of a workpiece.
- Coaxial surface illumination: An illumination method whereby a workpiece is illuminated by light transmitted coaxially to the lens for the observation/measurement of a surface. (A half-mirror or a projection lens with a built-in half-mirror is needed.)
- Oblique surface illumination: A method of illumination by obliquely illuminating the workpiece surface. This method provides an image of enhanced contrast, allowing it to be observed three-dimensionally and clearly. However, note that an error is apt to occur in dimensional measurement with this method of illumination.
  (An oblique mirror is needed. **PJ-H30** models are supplied with an oblique mirror.)

Telecentric Optical System

An optical system based on the principle that the primary rays are aligned parallel to the optical axis by placing a lens stop on the focal point on the image side. Its functional feature is that the image will not vary in size even though the image blurs as the object is shifted along the optical axis.

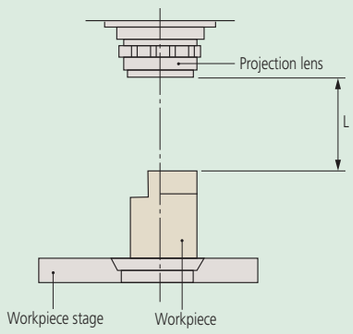
For measuring projectors and measuring microscopes, an identical effect is obtained by placing a lamp filament at the focal point of a condenser lens instead of a lens stop so that the object is illuminated with parallel beams. (See the figure below.)



Telecentric contour illumination

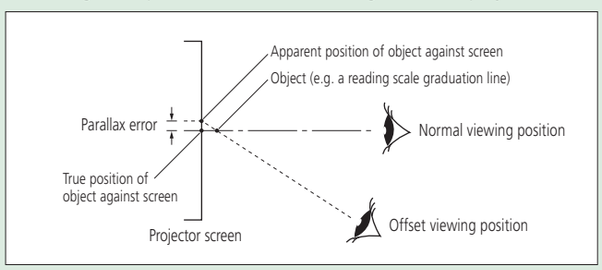
Working distance

Refers to the distance from the face of the projection lens to the surface of a workpiece in focus. It is represented by L in the diagram below.



Parallax error

This is the displacement of an object against a fixed background caused by a change in the observer's position and a finite separation of the object and background planes. Can cause a reading error on a projector screen.



Field of view diameter

The maximum diameter of the workpiece that can be projected using a particular lens.

$$\text{Field of view diameter (mm)} = \frac{\text{Screen diameter of profile projector (mm)}}{\text{Magnification of projection lens used}}$$

Example: If a 5X magnification lens is used for a projector with a screen of ø500 mm:
Field of view diameter is given by $\frac{500\text{ mm}}{5} = 100\text{ mm}$

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MF
SERIES 176 — Measuring Microscopes

- An easy-to-operate standard measuring microscope using specially designed long working distance **ML** objectives.
- Measuring accuracy is the highest in its class (and conforms to JIS B 7153).
- Illumination can be selected from an LED unit, which has a longer life, or a powerful halogen unit for high-magnification applications.
- Excellent usability, a high-NA and long working distance objectives enable effective observation.

Manual type

- Stages range in size from 100×100 mm to 400×200 mm.
- The XY stage is equipped with a quick-release mechanism that enables switching between coarse and fine feed to provide swift and precise stage movement, even over a large distance.

MF-B2017D
Note: The binocular tube (eyepiece) and illumination unit are optional accessories.

SPECIFICATIONS

Without Z-axis scale	Model No.	**MF-A1010D**	**MF-A2010D**	**MF-A2017D**	**MF-A3017D**	**MF-A4020D**
	Order No.	**176-861***1	**176-862***1	**176-863***1	**176-864***1	**176-865***1
With Z-axis scale	Model No.	**MF-B1010D**	**MF-B2010D**	**MF-B2017D**	**MF-B3017D**	**MF-B4020D**
	Order No.	**176-866***1	**176-867***1	**176-868***1	**176-869***1	**176-870***1
Observation image		BF (Bright-field)/Erect image				
Eyepiece with diopter adjustment		10X (eyepiece field number: 24), 15X, 20X Note: Monocular - one 10X eyepiece provided as standard; Binocular - two 10X eyepieces provided as standard				
Objective		**ML** objective 3X (provided as standard), 1X, 5X, 10X, 20X, 50X, 100X				
Illumination unit (One of the two options must be selected.)	LED illumination unit	Transmitted illumination: Telecentric system, Built-in aperture diaphragm, White LED light source, stepless light intensity control with cooling fan Reflected illumination: Koehler illumination, Variable aperture diaphragm mechanism, White LED light source, stepless light intensity control Control unit: Power ON/OFF switch (main switch), AC100 to 240 V power input connector				
	Halogen illumination unit	Transmitted illumination: Telecentric system, Built-in aperture diaphragm, Halogen bulb (50 W), stepless light intensity control, With cooling fan Reflected illumination: Koehler illumination, Variable aperture diaphragm mechanism, Halogen bulb (50 W), stepless light intensity control, With cooling fan Control unit: Power ON/OFF switch (main switch), AC100 to 240 V power input connector				
Stage	Measuring range	100×100 mm	200×100 mm	200×170 mm	300×170 mm	400×200 mm
	Quick-release mechanism	Provided as standard for the X and Y axes				
	Zero-set button	Provided as standard for the X and Y axes (and for the Z axis only for the **MF-B** type)				
Z axis	Max. workpiece height	150 mm		220 mm		
	Feed mechanism	Coaxial coarse and fine feed, handles on both sides (coarse: 30 mm/rotation, fine: 0.2 mm/rotation)				
Measuring accuracy*2 (X and Y axes, when not loaded)		(2.2 + 0.02L) µm L=measuring length (mm)				
Digital display	Resolution	1/0.5/0.1 µm 0.0001/0.00005/0.00001 in (switchable)				
	Display axes	X and Y (or X, Y, and Z only for the **MF-B** type)				
	Functions	Zero-setting, direction switching, RS-232C output, USB output (specific to **QSPAK**)				

*1 The following suffixes are added to the order No.to specify the User Manual's language: -10 for English; -11 for Simplified Chinese; No suffix for Japanese.
*2 Measuring method complies with JIS B 7153.

Motor-Driven Z-axis

- Freedom from burdensome focus adjustment even on a workpiece with many asperities allows the operator to perform stress-free measurement.
- Using the Vision Unit (optional) enables the image AF function.

MF-J2017D
Note: The binocular tube (eyepiece) and illumination unit are optional accessories.

SPECIFICATIONS for Motor-Driven Z-axis MF models

Model No.		**MF-J2017D**	**MF-J3017D**	**MF-J4020D**
Order No.		**176-891***1	**176-892***1	**176-893***1
Vision AF*2		Available		
Stage	Quick release mechanism	Fitted to X and Y axes		
	Zero set switch	Fitted to X and Y axes		
Z axis	Max. workpiece height	220 mm		
	Feed mechanism	Motordrive (Maximum measuring speed: 20 mm/s)		

*1 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix is required for PSE.
*2 Vision Unit and an image AF cable are separately required.
Note: The specification other than the above is subject to the **MF** Series.

Refer to the **MF**/**MF-U** Series Brochure (**E14003**) for more details.

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MF-U
SERIES 176 — Universal Measuring Microscopes

- Integration of metallurgical and measurement microscope functions provides high-resolution observation and a high-accuracy measurement solution.

MF-UB2017D
Note: The turret, objectives and illumination unit are optional accessories.

- Measuring accuracy is the highest in its class (and conforms to JIS B 7153).
- Illumination can be selected from an LED unit, which has a longer life, or a powerful halogen unit for high-magnification applications.
- Excellent usability, a high-NA and long working distance objectives enable effective observation.

Manual type

- Stages range in size from 100×100 mm to 400×200 mm.
- The XY stage is equipped with a quick-release mechanism that enables switching between coarse and fine feed to provide swift and precise stage movement, even over a large distance.

Refer to the **MF**/**MF-U** Series Brochure (**E14003**) for more details.

J

SPECIFICATIONS

BF (Bright-field)	Without Z-axis scale	Model No.	**MF-UA1010D**	**MF-UA2010D**	**MF-UA2017D**	**MF-UA3017D**	**MF-UA4020D**
		Order No.	**176-871***1	**176-872***1	**176-873***1	**176-874***1	**176-875***1
	With Z-axis scale	Model No.	**MF-UB1010D**	**MF-UB2010D**	**MF-UB2017D**	**MF-UB3017D**	**MF-UB4020D**
		Order No.	**176-876***1	**176-877***1	**176-878***1	**176-879***1	**176-880***1
BD (Bright-field/ Dark-field)	Without Z-axis scale	Model No.	**MF-UC1010D**	**MF-UC2010D**	**MF-UC2017D**	**MF-UC3017D**	**MF-UC4020D**
		Order No.	**176-881***1	**176-882***1	**176-883***1	**176-884***1	**176-885***1
	With Z-axis scale	Model No.	**MF-UD1010D**	**MF-UD2010D**	**MF-UD2017D**	**MF-UD3017D**	**MF-UD4020D**
		Order No.	**176-886***1	**176-887***1	**176-888***1	**176-889***1	**176-890***1
Observation image			BF (Bright-field), DF (Dark-field) (**MF-UC** and **MF-UD** models only), Polarization, Differential Interference Contrast (DIC)/Erect image				
Eyepiece (optional) with diopter adjustment			10X (eyepiece field number: 24, two eyepieces provided as standard), 15X, 20X				
Turret (required)	Bright-field (BF)		Manual/Motor (select either one)				
	Bright-field/dark-field (BD)						
Objective (optional)	Bright-field (BF)		**M Plan Apo**, **M Plan Apo HR**, **M Plan Apo SL**, **G Plan Apo**				
	Bright-field/dark-field (BD)		**BD Plan Apo**				
Illumination unit (One of the two options must be selected.)	LED illumination unit		Transmitted illumination: Telecentric system, Built-in aperture diaphragm, White LED light source, stepless light intensity control, With cooling fan Reflected illumination: Koehler illumination, Variable aperture diaphragm mechanism, White LED light source, stepless light intensity control Control unit: Power ON/OFF switch (main switch), AC100 to 240 V power input connector				
	Halogen illumination unit		Transmitted illumination: Telecentric system, Built-in aperture diaphragm, Halogen bulb (50 W), stepless light intensity control, With cooling fan Reflected illumination: Koehler illumination, Variable aperture diaphragm mechanism, 100 W or 150 W halogen bulb (selectable), external fiber-optic illumination, stepless light intensity control Control unit: Power ON/OFF switch (main switch), AC100 to 240 V power input connector				
Stage	Measuring range		100×100 mm	200×100 mm	200×170 mm	300×170 mm	400×200 mm
	Quick-release mechanism		Provided as standard for the X and Y axes				
	Zero-set button		Provided as standard for the X and Y axes (and for the Z axis only for the **MF-UB** and **-UD** types)				
Z axis	Max. workpiece height		150 mm		220 mm		
	Feed mechanism		Coaxial coarse and fine feed, handles on both sides (coarse: 10 mm/rotation, fine: 0.1 mm/rotation)				
Measuring accuracy*2 (X and Y axes, when not loaded)			(2.2 + 0.02L) µm L=measuring length (mm)				
Digital display	Resolution		1/0.5/0.1 µm 0.0001/0.00005/0.00001 in (switchable)				
	Display axes		X and Y (or X, Y, and Z only for the **MF-UB** and **-UD** types)				
	Functions		Zero-setting, direction switching, RS-232C output, USB output (specific to **QSPAK**)				

*1 The following suffixes are added to the order No.to specify the User Manual's language: -10 for English; -11 for Simplified Chinese; No suffix for Japanese.
*2 Measuring method complies with JIS B 7153.

Motor-Driven Z-axis

- Freedom from burdensome focus adjustment even on a workpiece with many asperities allows the operator to perform stress-free measurement.
- Using Vision Unit (optional) enables the image AF function.

MF-UJ2017D
Note: The turret, objectives and illumination unit are optional accessories.

J

SPECIFICATIONS for Motor-Driven Z-axis MF-U models

BF (Bright-field)	Model No.	**MF-UJ2017D**	**MF-UJ3017D**	**MF-UJ4020D**
	Order No.	**176-894**[*1]	**176-895**[*1]	**176-896**[*1]
BD (Bright-field/Dark-field)	Model No.	**MF-UK2017D**	**MF-UK3017D**	**MF-UK4020D**
	Order No.	**176-897**[*1]	**176-898**[*1]	**176-899**[*1]
Eyepiece (optional) with diopter adjustment		10X (eyepiece field number: 24, two eyepieces provided as standard), 15X, 20X		
Objective (optional)	Bright-field (BF)	**M Plan Apo**, **M Plan Apo HR**, **M Plan Apo SL**, **G Plan Apo**		
	Bright-field/dark-field (BD)	**BD Plan Apo**		
Vision AF[*2]		Available		
Stage	Measuring range	200×170 mm	300×170 mm	400×200 mm
	Quick release mechanism	Fitted to X and Y axes		
	Zero set switch	Fitted to X and Y axes		
Z axis	Max. workpiece height	220 mm		
	Feed mechanism	Motor drive (measuring speed: max. 20 mm/s)		
Measuring accuracy[*3] (X and Y axes, when not loaded)		(2.2 + 0.02L) µm L=measuring length (mm)		
Digital display	Resolution	1/0.5/0.1 µm 0.0001/0.00005/0.00001 in (switchable)		
	Display axes	X, Y and Z		
	Functions	Zero-setting, direction switching		

*1 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix is required for PSE.
*2 Vision Unit and an image AF cable are separately required.
*3 Measuring method complies with JIS B 7153.
Note: For all specifications not included above see page J-7.

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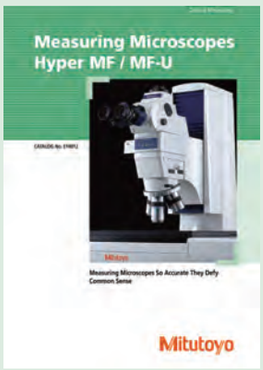
Hyper MF/MF-U
SERIES 176 — High-Accuracy Measuring Microscopes

- Ultra-high accuracy measuring microscopes achieving (0.9 + 3L/1,000) µm of accuracy.
- Three-axis motorized front operation joystick control, which makes a refreshing change from conventional microscope operation, allows fine positioning even during fast movement.
- Large workstage with stroke of 250×150 mm provides enough margin for the measurement of larger workpieces.
- The Vision Unit can be integrated to provide an effective and stable measurement environment.

Hyper MF-U
Note: The optical tube, turret, and objectives are optional.



Refer to the Hyper **MF/MF-U** Brochure (**E14012**) for more details.

J

SPECIFICATIONS

Model No.		HyperMF-B2515B	HyperMF-UB2515B	HyperMF-UD2515B	HyperMF-UE2515B	HyperMF-UF2515B
Order No.		176-430*1	176-431*1	176-432*1	176-433*1	176-434*1
Optical tube		Finite correction optical system BF (Bright-field)	Infinity-correction optical system BF (Bright-field)	Infinity-correction optical system BD (Bright/Dark-field)	Infinity-correction optical system BF (Bright-field) with the LAF function	Infinity-correction optical system BD (Bright/Dark-field) with the LAF function
	Standard reticle (Built-in)	90° broken-cross line (line width 5 µm)				
	Pupil distance adjustment	Siedentopf type Adjustment range: 51 to 76 mm				
	Optical path switching ratio	Observation/TV-photomicrography=50/50				
	Vertical tilt angle	25°	Tilting			
	TV port	Provided as standard				
Observation image		Erect image				
Eyepiece	Magnification	10X, 15X, 20X				
Objective (optional)		Selectable from the monocular unit (equipped with one eyepiece) or binocular tube (equipped with two eyepieces)	Equipped with two 10X eyepieces			
	ML Series objective	1X, 3X, 5X, 10X, 20X, 50X, 100X	—			
	BF (Bright-field)	—	**M Plan Apo**, **M plan Apo SL**, **G plan Apo**			
	BD (Bright/Dark-field)	—	**BD Plan Apo**			
Turret (optional)	BF (Bright-field)	—	(Equipped with a four-hole manual turret/motorized five-hole turret*2)			
	BD (Bright/Dark-field)	—	(Equipped with a four-hole manual turret/motorized four-hole turret*3)			
Focusing section	Maximum height of workpiece	150 mm				
	Measuring accuracy	(1.5 + 10L/1000) µm L=Measuring length (mm)				
	Drive method	Motorized control using a joystick				
Illumination unit	Transmitted illumination device	Telecentric system, Built-in aperture diaphragm, Halogen bulb (50 W), 100-step light intensity control, Fiber-optic cable cold light illumination				
	Reflected illumination unit	Koehler illumination, Variable aperture diaphragm mechanism, Halogen bulb (100 W), 100-step light intensity control, Fiber-optic cable cold light illumination				
Workstage	Measuring range (X×Y)	250×150 mm				
	Measuring accuracy*4 (When no load is put on the X or Y axis)	(0.9 + 3L/1000) µm L=Measuring length (mm)				
	Dimensions of the top plane	460×350 mm				
	Usable dimensions of the stage glass	300×200 mm				
	Swiveling angle	±3°				
	Maximum loading mass	30 kg				
	Drive method	Motorized control using a joystick				
Detector		High precision digital scale (Patented)				
Digital display	Resolution	0.01 µm				
	Axes to be displayed	X, Y, Z				
	Data processing unit	Vision Unit (required)				
Operation section	LAF (just focus)	—	—		Available	
	LAF (tracking focus)	—	—		Available	

*1 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, DC for CCC, E for BS, K for KC, C and No suffix is required for PSE.
*2 and *3 are factory-installed options.
*4 Measurement accuracy complies with JIS B 7153.

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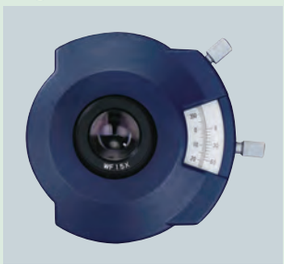
TM
SERIES 176 — Toolmakers' Microscopes

- Compact universal toolmakers' microscope that can be installed on any site.
- Newly designed LED illuminators provide enhanced observation for higher accuracy and resolution.
- Optional LED circular illuminator available for applications requiring all-round lighting.
- Achieves a maximum measuring height of 115 mm despite the compact size.
- Installation of Digimatic micrometer heads (**164-163**, optional) makes measurement easy and precise.
- A vernier scale (Angle Index) built into the eyepiece mount enables accurate angular measurements.
- Lenses are available for a wide range of magnifications (20X to 200X in total).

Angle Index (Standard Accessory)



TM-505B

TM-1005B

Note: Micrometer heads are optional.

SPECIFICATIONS

Model No.		**TM-505B**	**TM-1005B**
Order No.		**176-818**	**176-819**
Optical tube		Monocular type (Vertical tilt angle: 30°)	
Observation image		Erect	
Eyepiece protractor		Resolution (graduation): 1°, Rotation angle: 360°, Resolution (angle): 6', Adjustable zero point	
Eyepiece		Standard accessory: 15X (field number: 13), Options: 10X, 20X	
Objective		Standard accessory: 2X, Optional: 5X, 10X	
Microscope head	Maximum height of workpiece	115 mm	107 mm
	Focusing method	Manual (Coarse feed)	
Illumination unit	Transmitted illumination	Stepless brightness adjustment, White LED light source with green filter	
	Reflected illumination	Oblique single-source type, Stepless brightness adjustment, White LED light source	
Cross-travel stage	Measuring range	50×50 mm	100×50 mm (An optional 50 mm gauge block is required to cover full range. A CERA block is recommended.)
	Table size	152×152 mm	240×152 mm
	Usable area of the stage glass	96×96 mm	154×96 mm
	Maximum stage glass loading	5 kg	
Linear measurement method		Micrometer head*	
Resolution		Depends on the micrometer head specifications* (for **164-163**: 0.001 mm)	
Micrometer head travel range		For **164-163**: 50 mm	
Power supply		AC100 to 240 V 50/60 Hz Maximum power consumption: 4.2 W	
Main unit mass		14 kg	15 kg

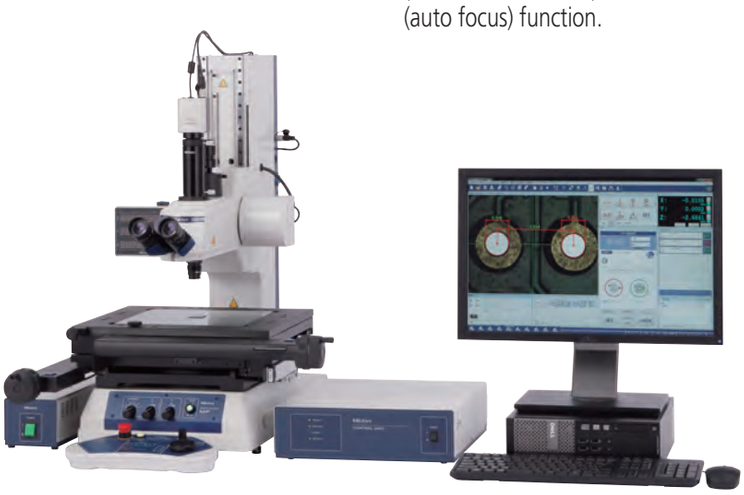
* Micrometer heads are optional for **TM-505B** and **TM-1005B**.
Note: The main unit with Digimatic micrometer head (**164-164**) is provided in the **TM** Series.
TM-A505B (**176-820A**)
TM-A1005B (**176-821A**)
Other specifications are the same as the other **TM** Series.

Refer to the **TM** Series Brochure (**E14013**) for more details.

MeasurLink® ENABLED
Data Management Software by Mitutoyo

Vision Unit
SERIES 359 — Vision System Retrofit for Microscopes

- The measurement tools and various macro icons allow measurement in one easy step.
- The graphics and measurement navigation functions facilitate operation.
- The image saving function and the data output function to the spreadsheet software are standard.
- Combined use with the **MF**/**MF-U** Series (Motor-Driven Z-axis) achieves the image AF (auto focus) function.



MF-J2017D plus Vision Unit

Foot switch
12AAJ088

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SPECIFICATIONS

Model	**Vision Unit**
Order No.	**359-763**
Magnification of the optical system	When installed on the microscope 0.5X (using the 0.5X TV adapter)
Image detection	High-sensitivity 1/2 inch color CMOS camera 3 megapixel
Resolution	0.1 µm
Accuracy (Measurement environment: 20 °C)	Depends on the accuracy specification of the Mitutoyo measuring microscope to which the unit is fitted. For reference: When using an **ML** Series 3X objective (In an inspection using a sample workpiece based on the Mitutoyo standards) Measurement accuracy in the screen: Within ±2.5 µm Repetitive accuracy in the screen (±2σ): Within ±1 µm
Software (optional)	**QSPAK VUE**

Note: Software (**QSPAK VUE**) and calculation processor are required separately.

Applicable Models

Mitutoyo **MF** Series, **MF-U** Series, **Hyper MF** Series, **Hyper MF-U** Series

Refer to the **QM-Data200** and Vision Unit Brochure (**E14008**) for more details.

MeasurLink® ENABLED
Data Management Software by Mitutoyo

QM-Data200
SERIES 264 — 2D Data Processing Unit

- 2D Data Processor designed to perform arithmetic processing of XY coordinate data acquired from projectors and measuring microscopes for local display or output to a printer.
- Informative color-graphic displays on the large LCD screen make for easy measurement operations.
- The AI measurement function (automatic identification of measuring item) eliminates switching between the measurement command keys.
- Equipped with a measurement procedure teaching function and measuring position navigation in Repeat mode.
- The user menu function allows users to register measurement commands or part programs to create their own menus.
- Measurement result output to CSV format in spreadsheet software.
- Measurement procedures and calculation results can be saved on a USB-compatible memory device.

QM-Data200
(stand type)

Foot switch
12AAJ088

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SPECIFICATIONS

Model No.	QM-Data200		
Order No.	Stand type	Flexible arm type	Stand type
	264-155*1	**264-156***1	**264-159***1
Applicable models (Conventional models)*2	**PJ-PLUS** Series **PJ-H30** Series **PV-5110** **PH-3515F** **MF** Series **MF-U** Series	**PJ-PLUS** Series **PJ-H30** Series **PV-5110***3 **PH-3515F***3	**Hyper MF/MF-U**
Unit of measurement	Length: mm Angle: Switchable between decimal degree and sexagesimal notation		
Resolution	0.1 µm		0.01 µm
Program function	Creating, performing, and editing of measurement procedures		
Statistical processing	Number of data, maximum value, minimum value, mean value, standard deviation, range, histogram, Statistics classified by each measurement function (Statistics classified by each command)		
Display unit	Color graphic LCD (equipped with LED backlight)		
ABS point	—		Available (Automatic movement)
LAF (Laser AF)	—		Available
Edge sensor position correction	Available (Profile Projectors with OPTOEYE 200)		—
Input/output	XYZ: Data input from linear scales (Maximum number of axes: 3) RS-232C 1: Connection to an external PC RS-232C 2: Connection to a measuring unit counter OPTOEYE: Connection to an OPTOEYE edge signal (OPTOEYE 200) FS: For the connection to the foot switch PRINTER: For the connection to an external printer USB-MEMORY: For the connection to a USB memory		
Measurement result file output	RS-232C output (CSV format, MUX-10 format)		
Display language	16 languages (Japanese, English, German, French, Italian, Spanish, Portuguese, Czech, Chinese (simplified/traditional), Korean, Turkish, Swedish, Polish, Dutch, Hungarian)		
Power supply	AC100 to 240 V		
Maximum power consumption	17 W (excluding optional accessories)		
External dimensions (W×H×D)	260×242×310 mm (including the stand section)	318×153×275 mm (when the arm is horizontal)	260×242×310 mm (including the stand section)
Mass	Approx. 2.9 kg	Approx. 2.8 kg	Approx. 2.9 kg
Standard Accessories	AC adapter, Power cable, Quick Operation Guide		

*1 To denote your AC power cable add the following suffixes to the order No.: A for UL/CSA, D for CEE, E for BS, K for KC, C and No suffix is required for PSE, and 00 for power cord other than A, D, E, K, C, No suffix.
*2 Please contact Mitutoyo sales office with respect to the models that are applicable to the models other than mentioned above.
*3 The flexible arm type cannot be used concurrently with a counter stand.

Refer to the **QM-Data200** and Vision Unit Brochure (**E14008**) for more details.

Mitutoyo

FS70
SERIES 378 — Microscope Unit for Semiconductor Inspection

- Compact microscope unit equipped with an eyepiece observation section.
- Can be used with YAG (near-infrared, visible, near-ultraviolet, or ultraviolet) lasers.*1

  *1 The performance and safety of laser-equipped system products is not guaranteed.

- Usable in infrared optical systems*2. Applications: observation of silicon wafers; spectral characteristics analysis using infrared.

  *2 An infrared source and infrared camera are necessary.

- Models supporting BF (Bright-field), DF (Dark-field), Polarization, and Differential Interference Contrast (DIC) are available.
- The inward-facing turret and long working distance objectives maintain the high operability of the microscope.

FS70Z

FS70L4

Note: The parfocal manual turret, eyepieces and objectives are optional.

Refer to the Microscope Units and Objectives Brochure (**E14020**) for more details.

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SPECIFICATIONS

Standard head type	Model No.	**FS70**	—	**FS70Z**	—	**FS70ZD**	**FS70L**	**FS70L4**
	Order No.	**378-184-1**	—	**378-185-1**	—	Made-to-order	**378-186-1**	**378-187-1**
Tilting head type	Model No.	—	**FS70-TH**	—	**FS70Z-TH**	**FS70ZD-TH**	**FS70L-TH**	**FS70L4-TH**
	Order No.	—	**378-184-3**	—	**378-185-3**	Made-to-order	**378-186-3**	**378-187-3**
Focus adjustment		50 mm travel range with concentric coarse (3.8 mm/rev) and fine (0.1 mm/rev) focusing wheels (right/left)						
Observation image		Erect image						
	BF (Bright-field)	✔	✔	✔	✔		✔	✔
	BD (Bright-field/Dark-field)					✔		
	Polarization	✔	✔	✔	✔	✔	✔	✔
	Differential Interference Contrast (DIC)	✔	✔	✔	✔	✔		
Optical tube type		Siedentopf, adjustable interpupillary distance range: 51 to 76 mm						
Field number		24 mm						
Tilt angle		0 to 20°, displacement of eye point: 114 mm (only for tilting head type)						
Optical pass ratio		Fixed type (Eyepiece/TV=50/50)	Switchable type (Eyepiece/Tube=100/0: 0/100)	Fixed type (Eyepiece/TV=50/50)	Switchable type (Eyepiece/Tube=100/0: 0/100)	Fixed type*1 (Eyepiece/TV=50/50)	Switchable type (Eyepiece/Tube=100/0: 0/100)	
Protective filter		—					Built-in laser beam filter	
Tube lens		1X		1X to 2X zoom			1X	
Applicable laser		—					1064/532/355 nm	532/266 nm
Camera mount		C-mount (using optional adapter B*2)					Use a laser with TV port.	C-mount receptacle (with green filter switch)
Optical system epi-illumination		Epi-illumination for Bright-field (Koehler illumination, with aperture diaphragm)						
Illumination unit (optional)		Fiber-optic illumination unit (100 W), stepless adjustment, light guide length: 1.5 m						
Objective, optional (for observation)		**M Plan Apo/HR/SL, G Plan Apo**				**BD Plan Apo**	**M Plan Apo/HR/SL, G Plan Apo**	
Objective, optional (for laser-cutting)		—					**NIR** Series **NUV** Series	**UV** Series
Loading*3		14.5 kg	13.6 kg	14.1 kg	13.2 kg	14.1 kg (tilting head type: 13.2 kg)	14.2 kg (tilting head type: 13.5 kg)	13.9 kg (tilting head type: 13.1 kg)
Mass (main unit)		6.1 kg	7.1 kg	6.6 kg	7.5 kg	6.6 kg (tilting head type: 7.5 kg)	6.4 kg (tilting head type: 7.2 kg)	6.7 kg (tilting head type: 7.5 kg)

*1 It is a switchable type when using **FS70ZD-TH** (Tilting head type).
*2 Installation is optional.
*3 Loading on optical tube excluding weight of objectives and eyepieces

Note: Observe the following precautions when using **FS70L** or **FS70L4** with YAG laser source attached.
- Be aware of the laser power and energy density limitations of the optical system to avoid damage.
- Check the mass of the laser source. When mounting on a high-speed device or acceleration/deceleration device, please contact us.

VMU
SERIES 378 — Microscope unit for incorporating in Equipment

- Compact and lightweight microscope designed to be built in for camera observation
- Can be used with YAG (near-infrared, visible, near-ultraviolet, or ultraviolet) lasers.*1

*1 The performance and safety of laser-equipped system products is not guaranteed.

- For **VMU-LB** and **VMU-L4B**, the rigidity and general performance of the microscope main unit have been enhanced compared with previous models.
- Compatible with infrared optical systems*2

*2 An infrared source and infrared camera are necessary.

- Telecentric system equipped with an aperture diaphragm is standard on the epi-illumination optical system.
- Best suited to process images for which uniform illumination is required.
- Design and manufacture are flexible to meet your demands such as double camera mounting or double (low/high) magnification.

VMU-V　VMU-H　VMU-LB　VMU-L4B

SPECIFICATIONS

Model No.		VMU-V	VMU-H	VMU-LB	VMU-L4B
Order No.		378-505	378-506	378-513	378-514
Camera mounting direction		Vertical	Horizontal	Vertical (Rotatable)	
Observation		Bright-field/Erect image	Bright-field/Inverted image	Bright-field/Erect image	
Optical tube	TV adapter	Equipped with a C-mount			Equipped with a C-mount (Equipped with a green filter switching mechanism)
	Image forming (tube) lens	Built-in 1X (visible/near-infrared calibration)		Built-in 1X (near-infrared/visible/near-ultraviolet calibration)	Built-in 1X (ultraviolet/visibility compensation)
	Available for lasers	—		YAG laser source (Fundamental, Second/Third harmonic) mountable	YAG laser source (Second/Third/Fourth harmonic) mountable
Objective (optional)	For observation	**M Plan Apo**, **M Plan Apo HR**, **M Plan Apo SL**, **G Plan Apo**			
	For laser processing	—		**NIR** Series **NUV** Series Note 1: Selected depending on the wavelength of the laser source	**NIR** Series **NUV** Series **UV** Series Note 2: Selected depending on the wavelength of the laser source
Applicable camera (s)		2/3 type or less cameras (C-mount type)			
Optical system epi-illumination		Telecentric system equipped with an aperture diaphragm			
Illuminated lens tube		Bright-field illuminated lens tube			
Illumination unit (optional)		Fiber-optic cable illumination unit (100 W) (**378-700**)			
Main unit mass		650 g	750 g	1270 g	1300 g

Note 3: The **M Plan Apo 1X** objective is used with the polarization unit (**378-710** or **378-715**).

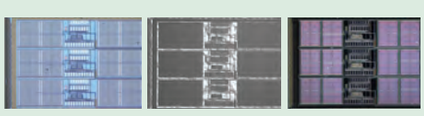
Refer to the Microscope Units and Objectives Brochure (**E14020**) for more details.

WIDE VMU

- Observation over a wide field of view (Image field of ø30 mm)
- Greatly enhanced brightness on the periphery of the field of view (Reduces the dependence on the light distribution characteristics.)
- Compatible with infrared optical systems*

* An infrared source and infrared camera are necessary. For more details on infrared observation, contact your local Mitutoyo sales office.

- Small optical observation system
- Compatible with **HR** series of high resolving power lens (Designed with pupil diameter of ø16.8 mm)
- Available for various observation methods (Including bright-field, dark-field for visual or scratch inspection, and polarized observation of objects with polarization characteristics)



Bright-field　Infrared　Dark-field

WIDE VMU-HR　WIDE VMU-BDV　WIDE VMU-BDH

SPECIFICATIONS

		For Bright-field Observation	For Bright/Dark-field Observation	
Model No.		**WIDE VMU-HR**	**WIDE VMU-BDV**	**WIDE VMU-BDH**
Order No.		**378-519**	**378-517**	**378-518**
Camera mounting orientation		Vertical	Vertical	Horizontal
Observation		Bright-field/Erect image	Bright/Dark-field/Erect image	Bright/Dark-field/Inverted image
Optical tube	Optical system	Magnification: 1X　Visible light - Near-infrared light	Magnification: 1X　Visible light	
	Camera Mount	F-Mount, C-Mount (with aligning and parfocal adjustment mechanism)		
	Imaging forming (tube) lens	Built in 1X (visible - NIR)	Built in 1X (visible)	
	Image field	ø30		
	Polarized unit*1	Mountable		
Objective (required option)		**M Plan Apo**, **M Plan Apo HR**, **M Plan Apo SL**, **G Plan Apo**, **NIR** Series	**BD Plan Apo**	
Applicable camera		Diagonal line length: 30 mm or less (equivalent to APS-C format)		
Optical system epi-illumination		Telecentric (Pupil diameter of ø16.8) Note: Coaxial epi-illumination, with aperture diaphragm	Telecentric illumination, Bright/Dark-field illumination optical tube (Dual-port fiber-optic illumination) Bright/Dark-field switching with light source on-off	
Illuminated lens tube		Bright-field illuminated lens tube (rotatable) *3, selectable between LED adapter and fiber adapter (both supplied as standard)	Bright-field illuminated lens tube (rotatable) *3	
Illumination unit (optional)*2		Fiber-optic illumination unit (100 W) (**378-700**)		
Main unit mass		1400 g	2000 g	2150 g

*1 Polarized observation by Bright-field illumination　*2 Support for third-party LED illuminators (**WIDE VMU-HR** only)
*3 The fiber (light source) mount orientation can be changed.

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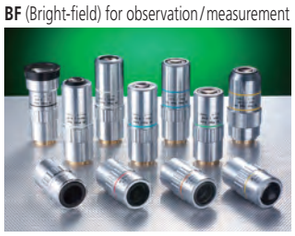
Mitutoyo

FS Objectives
SERIES 378 — Ultra-long working distance Objectives

- **M**/**BD Plan Apo** (M Plan Apochromat Bright/Dark-field) objectives feature the image evenness over the entire view field needed to achieve high color reproducibility.
- The following objectives support a wide range of wavelength including near infrared, visible, and ultraviolet lasers. Specialty LCD laser objectives are available: **NIR** (**-HR**) Series (Near-infrared lenses for laser processing featuring ultra-long working distances), **NUV** Series (Near-ultraviolet lenses), **UV** Series (Ultraviolet lenses), and **G Plan Apo** (Cover Glass corrected lenses that allow focusing through a window for vacuum and high temperature applications).
- Uses environment-friendly glass (no lead or arsenic) for the lens material.

BF (Bright-field) for observation/measurement



BD (Bright/Dark-field) for observation/measurement

For near-infrared calibration (**NIR**)

For near-ultraviolet calibration (**NUV**)

For the ultraviolet calibration (**UV**)

Refer to the Microscope Units and Objectives Brochure (**E14020**) for more details.

Varifocal Lens
TAGLENS

- Without changing the required magnification, ultra-high speed variable focal length enables obtaining perfectly focused images in real-time with stress-free operation.
- The time required for auto-focusing is drastically reduced, and the optical system focus range is extended without the expense of a mechanical drive.

TAGLENS-T1

Ultra-high speed, varifocal lens.
A dedicated controller and software are equipped as standard.

SPECIFICATIONS

Operating principle	Variable refraction index
Resonance frequency	70 kHz
Effective aperture	ø11 mm*
Transmittance	90% or more (λ400 to 700 nm)*

* The above value are based on optical design theoretically.

Video Microscope Unit VMU-T1

Microscope unit for configuring a varifocal optical system by incorporating **TAGLENS-T1**, the objective and the camera.

SPECIFICATIONS

Compatible TAGLENS	**TAGLENS-T1**
Imaging lens magnification	1X
Imaging area	ø11 mm
Applicable objective	**M Plan Apo** Series
Options	Manual turret, Power turret, Polarizer, Focusing unit A or B, XY stage, Simplified stand.

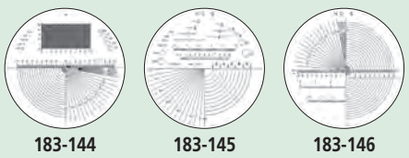
M Plan Apo Series

Objective		1X	2X	5X	7.5X	10X	20X	50X
Depth of focus×2 (mm)		0.88	0.18	0.028	0.012	0.007	0.003	0.0018
Total scanning width (mm)		16	4.0	0.64	0.28	0.16	0.04	0.007
Real FOV (mm)	1/2 inch camera	4.8×6.4	2.4×3.2	0.96×1.28	0.64×0.85	0.48×0.64	0.24×0.32	0.096×0.128
	2/3 inch camera	6.6×8.8	3.3×4.4	1.32×1.76	0.88×1.17	0.66×0.88	0.33×0.44	0.132×0.176

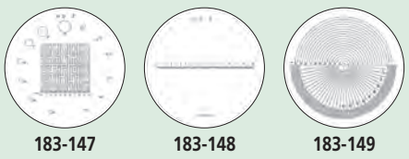
Refer to the Varifocal Lens **TAGLENS** Brochure (**E14025**) for more details.

Optional Reticles for pocket comparators

183-141 183-142 183-143



183-144 183-145 183-146



183-147 183-148 183-149

183-150 183-151 183-152

Mini Scope SERIES 183

- Portable and easy to carry. Provides 25X magnification for high-resolution observation.

183-210

SPECIFICATIONS

Magnification	Order No.	Remarks
25X	**183-210**	Pen type

Note: Not compatible with the interchangeable reticles.

Pocket Comparators SERIES 183

- By replacing optional reticles, dimensional, angle, and other types of measurement can be performed.

183-140

SPECIFICATIONS

Magnification	Order No.	Remarks
10X	**183-140**	Optional reticles available

Clear Loupe SERIES 183

- Three magnification options selectable according to your application.

183-310 183-311 183-312

SPECIFICATIONS

Magnification	Order No.	Remarks
5X	**183-310**	Drawtube removable
10X	**183-311**	Drawtube removable
15X	**183-312**	Drawtube removable

Note: Not compatible with the interchangeable reticles.

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Quick Guide to Precision Measuring Instruments

Microscopes

Numerical Aperture (NA)

The NA figure is important because it indicates the resolving power of an objective. The larger the NA value the finer the detail that can be seen. A lens with a larger NA also collects more light and will normally provide a brighter image with a narrower depth of focus than one with a smaller NA value.

$$NA = n \cdot \sin\theta$$

The formula above shows that NA depends on n, the refractive index of the medium that exists between the front of an objective and the specimen (for air, n = 1.0), and angle θ, which is the half-angle of the maximum cone of light that can enter the lens.

Resolving Power (R)

The minimum detectable distance between two image points, representing the limit of resolution. Resolving power (R) is determined by numerical aperture (NA) and wavelength (λ) of the illumination.

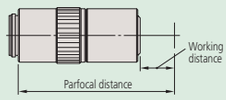
$$R = \frac{\lambda}{2 \cdot NA} \ (\mu m) \quad \lambda = 0.55\ \mu m \text{ is often used as the reference wavelength}$$

Working Distance (W.D.)

The distance between the front end of a microscope objective and the surface of the workpiece at which the sharpest focusing is obtained.

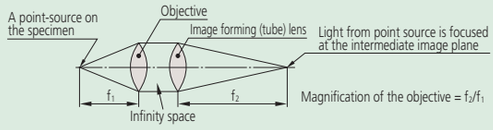
Parfocal Distance

Distance between the surface of the specimen and the objective's seating surface when in focus.



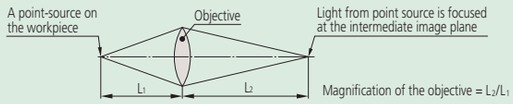
Infinity-corrected Optical System

An optical system in which the image is formed by an objective and a tube lens with an 'Infinity Space' between them, into which optical accessories can be inserted.



Finite-corrected Optical System

An optical system in which the image is formed only by an objective.



Focal Length (f)

unit: mm

The distance from the principal point to the focal point of a lens: if f_1 represents the focal length of an objective and f_2 represents the focal length of an image forming (tube) lens then magnification is determined by the ratio between the two. (In the case of the infinity-correction optical system.)

$$\text{Objective magnification} = \frac{\text{Focal length of the image-forming (tube) lens}}{\text{Focal length of the objective}}$$

Example: $1X = \frac{200}{200}$ Example: $10X = \frac{200}{20}$

Focal Point

Light rays traveling parallel to the optical axis of a converging lens system and passing through that system will converge (or focus) to a point on the axis known as the rear focal point, or image focal point.

Depth of Focus (DOF)

unit: mm

This is the distance (measured in the direction of the optical axis) between the two planes which define the limits of acceptable image sharpness when the microscope is focused on an object. As the numerical aperture (NA) increases, the depth of focus becomes shallower, as shown by the expression below:

$$DOF\,(\mu m) = \frac{\lambda}{2 \cdot (NA)^2} \quad \lambda = 0.55\ \mu m \text{ is often used as the reference wavelength}$$

Example: For an **M Plan Apo 100X** lens (NA = 0.7)
The depth of focus of this objective is

$$\frac{0.55\ \mu m}{2 \times 0.7^2} = 0.6\ \mu m$$

Bright-field and Dark-field Illumination

In bright-field illumination a full cone of light is focused by the objective on the specimen surface. This is the normal mode of viewing with an optical microscope. With dark-field illumination, the inner area of the light cone is blocked so that the surface is only illuminated by light from an oblique angle. Dark-field illumination is good for detecting surface scratches and contamination.

Apochromat and Achromat Objectives

An apochromat objective is a lens corrected for chromatic aberration (color blur) in three colors (red, green, blue). An achromat objective is a lens corrected for chromatic aberration in two colors (red, blue).

Magnification

The ratio of the size of a magnified object image created by an optical system to that of the object. Magnification commonly refers to lateral magnification although it can mean lateral, vertical, or angular magnification.

Principal Ray

A ray considered to be emitted from an object point off the optical axis and passing through the center of an aperture diaphragm in a lens system.

Aperture Diaphragm

An adjustable circular aperture which controls the amount of light passing through a lens system. It is also referred to as an aperture stop and its size affects image brightness and depth of focus.

Field Stop

An aperture which controls the field of view in an optical instrument.

Telecentric System

An optical system where the light rays are parallel to the optical axis in object and/or image space. This means that magnification is nearly constant over a range of working distances, therefore almost eliminating perspective error.

Erect Image

An image in which the orientations of left, right, top, bottom and moving directions are the same as those of a workpiece on the workstage.

Field number (FN), real field of view, and monitor display magnification

unit: mm

The observation range of the sample surface is determined by the diameter of the eyepiece's field stop. The value of this diameter in millimeters is called the field number (FN). In contrast, the real field of view is the range on the workpiece surface when actually magnified and observed with the objective. The real field of view can be calculated with the following formula:

(1) The range of the workpiece that can be observed with the microscope (diameter)

$$\text{Real field of view} = \frac{\text{FN of eyepiece}}{\text{Objective magnification}}$$

Example: The real field of view of a 10X lens is $2.4 = \frac{24}{10}$

(2) Monitor observation range

$$\text{Monitor observation range} = \frac{\text{The size of the camera image sensor (Length} \times \text{Height)}}{\text{Objective magnification}}$$

Size of image sensor

Format	Diagonal length	Length	Height
1/3 in	6.0	4.8	3.6
1/2 in	8.0	6.4	4.8
2/3 in	11.0	8.8	6.6

(3) Monitor display magnification

$$\text{Monitor display magnification} = \text{Objective magnification} \times \frac{\text{Display diagonal length on the monitor}}{\text{Diagonal length of camera image sensor}}$$

CNC Vision Measuring System
QUICK VISION Pro Series

Refer to page K-4 for details.

Vision Measuring Machine with Micro-Form Scanning Probe
MiSCAN Vision System

Refer to page K-10 for details.

Vision Measuring System
QUICK SCOPE QS-L

Refer to page K-13 for details.

K

Vision Measuring Systems

Smart Measuring System

An online system to monitor the operational and mechanical statuses of measuring machines. This allows you to grasp the state of a process flow from the operational statuses of measuring machines within a production process.

MeasurLink® ENABLED
Data Management Software by Mitutoyo

Measurement Data Network System

MeasurLink® is a measurement data management system based on databases (SQL Server). You can build a network to manage the measurement results and measuring machines by simply combining the functions necessary for your purpose.

MeasurLink® is a registered trademark of Mitutoyo Corporation in Japan and Mitutoyo America Corporation in the United States.

Measuring Instruments Shipped with Inspection Certificate

Mitutoyo guarantees product quality as a leading precision measuring instrument manufacturer and ships measuring instruments with an inspection certificate that includes inspection data so that customers can use them with confidence.

MiCAT
Mitutoyo Intelligent Computer Aided Technology
the standard in world metrology software
VISION

Measurement Program

"MiCAT Planner" automatic measurement program generation software is supported.

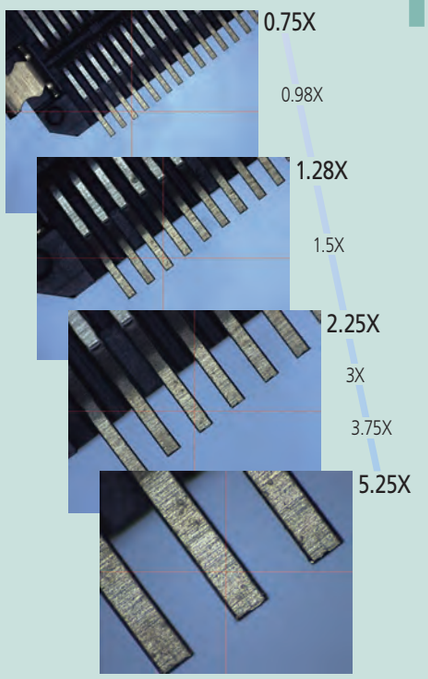
INDEX

Mitutoyo

QV Active
CNC Vision Measuring System

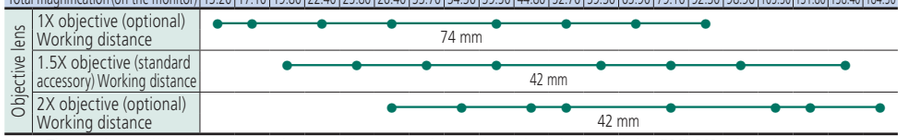
- Cost effective, multifunction, CNC Vision Measuring System.
- Usability has been improved by adopting a color camera and 8-step zoom optics.
- The zoom ratio of 7X (14X at maximum by changing the fixed-magnification objective lens) enables a wide range of inspection from wide view measurement at low magnification to micro-measurement at high magnification.
- The 74 mm maximum working distance (1X optional objective) promotes safe working by reducing the risk of collision, and allows greater freedom in fixture design.

QV Active 404



From wide view measurement to micro-measurement

Optical magnification		0.5X	0.65X	0.75X	0.85X	0.98X	1X	1.28X	1.3X	1.5X	1.7X	2X	2.25X	2.5X	3X	3.5X	3.75X	4X	5X	5.25X	7X
View field (mm)	Horizontal (H)	13.60	10.46	9.07	8.00	6.94	6.80	5.31	5.23	4.53	4.00	3.40	3.02	2.72	2.27	1.94	1.81	1.70	1.36	1.30	0.97
	Vertical (V)	10.80	8.31	7.20	6.35	5.51	5.40	4.22	4.15	3.60	3.18	2.70	2.40	2.16	1.80	1.54	1.44	1.35	1.08	1.03	0.77
Total magnification (on the monitor)		13.20	17.10	19.80	22.40	25.80	26.40	33.70	34.30	39.50	44.80	52.70	59.30	65.90	79.10	92.30	98.90	105.50	131.80	138.40	184.50



Note: The total magnification indicates the magnification on the monitor when the size of the **QVPAK** video window is 178.8×143.0 mm (default).

SPECIFICATIONS

Model No.		QV Active 202	QV Active 404
Type		Standard model	Standard model
Measuring range (X×Y×Z)		250×200×150 mm (250×200×118 mm: when 1X objective is used)	400×400×200 mm (400×400×168 mm: when 1X objective is used)
Observation unit		Zoom unit (8 positions)	
Imaging device		Color CMOS camera	
Vision measuring accuracy*	E_{1X}, E_{1Y}	(2 + 3L/1000) µm	
	E_{1Z}	(3 + 5L/1000) µm	
	E_2	(2.5 + 4L/1000) µm	
	Accuracy guaranteed with optics specified	Objective: 1.5X, Optical magnification: 5.25X	
Accuracy guaranteed temperature		20±1 °C	20±1 °C

* Inspected to a Mitutoyo standard. L=length between two arbitrary points (mm)

Refer to the **QUICK VISION Active** Series Brochure (**E14022**) for more details.

QV APEX Pro/QV HYPER Pro CNC Vision Measuring System

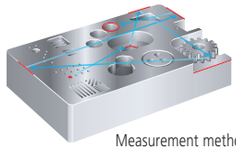
- Equipped with a strobe light and the newly developed StrobeSnap function, **QUICK VISION Pro** models deliver high-speed, high-accuracy measurements.
- The STREAM function is an optional upgrade to improve productivity by up to five times.

QV APEX 404 Pro

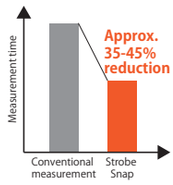
QV HYPER 302 Pro

StrobeSnap

All the **QUICK VISION Pro** models are equipped with a strobe light, and the newly developed vision measuring function "StrobeSnap" delivers measurements with both high throughput and high accuracy. Regardless of the continuity of measuring positions, measuring time can be shortened by about 35 to 45% for most measurement samples.



Measurement method

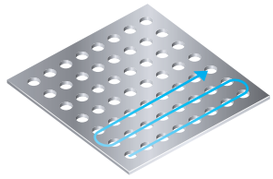


Note: Comparison with old specifications using our demo sample

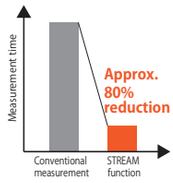
STREAM function (optional)

The STREAM function provides an amazingly high throughput, due to the non-stop measurement where the camera motion and the strobe light are synchronized.
It can shorten measuring time more than StrobeSnap on account of continuous element measurement as shown in the following conceptual image of measurement.

XY=0.2 mm pitch, 626
Measured with a field of view of 0.62×0.47 mm
STREAM measurement 36 sec.



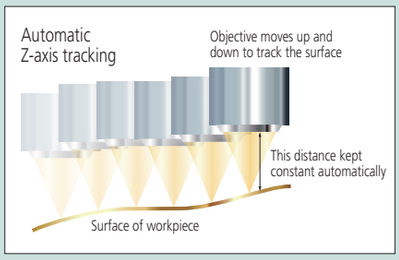
Measurement method



Note: Comparison with old specifications using our demo sample

Tracking Auto Focus (TAF)

Laser emitted from the objective lens enables automatic focusing.
The system automatically keeps the object in focus according to its shape, eliminating the task of focus adjustment and increasing measurement throughput.



Laser source	Semiconductor laser (peak wavelength: 690 nm)
Laser safety	Class 2 (JIS C6802: 2014, EN/IEC 60825-1: 2014)
Auto focus system	Objective co-axial autofocusing (knife-edge method)

Refer to the **QUICK VISION** Series Brochure (**E14028**) for more details.

SPECIFICATIONS

QV APEX Pro

Items \ Model No.		QV APEX 302 Pro	QV APEX 404 Pro	QV APEX 606 Pro
Measuring range (X×Y×Z)		300×200×200 mm	400×400×250 mm	600×650×250 mm
Observation unit		Programmable power turret 1X-2X-6X		
Imaging device		B&W CMOS		
Vision measuring accuracy*	E_{UX}/E_{UY}, MPE	(1.5 + 3L/1000) µm		
	E_{UXY}, MPE	(2.0 + 4L/1000) µm		
	E_{UZ}, MPE	(1.5 + 4L/1000) µm		

QV HYPER Pro (Specifications other than as quoted in the table are the same as the QV APEX Pro specifications.)

Items \ Model No.		QV HYPER 302 Pro	QV HYPER 404 Pro	QV HYPER 606 Pro
Imaging device		B&W CMOS		
Vision measuring accuracy*	E_{UX}/E_{UY}, MPE	(0.8 + 2L/1000) µm		
	E_{UXY}, MPE	(1.4 + 3L/1000) µm		
	E_{UZ}, MPE	(1.5 + 2L/1000) µm		

* L=length between two arbitrary points (mm)

SMS Smart Measuring System

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PROPRIETARY INSPECTION CERTIFICATE

QV ACCEL
Large CNC Vision Measuring System

- This is a vision measuring machine with moving-bridge type main unit structure suitable for measuring large, thin workpieces.
- **QV ACCEL 1212** (range: 1250×1250×100 mm) and **QV ACCEL 1517** (range: 1500×1750×100 mm) are available to special order.
- As the stage is immobile on the moving-bridge structure, you can use a simple method to fix a workpiece.

QV ACCEL 808

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SPECIFICATIONS

Items \ Model No.			QV ACCEL 808	QV ACCEL 1010
Measuring range (X×Y×Z)			800×800×150 mm	1000×1000×150 mm
Observation unit			Programmable power turret 1X-2X-6X	
Imaging device			B&W CCD (1/2 in)	
Vision measuring accuracy*	E_{1X}, E_{1Y}		(1.5 + 3L/1000) μm	
	E_{1Z}		(1.5 + 4L/1000) μm	
	E_{2XY}		(2.5 + 4L/1000) μm	
Repeatability*	Short dimension	X, Y axis	3σ≤0.2 μm	
	Long dimension		3σ≤0.7 μm	
Tracking auto focus device			Optional	

* Inspected to a Mitutoyo standard. L=length between two arbitrary points (mm)

Refer to the **QUICK VISION** Series Brochure (**E14028**) for more details.

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Data Management Software by Mitutoyo

ULTRA QV
Ultra-High Accuracy CNC Vision Measuring System

ULTRA QV 404

- Ultra-high accuracy CNC vision measuring machine with measuring accuracy of E_{1XY} (0.25 + L/1000) µm.
- Our proprietary high-resolution (Resolution: 0.01 µm) and high-accuracy low-expansion glass scales are used on the X, Y and Z axes.
- The main unit utilizes a highly rigid moving Y-axis table with a fixed bridge. The base is made of high stability granite.
- This model is standard-equipped with an automatic temperature compensation function that uses a temperature sensor on the main unit of the measuring machine and a temperature sensor for the workpiece.

SPECIFICATIONS

Items \ Model No.		ULTRA QV 404
Measuring range (X×Y×Z)		400×400×200 mm
Observation unit		Programmable power turret 1X-2X-6X
Imaging device		B&W CCD (1/2 in)
Vision measuring accuracy*1	E_{1X}, E_{1Y}	(0.25 + L/1000) µm
	E_{1Z} (Full stroke)	(1.5 + 2L/1000) µm (Range 200 mm)
	E_{1Z} (50 mm stroke)*2	(1.0 + 2L/1000) µm (Range 10 to 60 mm)
	E_{2XY}	(0.5 + 2L/1000) µm
Tracking auto focus device		Optional

*1 Inspected to a Mitutoyo standard. L=length between two arbitrary points (mm)
*2 Verified at shipment from factory.

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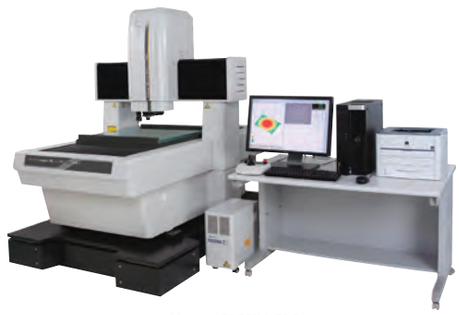
Data Management Software by Mitutoyo

Hyper QVWLI
Non-contact 3D Measuring System



Hyper QVWLI 606

- **Hyper QVWLI** is a high-accuracy dual 3D measurement system consisting of **QV** and a white light interferometer.
- You can perform 3D surface texture analysis from 3D data captured by the WLI optical system. You can also perform dimension measurement and cross-section measurement at a specific height using the 3D data.

SPECIFICATIONS

Items \ Model No.		Hyper QVWLI 302	Hyper QVWLI 404	Hyper QVWLI 606
Measuring range (X×Y×Z)	Vision measuring area	300×200×190 mm	400×400×240 mm	600×650×220 mm
	WLI measuring area*1	215×200×190 mm	315×400×240 mm	515×650×220 mm
WLI optical head unit				
View field (H×V)		5X lens: approx. 0.64×0.48 mm/10X lens: approx. 0.32×0.24 mm/ 25X lens: approx. 0.13×0.10 mm/50X lens: approx. 0.064×0.048 mm		
Z repeatability		2σ ≤ 0.08 µm		
Vision optical head unit				
Observation unit		Programmable power turret 1X-2X-6X		
Imaging device		B&W CCD (1/2 in)		
Vision measuring accuracy*2	E_{1X}, E_{1Y}	(0.8 + 2L/1000) µm		
	E_{1Z}	(1.5 + 2L/1000) µm		
	E_{2XY}	(1.4 + 3L/1000) µm		

*1 Movable range of **WLI** optical head.
*2 Inspected to a Mitutoyo standard. L=length between two arbitrary points (mm)

Refer to the **QUICK VISION** Series Brochure (**E14028**) for more details.

Mitutoyo

QV TP Active/QV TP Pro
CNC Vision Measuring System equipped with a Touch Trigger Probe

Non-contact and contact measurement on one machine

- **QV** touch-trigger probe unit enables both vision measurement and touch-trigger probe measurement.

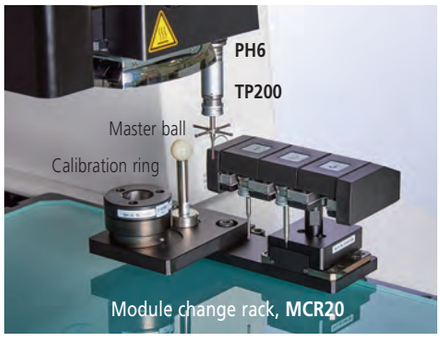
3D workpiece measurement

- Enables 3D measurement of workpieces, such as press-molded products, plastic-molded products, and machined products, that until now could not be measured with image processing alone.

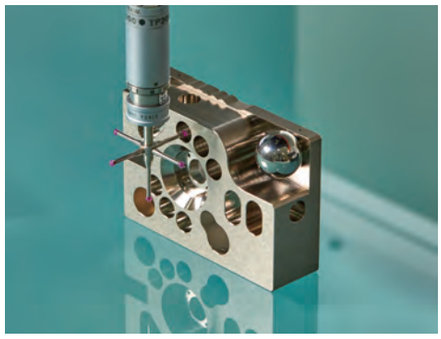
Module change rack available

- Using the module change rack enables switching between vision measurement and touch probe measurement during an automatic measuring sequence.

QV TP HYPER 404 Pro



Module change rack, **MCR20**



SPECIFICATIONS WITH TOUCH-TRIGGER PROBE OPTIONS MOUNTED

Items / Model No.		QV TP Active 202	QV TP Active 404
Measuring range*1 (XxYxZ)	Vision	250×200×150 mm	400×400×200 mm
	Common to Touch-trigger Probe	184×200×150 mm	334×400×200 mm
Measuring accuracy*2 (Touch-trigger probe)	E_{1X}, E_{1Y}, E_{1Z}	(2.4 + 3L / 1000) µm	(2.4 + 3L / 1000) µm

Items / Model No.		QV TP APEX 302 Pro	QV TP APEX 404 Pro	QV TP APEX 606 Pro	QV TP HYPER 302 Pro	QV TP HYPER 404 Pro	QV TP HYPER 606 Pro
Measuring range*1 (XxYxZ)	Vision	300×200×200 mm	400×400×250 mm	600×650×250 mm	300×200×200 mm	400×400×250 mm	600×650×250 mm
	Common to Touch-trigger Probe	234×200×200 mm	334×400×250 mm	534×650×250 mm	234×200×200 mm	334×400×250 mm	534×650×250 mm
Measuring accuracy*2 (Touch-trigger probe)	E_X, $_{MPE}$/E_Y, $_{MPE}$/ E_Z, $_{MPE}$	(1.8 + 3L / 1000) µm			(1.7 + 3L / 1000) µm		

*1 When a module change rack, a master ball, and a calibration ring are mounted, the measurement ranges are smaller than those in the table. Other specifications are the same as those for **QV Active**, **QV APEX Pro**, and **QV HYPER Pro**. Please contact our sales office for more details.

*2 L=length between two arbitrary points (mm)

Refer to the **QUICK VISION** Series Brochure (**E14028**) for more details.

SMS Smart Measuring System

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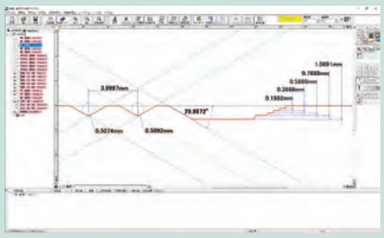
PROPRIETARY INSPECTION CERTIFICATE

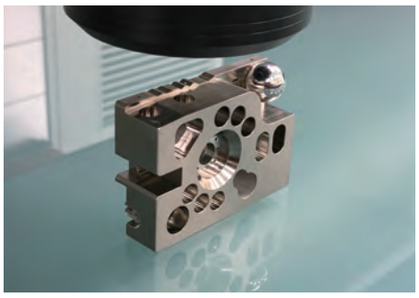
QVH4 Pro

CNC Vision Measuring System equipped with Non-contact displacement sensor

- This dual system with a non-contact displacement sensor has a scanning function that enables measurement of minute height differences and 3D shapes.
- The non-contact displacement sensor (CPS probe) uses the wavelength confocal method.
- The LED used as the light source of the displacement sensor has an auto-brightness control function that enables seamless measurement of materials with different reflectivity.

Example of 3D form comparison





QVH4 HYPER 606 Pro

Features: QVH4 Pro

- Enables detection of high inclination angles for both mirror and diffused surfaces.
- The automatic lighting adjustment function allows for high accuracy measurements.
- Surface roughness or thickness measurement of thin and transparent objects such as film.

COMMON SPECIFICATIONS

Items \ Model No.		QVH4 APEX 302 Pro	QVH4 APEX 404 Pro	QVH4 APEX 606 Pro	QVH4 HYPER 302 Pro	QVH4 HYPER 404 Pro	QVH4 HYPER 606 Pro
Measuring range (X×Y×Z)	Vision	300×200×200 mm	400×400×250 mm	600×650×250 mm	300×200×200 mm	400×400×250 mm	600×650×250 mm
	Non-contact displacement sensor	176×200×200 mm	276×400×250 mm	476×650×250 mm	176×200×200 mm	276×400×250 mm	476×650×250 mm
Vision measuring accuracy*1	E_{UX}/E_{UY}, MPE	(1.5 + 3L/1000) µm			(0.8 + 2L/1000) µm		
	E_{UXY}, MPE	(2.0 + 4L/1000) µm			(1.4 + 3L/1000) µm		
	E_{UZ}, MPE	(1.5 + 4L/1000) µm			(1.5 + 2L/1000) µm		
Displacement sensor measuring accuracy*1*2	E_{1Z}	(1.5 + 4L/1000) µm			(1.5 + 2L/1000) µm		

*1 L=length between two arbitrary points (mm) *2 Inspected to a Mitutoyo standard.

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Data Management Software by Mitutoyo

CLASS 1 LASER PRODUCT

Safety precautions regarding QV HYBRID TYPE1

This product uses a low-power invisible laser (780 nm) for measurement. The laser is a CLASS 1 EN/IEC 60825-1 device. A warning and explanation label, as shown above, is attached to the product as appropriate.

QV HYBRID TYPE1

CNC Vision Measuring System equipped with Non-contact displacement sensor

- This dual system with a non-contact displacement sensor has a scanning function that enables measurement of minute height differences and 3D shapes.
- The double-pinhole technique is used as the detection method of the displacement sensor. It is less directional compared with the knife-edge and triangulation techniques.
- The small laser spot with diameter of about 2 µm makes it possible to measure minute shapes.

Features: QV HYBRID TYPE1

- The focusing point method minimizes the difference in the measuring face reflectance and achieves high measurement reproducibility.
- Capable of measuring detailed shapes in high resolution.

COMMON SPECIFICATIONS

Items \ Model No.		QVH1 Apex 302	QVH1 Apex 404	QVH1 Apex 606	Hyper QVH1 302	Hyper QVH1 404	Hyper QVH1 606
Measuring range (X×Y×Z)	Vision	300×200×200 mm	400×400×250 mm	600×650×250 mm	300×200×200 mm	400×400×250 mm	600×650×250 mm
	Non-contact displacement sensor	180×200×200 mm	280×400×250 mm	480×650×250 mm	180×200×200 mm	280×400×250 mm	480×650×250 mm
Vision measuring accuracy*	E_{1X}, E_{1Y}	(1.5 + 3L/1000) µm			(0.8 + 2L/1000) µm		
	E_{1Z}	(1.5 + 4L/1000) µm			(1.5 + 2L/1000) µm		
	E_{2XY}	(2.0 + 4L/1000) µm			(1.4 + 3L/1000) µm		
Displacement sensor measuring accuracy*	E_{1Z}	(1.5 + 4L/1000) µm			(1.5 + 2L/1000) µm		

* Inspected to a Mitutoyo standard. L=length between two arbitrary points (mm)

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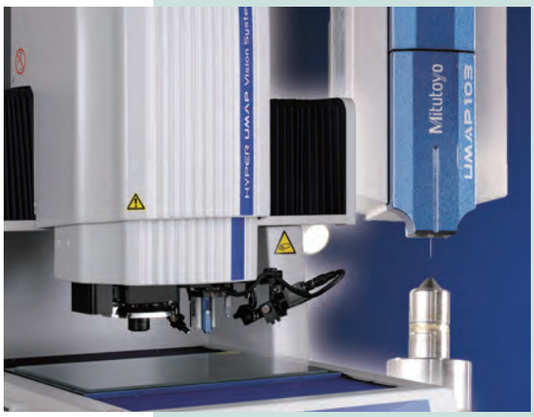
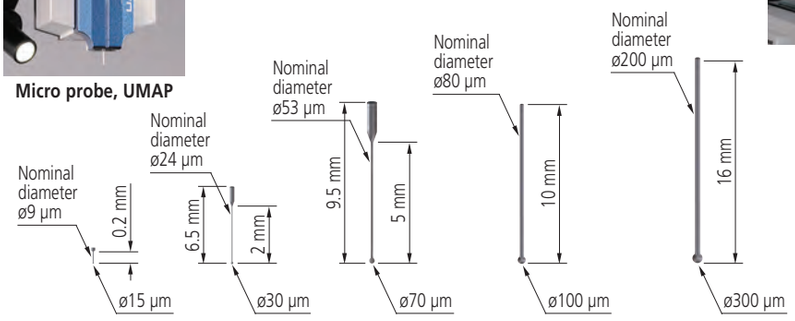
UMAP Vision System TYPE2
Micro Form Measuring System

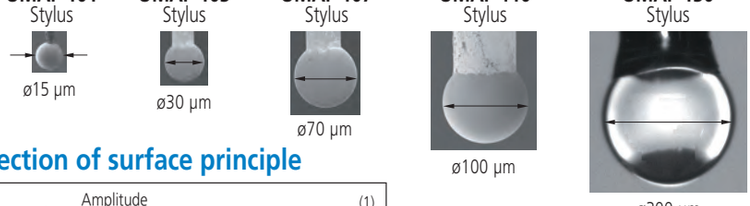
Ultrasonic Micro Probe UMAP

Contact measurement of a small hole's diameter and its section or contour is possible, which is difficult with a conventional Vision Measuring System or CMM. Capable of high accuracy, sophisticated, non-contact and contact measurement on one machine. With a minimum measuring force of 1 μN, it is not only less likely to mark workpiece surfaces, but also enables measurement of workpieces that are highly susceptible to deformation.

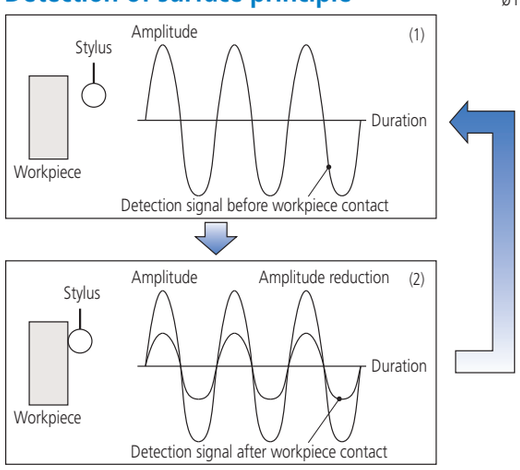


Micro probe, UMAP





Detection of surface principle



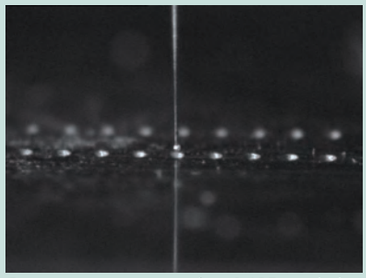
(1) In this drawing, the stylus is vibrating with micro amplitude. If it does not come into contact with the workpiece the vibration state is maintained.
(2) As the stylus comes into contact with the workpiece surface the vibration amplitude decreases as the contact increases. When the decreasing amplitude falls below a certain level, a touch-trigger signal is generated.

SPECIFICATIONS

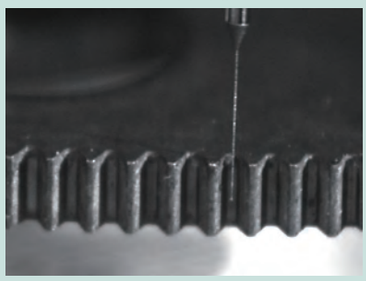
Items	Model No.		TYPE2 Hyper UMAP 302	TYPE2 ULTRA UMAP 404
Measuring range (common to vision and **UMAP**)	X axis×Y axis		185×200 mm	285×400 mm
	Z axis	**UMAP 101/103**	175 mm	
		UMAP 107/110	180 mm	
		UMAP 130	185 mm	
Vision measuring accuracy*	E_{1X}, E_{1Y}		(0.8 + 2L/1000) μm	(0.25 + L/1000) μm
	E_{1Z}		(1.5 + 2L/1000) μm	
Repeatability	**UMAP 101/103/107**		σ=0.1 μm	σ=0.08 μm
	UMAP 110/130		σ=0.15 μm	σ=0.12 μm

* Inspected to a Mitutoyo standard. L=length between two arbitrary points (mm)

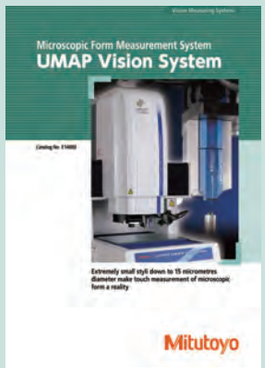
Typical applications



Contour measurement of a ø0.125 mm hole



Measuring form of micro gear teeth



Refer to **UMAP Vision System** Brochure (**E14000**) for more details.

SMS Smart Measuring System

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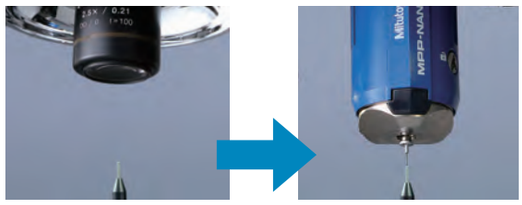
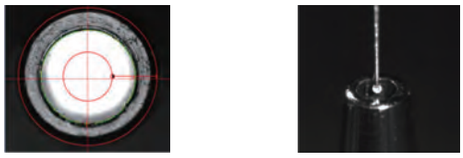
Data Management Software by Mitutoyo

PROPRIETARY INSPECTION CERTIFICATE

Vision Measuring Machine with Micro-Form Scanning Probe MiSCAN Vision System

- Hybrid measuring machine with vision head and scanning probe (**MPP-NANO**, **SP25M**).
- Newly developed **MPP-NANO** probe on which styli as small as 125 µm diameter can be mounted achieves autonomous 3D scanning of fine detail. The highly proven **SP25M** scanning probe is also supported.
- Using the observation camera, the approach to the workpiece for **MPP-NANO** stylus where visual confirmation is difficult can be easily performed while also checking for dirt and scratches on the workpiece.
- Using the same vision head as the **QUICK VISION** Series, the best-selling vision measuring system, high level performance can be provided in vision measurement.





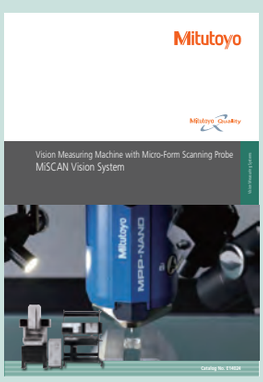
Precise positioning by monitoring the image

Measurement using **MPP-NANO** stylus

SPECIFICATIONS

Items \ Model No.			Hyper MVS 302	Hyper MVS 404	MVS Apex 404
Measuring range (XxYxZ)	Vision measuring area		300×200×200 mm	400×400×250 mm	
	MPP-NANO/**SP25M**		175×200×200 mm	275×400×250 mm	
Imaging device			B&W CCD camera		
Observation unit			Programmable power turret 1X-2X-6X		
Illumination unit			Co-axial light, Transmitted light, PRL (programmable ring light)		
Contact type probe			**MPP-NANO**/**SP25M**	**SP25M** only	
Measuring accuracy*	E_{1X}/E_{1Y}		(0.8 + 2L/1000) µm		(1.5 + 3L/1000) µm
	E_{1Z}		(1.5 + 2L/1000) µm		(1.5 + 4L/1000) µm
	E_{2XY}		(1.4 + 3L/1000) µm		(2.0 + 4L/1000) µm
	MPP-NANO	$E_{0, MPE}$	(1.9 + 4L/1000) µm	—	
	SP25M	$E_{0, MPE}$	(1.9 + 4L/1000) µm		(2.5 + 6L/1000) µm
Scanning accuracy	**MPP-NANO**		0.6 µm	—	
	SP25M	MPE_{THP}	2.5 µm		2.7 µm
Probing accuracy	**MPP-NANO**		0.6 µm	—	
	SP25M	$P_{FTU, MPE}$	1.9 µm		2.2 µm
Repeatabillity (σ)	**MPP-NANO**		0.05 µm	—	
Accuracy guaranteed temperature	Ambient temperature		18 to 23 °C		
	Temperature variation		0.5 °C/1 H and 1 °C/24 H		

* Vision measuring accuracy using a **QV-HR 2.5X** objective and 2X tube lens.



Refer to the **MiSCAN Vision System** Brochure (**E14024**) for more details.

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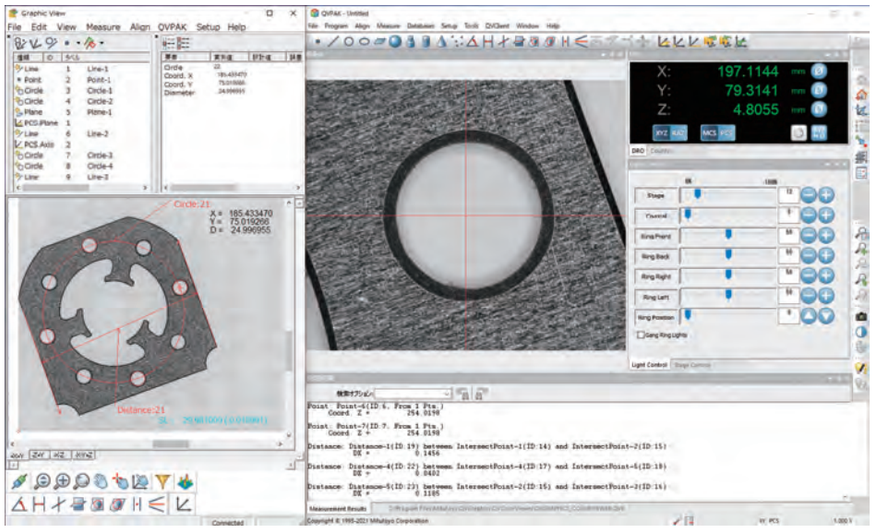
MiCAT
Mitutoyo Intelligent Computer Aided Technology
the standard in world metrology software
VISION

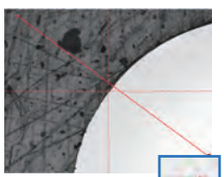
QVPAK
Data Processing Software for QUICK VISION

- The X, Y, and Z position data is detected from the measurement data gathered by the **QUICK VISION** system and the arithmetic processing of coordinates and dimensions is performed immediately.

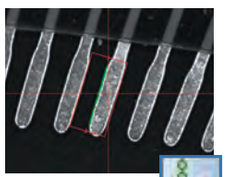


K

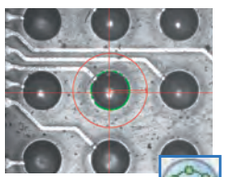
Edge Detection Tools



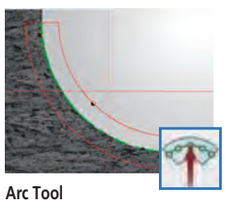
Simple Tool
This is a basic tool for detecting one point.



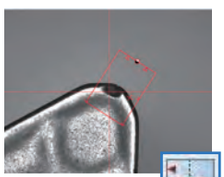
Box Tool
This tool detects linear edges with a minimum of one pixel interval. Compared to the simple tool, the Box tool can perform averaging and remove abnormal points, which enables stable measurements.



Circle Tool
This tool detects circular edges with a minimum of one pixel space. Edges can be specified easily with a single click.

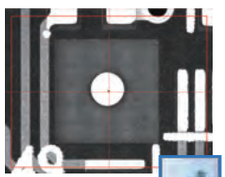


Arc Tool
This tool is suited to detection of arcs and corner radii.

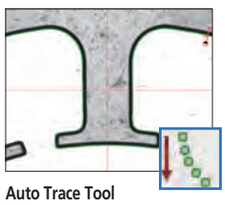


Maximum / Minimum Tool
This tool detects the maximum or minimum point within the range.

Area Centroid Tool
This tool detects the position of a form's centroid, and is suited to the positioning of different forms.



Pattern Search Tool
This tool performs pattern matching to detect a position, and is optimal for positioning alignment marks and similar tasks.



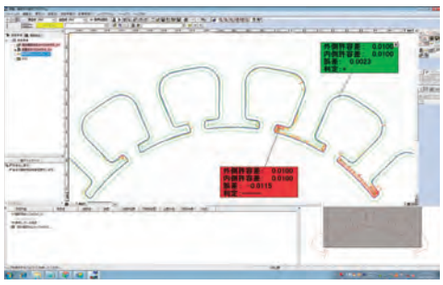
Auto Trace Tool
This is a shape-measuring tool that automatically tracks a contour with input consisting only of a start point and end point.

Refer to the **QUICK VISION** Series Brochure (**E14028**) for more details.

Application software (Optional)

Form assessment / analysis software
FORMTRACEPAK-AP

Verification of designed value and form analysis are performed on the basis of the contour data obtained via the **QV** auto trace tool, non-contact displacement sensor, PFF, and WLI.

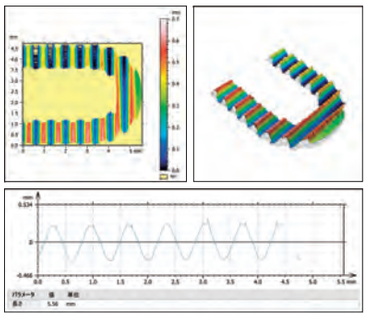


FORMTRACEPAK-PRO

This software performs 3D form analysis from the data obtained via the non-contact displacement sensor of the **QV HYBRID** Series.

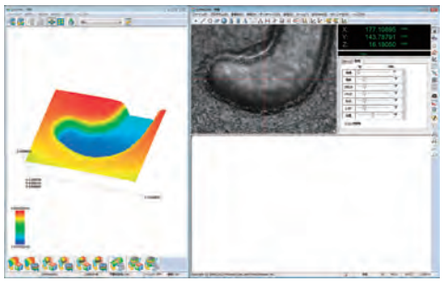
MCubeMap

Allows you to analyze parameters compliant with JIS B681-2: 2018 (ISO25178-6: 2010), such as Sa, Sq and other height parameters from the 3D data captured by **QVWLI**.



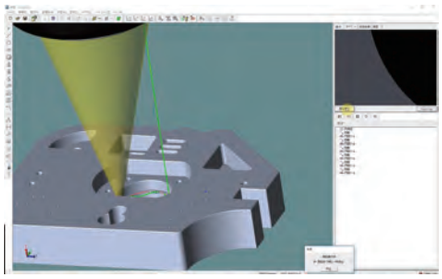
QV3DPAK

This software generates 3D forms from the PFF (Points From Focus) or WLI (White Light Interferometer) data.



Measurement support software
QV3DCAD

QV3DCAD uses 3D CAD models to easily create **QVPAK** part program both online and offline.



Offline teaching software
EASYPAG-PRO

This software creates **QVPAK** measurement procedure programs using 2D CAD data.

Statistical processing software
MeasurLink®

This software enables statistical arithmetic processing of measurement results.

External control software
QVEio

Allows you to externally control or output the operating status of a **QV** connected to a PLC or PC.

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QS-L/AFC
Manual Vision Measuring System

- Manual vision measuring system with a high speed, high-definition auto focus 3-megapixel camera.
- A 4-quadrant high-intensity LED ring light provides excellent observation performance.
- The newly designed zoom unit and interchangeable objectives achieve a maximum magnification ratio of 14X. Viewing possibilities extend from low magnification wide view measurement to high magnification micro-measurement.

Auto focus image

QS-L3017Z/AFC

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From wide view measurement to micro-measurement

Optical magnification		0.5X	0.65X	0.75X	0.85X	0.98X	1X	1.28X	1.3X	1.5X	1.7X	2X	2.25X	2.5X	3X	3.5X	3.75X	4X	5X	5.25X	7X
View field (mm)	Horizontal (H)	13.2	10.2	8.8	7.8	6.8	6.6	5.2	5.1	4.4	3.9	3.3	2.9	2.6	2.2	1.8	1.7	1.7	1.3	1.2	0.9
	Vertical (V)	9.9	7.7	6.6	5.9	5.1	5.0	3.9	3.8	3.3	2.9	2.4	2.2	2.0	1.6	1.4	1.3	1.2	1.0	1.0	0.7
Total magnification (on the monitor)		20	26	30	34	39	40	51	52	60	68	79.3	89	99.3	119	138.7	149	158.7	198.7	208	277.3
Objective lens	1X objective (optional) Working distance	74 mm																			
	1.5X objective (standard accessory) Working distance	42 mm																			
	2X objective (optional) Working distance	42 mm																			

Note: The total magnification indicates the magnification on the monitor when the size of the **QSPAK** video window is 252.7×214.9 mm (default).

SPECIFICATIONS

Model No.		QS-L2010Z/AFC	QS-L3017Z/AFC	QS-L4020Z/AFC
Drive method		Auto focus equipped, X, Y axis: manual; Z axis: motor-operated		
Measuring range (XxYxZ)		200×100×150 mm	300×170×150 mm	400×200×150 mm
Resolution/Scale unit		0.1 µm/Linear encoder		
Vision measuring accuracy*1*2	X axis, Y axis	(2.2 + 0.02L/1000) µm		
	Z axis	(4.5 + 0.006L/1000) µm		
Accuracy guaranteed temperature		20±1 °C		
Observation unit*3		7X zoom (8 steps) interchangeable objective lenses (1X objective 0.5X - 3.5X; 1.5X objective 0.75X - 5.25X; 2X objective 1X - 7X)		
Image detection method		3 megapixel, CMOS color camera (1/2 in)		
Illumination	Transmitted light	White LED		
	Co-axial light	White LED		
	Ring light	4-quadrant white LED		

*1 Inspected to a Mitutoyo standard. L=length between two arbitrary points (mm)
*2 3X lens magnification or greater
*3 1X and 2X objective lenses are optional

Refer to the **QUICK SCOPE QS-L** Brochure (**E14004**) for more details.

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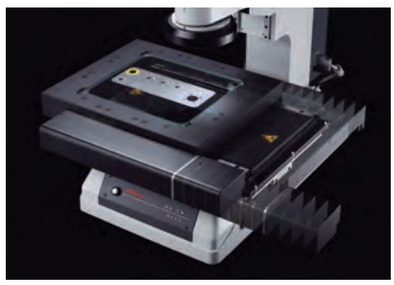
Quick Image
Non-contact 2D Vision Measuring System

- This series of manual 2D vision measuring machines offers high-efficiency measurement by employing a telecentric optical system that has a deep focal depth and a wide view monitor.
- The stitching function enables the entire display of a large workpiece so that highly accurate and speedy measurement can be performed.
- A model equipped with a motorized stage has been added to the series to offer easy and comfortable stage operation.
- A single click enables multiple measurements in one display. A batch measurement can be applied to multiple workpieces in the display after executing a pattern search based on the workpiece position.
- This series is equipped with a 3-megapixel color camera. Even with low magnification, high repeatability can be obtained.
- The choice of five stage sizes makes it easy to choose a machine to suit the user's application.
- The video window automatically displays the measurement data, which enables quick verification.

Refer to the **QUICK IMAGE** Series Brochure (**E14009**) for more details.

QI-C2017D



A motorized stage

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SPECIFICATIONS

Model No.	0.2X / 0.5X	Manual stage model					Motorized stage model		
		QI-A1010D / QI-B1010D	QI-A2010D / QI-B2010D	QI-A2017D / QI-B2017D	QI-A3017D / QI-B3017D	QI-A4020D / QI-B4020D	QI-C2010D	QI-C2017D	QI-C3017D
Measuring range (X×Y)		100×100 mm	200×100 mm	200×170 mm	300×170 mm	400×200 mm	200×100 mm	200×170 mm	300×170 mm
Effective stage glass size		170×170 mm	242×140 mm	260×230 mm	360×230 mm	440×232 mm	242×140 mm	260×230 mm	360×230 mm
Maximum stage loading*		Approx. 10 kg		Approx. 20 kg		Approx. 15 kg	Approx. 10 kg	Approx. 20 kg	
Main unit mass		Approx. 65 kg	Approx. 69 kg	Approx. 150 kg	Approx. 158 kg	Approx. 164 kg	Approx. 72 kg	Approx. 153 kg	Approx. 161 kg

* Does not include extremely offset or concentrated loads

Model No.			QI-A / QI-C	QI-B
View field			32×24 mm	12.8×9.6 mm
Measurement mode			High resolution mode / Normal mode *1	
Travel range (Z axis)			100 mm	
Vision measuring accuracy	Measurement accuracy within the screen *2	High resolution mode	±2 µm	±1.5 µm
		Normal mode	±4 µm	±3 µm
	Repeatability within the screen (±2σ) *3	High resolution mode	±1 µm	±0.7 µm
		Normal mode	±2 µm	±1 µm
	Measurement accuracy (E_{1XY}) *2		±(3.5 + 0.02L) µm L=arbitrary measuring length (mm)	
Monitor magnification *4			7.6X	18.9X
Optical system	Magnification (Telecentric Optical System)		0.2X	0.5X
	Depth of focus	High resolution mode	±0.6 mm	±0.6 mm
		Normal mode	±11 mm	±1.8 mm
	Working distance		90 mm	
Camera			3 megapixel, CMOS color camera (1/2 in)	
Illumination		Transmitted light	Green LED telecentric illumination	
		Co-axial light	White LED	
		Ring light	4-quadrant white LED	
Power supply			AC100 to 240 V 50/60 Hz	
Accuracy guaranteed temperature			20±1 °C	

*1 Patent registered (Japan)
*2 Inspected to Mitutoyo standards by focus point position.
*3 The measuring accuracy is guaranteed to be accurate within the depth of focus.
*4 For 1X digital zoom (when using a 22-inch-wide monitor)

Mitutoyo

Quick Guide to Precision Measuring Instruments

Vision Measuring Machines

Vision Measurement

Vision measuring machines mainly provide the following processing capabilities.

- **Edge detection**

  Detecting/measuring edges in the XY plane

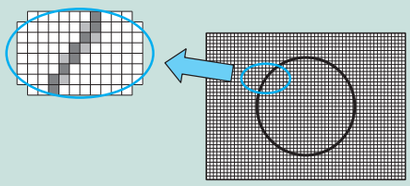
- **Auto focusing**

  Focusing and Z-axis measurement

- **Pattern recognition**

  Alignment, positioning, and inspecting a feature

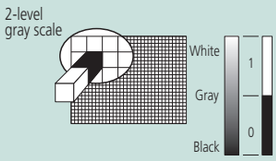
Image Storage



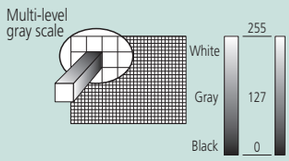
An image is comprised of a regular array of pixels. This is just like a picture on fine plotting paper with each square solid-filled differently.

Gray Scale

A PC stores an image after internally converting it to numeric values. A numeric value is assigned to each pixel of an image. Image quality varies depending on how many levels of gray scale are defined by the numeric values. The PC provides two types of gray scale: two-level and multi-level. The pixels in an image are usually displayed as 256-level gray scale.



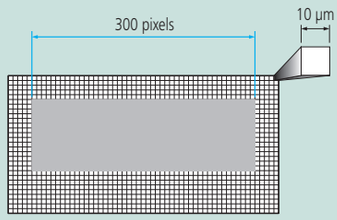
Pixels in an image brighter than a given level are displayed as white and all other pixels are displayed as black.



Each pixel is displayed as one of 256 levels between black and white. This allows high-fidelity images to be displayed.

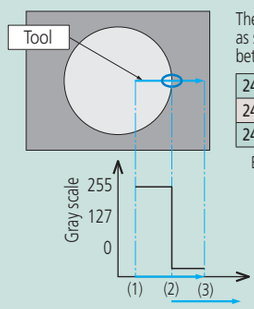
Dimensional Measurement

An image consists of pixels. If the number of pixels in a section to be measured is counted and is multiplied by the size of a pixel, then the section can be converted to a numeric value in length. For example, assume that the total number of pixels in the lateral size of a square workpiece is 300 pixels as shown in the figure below.
If a pixel size is 10 µm under imaging magnification, the total length of the workpiece is given by 10 µm×300 pixels=3000 µm=3 mm.



Edge Detection

How to actually detect a workpiece edge in an image is described using the following monochrome picture as an example. Edge detection is performed within a given domain. A symbol which visually defines this domain is referred to as a tool. Multiple tools are provided to suit various workpiece geometries or measurement data.



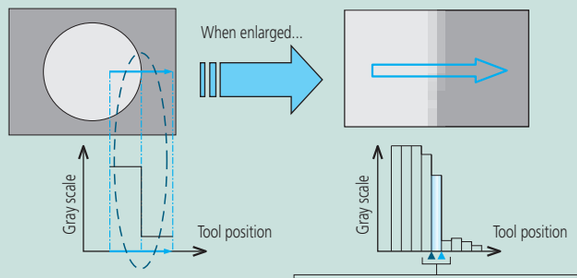
The edge detection system scans within the tool area as shown in the figure at left and detects the boundary between light and shade.

244	241	220	193	97	76	67	52	53	53
243	242	220	195	94	73	66	54	53	55
244	246	220	195	94	75	64	56	51	50

Example of numeric values assigned to pixels on the tool

(1) Scan start position
(2) Edge detection position
(3) Scan end position

High-resolution Measurement



A position the system recognizes as an edge may be in error by up to one pixel width using normal image processing. This will prevent the execution of high-resolution measurement.

To increase the accuracy in edge detection, sub-pixel image processing is used. An edge is detected by determining an interpolation curve from adjacent pixel data as shown below.
As a result, it allows measurement with a resolution better than 1 pixel.

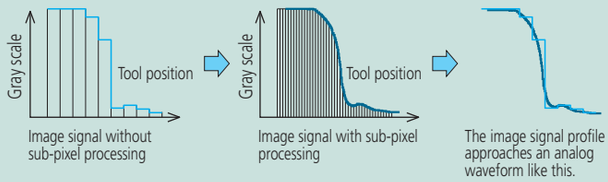


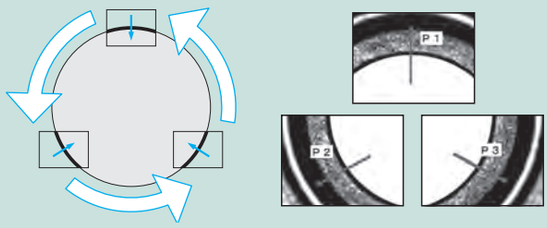
Image signal without sub-pixel processing

Image signal with sub-pixel processing

The image signal profile approaches an analog waveform like this.

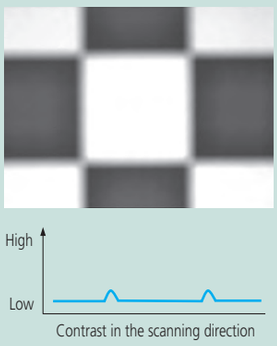
Measurement along Multiple Portions of an Image

Large features that cannot be contained on one screen have to be measured by precisely controlling the position of the sensor and stage so as to locate each reference point within individual images. By this means the system can measure even a large circle, as shown below, by detecting the edge while moving the stage across various parts of the periphery.

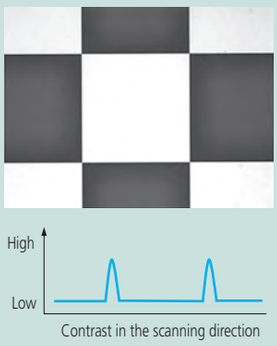


Variation in Contrast Depending on the Focus Condition

Edge contrast is low due to out-of-focus edges.

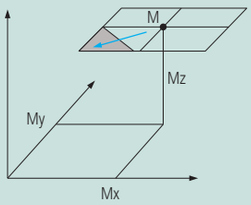


Edge contrast is high due to sharp, in-focus edges.



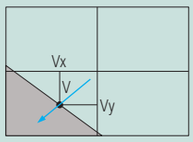
Composite Coordinates of a Point

Machine coordinate system



Measuring machine stage position
M = (Mx, My, Mz)

Vision coordinate system



Detected edge position (from the center of vision)
V = (Vx, Vy)

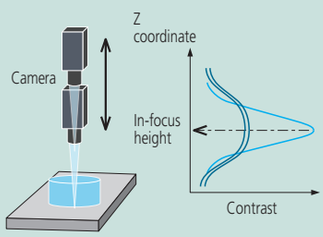
Actual coordinates are given by X=(Mx+Vx), Y=(My+Vy), and Z=Mz, respectively.

Since measurement is performed while individual measured positions are stored, the system can measure dimensions that cannot be included in one screen, without problems.

Principle of Auto Focusing

The system can perform XY-plane measurement, but cannot perform height measurement using only the camera image. The system is commonly provided with the Auto Focus (AF) mechanism for height measurement. The following explains the AF mechanism that uses a common image, although some systems may use a laser AF.

The AF system analyzes an image while moving the camera up and down in the Z axis. In the analysis of image contrast, an image in sharp focus will show a peak contrast and one out of focus will show a low contrast. Therefore, the height at which the image contrast peaks is the just-in-focus height.



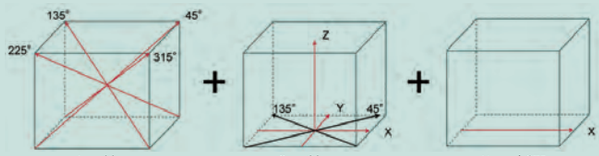
Overview of ISO 10360-7:2011

ISO 10360-7:2011 (Geometrical product specifications (GPS) -- Acceptance and reverification tests for coordinate measuring machines (CMM) -- Part 7: CMMs equipped with imaging probing systems) was published on June 1, 2011.
Some inspection items are listed in ISO 10360-7:2011. The following summarizes the test method for determining length measurement error (E) and probing error (P_{F2D}).

Length measurement error, *E*

Five test lengths in seven different directions within the measuring volume, each length measured three times, for a total of 105 measurements. Four directions are the space diagonal. Remaining three directions are user specified; default locations are parallel to the VMM axes.

When CTE (coefficient of thermal expansion) of the test-length artifact is < 2×10^{-6}/K, additional measurement using an artifact with a normal CTE (8 to 13×10^{-6}/K) is performed.



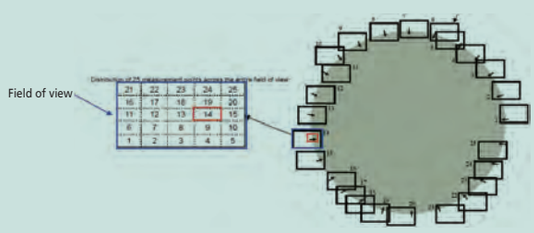
4 positions (space diagonals) | 3 positions (user specified) | Normal CTE additional inspection

Probing error, P_{F2D}

Measure 25 points distributed evenly around the test circle (14.4° pitch).

Each of the 25 points shall be measured using the specified 25 areas of the field of view.

Calculate probing error as the range of the 25 radial distances (Rmax - Rmin) from the center of the least-square circle.



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PROPRIETARY INSPECTION CERTIFICATE

Surftest SJ-500/SV-2100
SERIES 178 — Dedicated Control Unit Type Surface Roughness Tester

High precision and high performance type surface roughness tester with a dedicated control unit, offering a user-friendly display and simple operation.

- Equipped with a 7.5-inch, color TFT LCD, color icons and touch panel controls, the display unit is easy to read and simple to operate.
- A built-in joystick on the control unit allows quick and easy positioning. The manual adjustment knob allows fine positioning of a small stylus for measuring small holes.
- In addition to the roughness parameters compliant with ISO/JIS/ANSI/VDA surface roughness standards, contour analysis is also available.

SV-2100M4

SJ-500

SV-2100S4

SPECIFICATIONS

Model No.		SJ-500	SV-2100M4*1	SV-2100S4*1	SV-2100H4*1	SV-2100W4*1
Stand type		—*2	Manual stand	Motorized stand		
Measuring range	Z1 axis (detector)	800 µm, 80 µm, 8 µm				
	X axis	50 mm	100 mm			
Resolution	X axis	0.05 µm				
	Z1 axis (detector)	0.01 µm (800 µm), 0.001 µm (80 µm), 0.0001 µm (8 µm)				
	Z2 axis (column)	—	—	1 µm		
Assessed profile		Primary profile, Roughness profile, Waviness profile, DF profile, Roughness motif profile, Waviness motif profile				

*1 While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.
*2 Stand for **SJ-500** is optional.

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PROPRIETARY INSPECTION CERTIFICATE

Surftest SJ-500P/SV-2100M4
SERIES 178 — Data Processing Unit (PC) Surface Roughness Testers

L

A superior data processing tester with PC data analysis for higher efficiency.

Note: If a power column type (**SV-2100S4**/**H4**/**W4**) with PC data-processing is required, consider the **FORMTRACER Avant S3000** Series (Refer to page L-9 for specifications).

SJ-500P

SV-2100M4 (PC type)

FORMTRACEPAK: Best-selling Surface Roughness Analysis Program

Best-selling dedicated software for surface roughness measurement and analysis.
Features a flexible printer format and creation of an original inspection certificate.

SPECIFICATIONS

Type of data processing unit		PC type	
Model No.		SJ-500P	SV-2100M4*1
Elevating shaft mechanism of stand		—*2	Manual operation only
Measuring range	X axis	50 mm	100 mm
	Z1 axis (detector)	800 µm, 80 µm, 8 µm	
Z2-axis (column) travel range		—	350 mm
Resolution	X axis	0.05 µm	
	Z1 axis (detector)	0.01 µm (800 µm), 0.001 µm (80 µm), 0.0001 µm (8 µm)	
	Z2 axis (column)	—	—
Applicable standards		JIS 1982/JIS 1994/JIS 2001/ISO 1997/ANSI/VDA	
Assessed profile		Primary profile, Roughness profile, Waviness profile, Filtered waviness profile, Rolling circle waviness profile, Rolling circle center line waviness profile, Envelope residual profile, DIN4776 profile, Roughness motif profile, Waviness motif profile	

*1 While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.
*2 The simplified stand or manual column stand is available as an optional accessory.

Refer to the Surftest **SJ-500**/**SV-2100** Brochure (**E15006**) for more details.

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PROPRIETARY INSPECTION CERTIFICATE

Surftest Extreme SV-3000CNC/SV-M3000CNC SERIES 178 — CNC Surface Roughness Testers

SV-3000CNC
(Inclinable drive unit + Y-axis table)

SV-M3000CNC
(Surface Roughness Tester with built-in Y axis.)
(The photo represents a special specification model.)

- The X1, Y and Z2 axes have a maximum drive speed of 200 mm/s.
  This permits high-speed positioning that can potentially result in a large increase in the throughput of multiple-profile/multiple-workpiece measurement tasks.
- Capable of inclined plane measurement through 2 axis simultaneous control in X and Y.
- Models equipped with the α axis allow continuous measurement on horizontal and inclined surfaces by power-tilting the X1 axis.
- It is possible to expand the measuring range for multiple workpieces through positioning in Y.
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- Since the Z1-axis detector incorporates an anti-collision safety device, the detector unit will automatically stop if it touches a workpiece or fixture.
- Surftest Extreme **SV-M3000CNC** (CNC Surface Roughness Tester with a movable Y-axis table) that handles measurement of large/heavy workpieces, such as engine blocks or crankshafts, is also available.
- Optional external control function (Ext I/O) through bidirectional communication (RS-232C) with the PLC (programmable logic controller) is available.

SV-3000CNC SPECIFICATIONS

Model No.			SV-3000CNC
X1 axis (drive unit)	Measuring range		200 mm
	Resolution		0.05 µm
	Scale type		Reflective-type linear encoder
	Drive speed	CNC mode	Max. 200 mm/s
		Joystick mode	0 to 50 mm/s
	Measuring speed		0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0 mm/s
	Measuring direction		Backward
	Straightness		0.5 µm/200 mm
Y axis (table)	Measuring range		200 mm
	Resolution		0.05 µm
	Drive speed	CNC mode	Max. 200 mm/s
		Joystick mode	0 to 50 mm/s
	Maximum table loading		20 kg
Z2 axis (column)	Travel range	Z2 axis (column, type **S**)	300 mm
		Z2 axis (column, type **H**)	500 mm
	Resolution		0.05 µm
	Scale type		Reflective-type linear encoder
	Drive speed	CNC mode	Max. 200 mm/s
		Joystick mode	0 to 50 mm/s
Base unit	Base size (width×depth)		750×600 mm
	Base material		Granite

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

SV-M3000CNC SPECIFICATIONS

Model No.			SV-M3000CNC
X1 axis (drive unit)	Measuring range		200 mm
	Resolution		0.05 µm
	Scale type		Reflective-type linear encoder
	Drive speed	CNC mode	Max. 200 mm/s
		Joystick mode	0 to 50 mm/s
	Measuring speed		0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0 mm/s
	Straightness	When using a standard detector	0.5 µm/200 mm
Z2 axis (column)	Measuring range		500 mm
	Resolution		0.05 µm
	Scale type		Reflective-type linear encoder
	Drive speed	CNC mode	Max. 200 mm/s
		Joystick mode	0 to 50 mm/s
Y axis	Measuring range		800 mm
	Resolution		0.05 µm
	Scale type		Reflective-type linear encoder
	Drive speed	CNC mode	Max. 200 mm/s
		Joystick mode	0 to 50 mm/s
	Measuring speed		0.02 to 2 mm/s
	Straightness	When using a standard detector holder	Narrow range 0.5 µm/50 mm
			Wide range 2 µm/800 mm
Base unit	Base size (width×depth)		600×1500 mm
	Base material		Steel
	Maximum table loading		300 kg

Refer to the CNC Form Measuring Instrument Series Brochure (**E15021**) for more details.

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PROPRIETARY INSPECTION CERTIFICATE

Contracer CV-2100
SERIES 218 — Contour Measuring Instruments

CV-2100M4

Contour Measuring System enabling measurement that is fast, accurate, and easy.

- The operation flow is significantly shortened by arranging the controls for stylus position change, measurement start/stop and return on the front of the drive unit.

Centralized front control panel

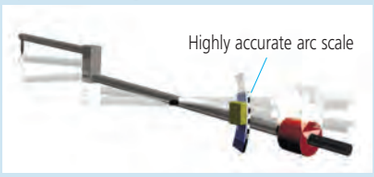
- Fine and coarse X-axis positioning can be performed easily by using the jog shuttle that covers the whole measuring range.

Motor-driven jog shuttle

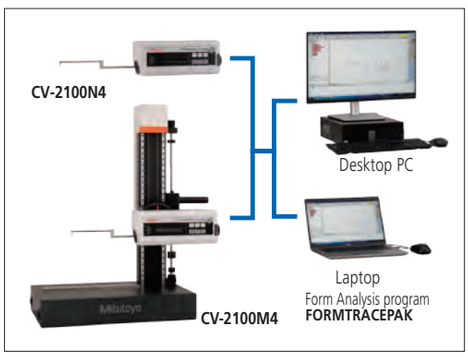
- The quick-vertical-motion stand allows operators to swiftly and easily move the drive unit to and from the measurement height without having to push or pull (only for **CV-2100M4**).

Quick-vertical-motion stand

- The detector unit (Z1 axis) is equipped with a highly accurate arc scale. This scale directly tracks the arc locus of the stylus tip so that the most accurate compensation can be applied to the scale output, which leads to higher accuracy and resolution. Operators are free from bothersome operations such as measurement magnification switching and calibrating each magnification as required for analog instruments.



Refer to the Contracer **CV-2100** Series Brochure (**E15020**) for more details.



Optional Column Stand for CV-2100N4

- Allows the use of the **CV-2100N4** in a fixed configuration.

218-042

Base material: Granite
Inclination range: ±45°
Vertical travel: 320 mm
Mass: 110 kg
Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

L

SPECIFICATIONS

Model No.		CV-2100M4	CV-2100N4
Measuring range	X axis	100 mm	
	Z1 axis (detector unit)	50 mm	
Z2-axis (column) travel range		350 mm	—
X-axis inclination angle		±45°	
Resolution	X axis	0.1 µm	
	Z1 axis	0.1 µm	
Drive method	X axis	Motor (0 to 20 mm/s)	
	Vertical travel (Z-axis column)	Manual (Quick-vertical-motion, fine)	—
Measuring speed		0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0 mm/s	
Straightness (when the X axis is horizontal)		2.5 µm/100 mm	
Accuracy (20 °C)	X axis	±(2.5+0.02L) µm L = Measurement Length (mm)	
	Z1 axis	±(2.5+|0.1H|) µm H = Measurementt height from horizontal position within ±25 mm	
Measuring direction		Both pulling and pushing directions	
Measuring face direction		Downward direction	
Measuring force		30±10 mN (3 gf)	
Traceable angle (using the standard stylus)		Ascent 77°, Descent 87° (according to surface property)	
External dimensions (W×D×H)		745×450×885 mm	651×143×138.5 mm
Mass		145.8 kg	5.8 kg

Note 1: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.
Note 2: For the **CV-2100N4**, a manual column stand (optionally available) or custom fixture is required.

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PROPRIETARY INSPECTION CERTIFICATE

FORMTRACER Avant S3000 Series
SERIES 178 — Surface Texture Measuring Instruments

FTA-S4S3000

- **FORMTRACER Avant S3000** Series are highly functional and user-friendly surface roughness measuring systems with innovative design features.
- **The FORMTRACER Avant S3000** Series includes models with inclined drive unit. Inclining the drive unit makes it easier to approach target surfaces and measure large workpieces.

Inclined drive unit

- Equipped with an operability focused, new style remote box. The new part program key strongly supports manual part-programming.
- High throughput is achieved thanks to high drive speed (X axis: Max. 80 mm/s, Z2 axis: Max. 30 mm/s) and acceleration (X axis: 30 mm/s^2).
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- The Z1-axis detector is equipped with a built-in anti-collision safety device.
- A variety of detector holders (optional) are available.
- A detector for measuring contours can be retrofitted.

Large sized base models and high-column models are added to the line-up.

Remote box with user-friendly operability

Detector holder (optional)

Refer to the **FORMTRACER Avant** Series Brochure (**E15030**) for more details.

SPECIFICATIONS

Model No.		FTA-S4S3000	FTA-H4S3000	FTA-W4S3000	FTA-L4S3000	FTA-S8S3000	FTA-H8S3000	FTA-W8S3000	FTA-L8S3000
Measuring range	X axis	100 mm				200 mm			
	Z1 axis	800 µm, 80 µm, 8 µm							
Straightness (when the X axis is horizontal)		(0.05+0.001L) µm L = Measurement Length (mm)				(0.1+0.002L) µm L = Measurement Length (mm)			
X-axis inclination angle		±45° (Only for models with X-axis inclining drive unit)							
Z2-axis (column) travel range		300 mm	500 mm		700 mm	300 mm	500 mm		700 mm
Base size (W×D)		60×450 mm		1000×450 mm		600×450 mm		1000×450 mm	
Base material		Granite							

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

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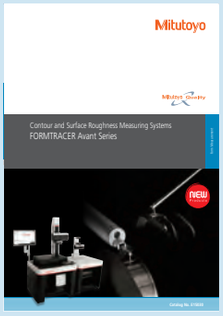
PROPRIETARY INSPECTION CERTIFICATE

FORMTRACER Avant C3000/4000 Series
SERIES 218 — Surface Texture Measuring Instruments

- **FORMTRACER Avant C3000/4000** Series are highly functional and user-friendly contour measuring systems with innovative design features.
- **FORMTRACER Avant C3000/4000** Series comes with the inclined drive unit as standard, making approach to the target surface and measurement of large workpieces much easier.


Inclined drive unit

- Equipped with an operability focused, new style remote box. The new part program key strongly supports manual part-programming.
- High throughput is achieved thanks to high drive speed (X axis: Max. 80 mm/s, Z2 axis: Max. 30 mm/s) and acceleration (X axis: 30 mm/s^2).
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- The Z1-axis detector is equipped with a built-in anti-collision safety device.
- A detector for measuring roughness can be retrofitted.
- The arm of the detector is a user-friendly, magnetic, one-touch, detachable mechanism.
- **C4000** type is a highly functional contour measuring system that has a wide-range digital detector (measuring range: 60 mm), top/bottom plane continuous measurement function, automatic variable measuring force function, and stylus drop detection function.



Refer to the **FORMTRACER Avant** Series Brochure (**E15030**) for more details.


Large sized base models and high-column models are added to the line-up.


Remote box with user-friendly operability

Detector

FTA-S4C3000

FTA-S4C4000

L

SPECIFICATIONS

Model No.		FTA-S4C3000 / FTA-S4C4000	FTA-H4C3000 / FTA-H4C4000	FTA-W4C3000 / FTA-W4C4000	FTA-L4C3000 / FTA-L4C4000	FTA-S8C3000 / FTA-S8C4000	FTA-H8C3000 / FTA-H8C4000	FTA-W8C3000 / FTA-W8C4000	FTA-L8C3000 / FTA-L8C4000
Measuring range	X axis	100 mm				200 mm			
	Z1 axis	60 mm (±30 mm in horizontal situation)							
Straightness (when the X axis is horizontal)		0.8 µm/100 mm				2 µm/200 mm			
Accuracy (20 °C) C3000	X axis	(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
	Z1 axis (detector unit)	±(1.2+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
Accuracy (20 °C) C4000	X axis	(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
	Z1 axis (detector unit)	±(0.8+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
X-axis inclination angle		±45°							
Z2-axis (column) travel range		300 mm	500 mm		700 mm	300 mm	500 mm		700 mm
Base size (W×D)		600×450 mm		1000×450 mm		600×450 mm		1000×450 mm	
Base material		Granite							

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

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FORMTRACER Avant D3000/4000 Series
SERIES 525 — Surface Texture Measuring Instruments

FTA-S4D3000
(Detector for surface roughness measurement attaching example, Inclined drive unit, with monitor arm)

FTA-S4D3000
(Detector for form/contour measurement attaching example, Inclined drive unit, with monitor arm)

- **FORMTRACER Avant D3000/4000** Series are highly functional and user-friendly surface texture measuring systems with innovative design features. Both surface roughness measurement and contour measurement are available on a single system just by replacing the detector.
- The contour/roughness detector can be replaced without turning off the controller power and without using any tool. Furthermore, the detector is recognized automatically.
- **FORMTRACER Avant D** Series comes with the inclined drive unit as standard, making approach to the target surface and measurement of large workpieces much easier.
- Equipped with an operability focused, new style remote box. The new part program key strongly supports manual part-programming.
- High throughput is achieved thanks to high drive speed (X axis: Max. 80 mm/s, Z2 axis: Max. 30 mm/s) and acceleration (X axis: 30 mm/s^2).
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- The Z1-axis detector is equipped with a built-in anti-collision safety device.
- The arm of the detector for contour measurement is a magnetic, one-touch, detachable mechanism.
- **D4000** type is a highly functional contour measuring system with a digital detector (measuring range: 60 mm) that enables wide range measurement, top/bottom plane continuous measurement function, automatic variable measuring force function, and stylus drop detection function.

Large sized base models and high-column models are added to the line-up.

Inclined drive unit

Connecting cables are contained within the measuring instrument.

Remote box with user-friendly operability

Detector holder (optional)

Detector

Refer to the **FORMTRACER Avant** Series Brochure (**E15030**) for more details.

SPECIFICATIONS

Model No.		FTA-S4D3000 / FTA-S4D4000	FTA-H4D3000 / FTA-H4D4000	FTA-W4D3000 / FTA-W4D4000	FTA-L4D3000 / FTA-L4D4000	FTA-S8D3000 / FTA-S8D4000	FTA-H8D3000 / FTA-H8D4000	FTA-W8D3000 / FTA-W8D4000	FTA-L8D3000 / FTA-L8D4000
Surface roughness measurement									
Measuring range	X axis	100 mm				200 mm			
	Z1 axis	800 µm, 80 µm, 8 µm							
Straightness (when the X axis is horizontal)		(0.05+0.001L) µm L = Measurement Length (mm)				(0.1+0.002L) µm L = Measurement Length (mm)			
Contour measurement									
Measuring range	X axis	100 mm				200 mm			
	Z1 axis	60 mm (±30 mm in horizontal situation)							
Straightness (when the X axis is horizontal)		0.8 µm/100 mm				2 µm/200 mm			
Accuracy (20 °C)	D3000 X axis	(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
	D3000 Z1 axis (detector unit)	±(1.2+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
	D4000 X axis	(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
	D4000 Z1 axis (detector unit)	±(0.8+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
Common specifications									
X-axis inclination angle		±45°							
Z2-axis (column) travel range		300 mm	500 mm		700 mm	300 mm	500 mm		700 mm
Base size (WxD)		600×450 mm		1000×450 mm		600×450 mm		1000×450 mm	
Base material		Granite							

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

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PROPRIETARY INSPECTION CERTIFICATE

CS-3300 Series
SERIES 525 — Surface Texture Measuring Instruments

- **CS-3300** Series are highly functional and user-friendly surface texture measuring systems with innovative design features. They enable simultaneous measurement of both surface roughness and contour without changing the detector.
- Large sized base models and high-column models are newly added to the line-up.
- Equipped with a wide range and high resolution Z1-axis detector.
- **CS-3300** Series comes with the inclined drive unit as standard, making approach to the target surface and measurement of large workpieces much easier.
- Equipped with an operability focused, new style remote box. The new part program key strongly supports manual part-programming.
- High throughput is achieved thanks to high drive speed (X axis: Max. 80 mm/s, Z2 axis: Max. 30 mm/s).
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- The Z1-axis detector is equipped with a built-in anti-collision safety device.

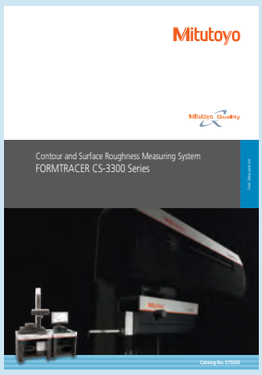
CS-3300H8

CS-3300H8
(With monitor arm)

Inclinable drive unit

Detector sliding mechanism

Connecting cables are contained within the measuring instrument.



Refer to the FORMTRACER **CS-3300** Series Brochure (**E15029**) for more details.

SPECIFICATIONS

Model No.			CS-3300S4	CS-3300H4	CS-3300W4	CS-3300L4	CS-3300S8	CS-3300H8	CS-3300W8	CS-3300L8
Measuring range	X axis		100 mm				200 mm			
	Z1 axis		5 mm (±2.5 mm in horizontal situation)							
Straightness (when the X axis is horizontal)			0.2 µm/100 mm				0.6 µm/200 mm			
Accuracy (20 °C)	X axis		±(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
	Z1 axis (detector unit)		±(1.5+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
Detector (Z1 axis)	Detection method		Differential inductance							
	Measuring force		0.75 mN							
	Stylus tip	Standard	Tip radius 2 µm, Tip angle 60°, Diamond (surface roughness/contour)							
		Cone	Tip radius 25 µm, Tip angle 30°, Sapphire (contour)							
	Stylus up/down		Available (stoppable at mid-stroke if required)							
X-axis inclination angle			±45°							
Z2-axis (column) travel range			300 mm	500 mm		700 mm	300 mm	500 mm		700 mm
Base size (W×D)			600×450 mm		1000×450 mm		600×450 mm		1000×450 mm	
Base material			Granite							

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

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Data Management Software by Mitutoyo

PROPRIETARY INSPECTION CERTIFICATE

Formtracer Extreme
SV-C4500CNC/SV-C4500CNC HYBRID TYPE1
SERIES 525 — CNC Surface Roughness and Contour Measuring Systems

SV-C4500CNC (Contour detector shown mounted together with the inclinable drive unit and Y-axis table)

SV-C4500CNC HYBRID TYPE1
(Mounting example of non-contact detector)

SV-C4500CNC SPECIFICATIONS

Model No.			SV-C4500CNC
X1 axis (Drive unit)		Measuring range	200 mm
		Resolution	0.05 µm
		Scale type	Reflective-type linear encoder
	Contour	Straightness	2 µm/200 mm
		Accuracy (20 °C)	±(0.8+4L/200) µm L: Measuring length (mm)
	Surface roughness	Straightness	0.5 µm/200 mm
Z1 axis (Detector)	Contour	Measuring range	60 mm (±30 mm from the horizontal)
		Resolution	0.02 µm
		Scale type	Arc
		Accuracy (20 °C)	±(0.8+|2H|/100) µm H: Measuring height from horizontal position (mm)
	Surface roughness	Measuring range	800 µm, 80 µm, 8 µm
		Resolution	0.01 µm, 0.001 µm, 0.0001 µm
Z2 axis (Column)		Drive range	Specification is selectable from 300 mm or 500 mm.
		Resolution	0.05 µm

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

SV-C4500CNC HYBRID TYPE1 SPECIFICATIONS

Model No.			SV-C4500CNC HYBRID TYPE1
X1 axis (Drive unit)		Measuring range	200 mm
		Resolution	0.05 µm
		Scale type	Reflective-type linear encoder
	Contour	Straightness (20 °C)	2 µm/200 mm
		Accuracy	±(0.8+4L/200) µm L: Measuring length (mm)
	Surface roughness	Straightness	0.5 µm/200 mm
	Non-contact type	Straightness	0.5 µm/200 mm
		Accuracy	±(0.8+4L/200) µm L: Measuring length (mm)
Y axis		Measuring range	200 mm
		Resolution	0.05 µm
		Maximum table loading	20 kg
Z1 axis	Contour	Measuring range	60 mm (±30 mm from the horizontal)
		Resolution	0.02 µm
		Scale type	Arc
		Accuracy (20 °C)	±(0.8+|2H|/100) µm H: Measuring height from horizontal position (mm)
	Surface roughness	Measuring range	800 µm, 80 µm, 8 µm
		Resolution	0.01 µm, 0.001 µm, 0.0001 µm
	Non-contact type detector **CPS2525***	Measuring range	1.2 mm
		Resolution	25 nm
	Non-contact type detector **CPS0517***	Measuring range	0.1 mm
		Resolution	5 nm
Z2 axis		Drive range	500 mm
		Resolution	0.05 µm

* Select either **CPS2525** or **CPS0517**.

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

SV-C4500CNC

- High-accuracy stylus type CNC Surface Roughness/Contour Measuring System that allows measurement of surface roughness and form/contour with one unit through detector replacement.
- For models with the α axis, it is possible to perform continuous measurement over horizontal and inclined surfaces by power-tilting the X1 axis. In addition, automatic measuring force adjustment function of Z1-axis detector for contour measurement enables automatic measurement with constant measuring force even with the X1-axis tilted.
- For models with the Y-axis table, it is possible to expand the measuring range for multiple workpieces through positioning in the Y-axis direction.
- Since the Z1-axis detector incorporates an anti-collision safety device, the machine will automatically stop if the detector touches a workpiece or jig.
- Optional external control function (Ext I/O) through bidirectional communication (RS-232C) with the PLC (programmable logic controller) is available.

SV-C4500CNC HYBRID TYPE1

- CNC Surface Roughness/Contour Measuring System equipped with a non-contact type detector as well as a contact type surface roughness contour measuring detector.
- Equipped with the Y-axis table, it is possible to expand the measuring range for multiple workpieces through positioning in the Y-axis direction.
- Since the Z1-axis detector incorporates an anti-collision safety device, the machine will automatically stop if the detector touches a workpiece or jig.
- Optional external control function (Ext I/O) through bidirectional communication (RS-232C) with the PLC (programmable logic controller) is available.

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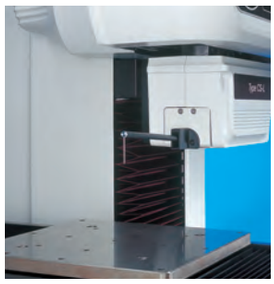
PROPRIETARY INSPECTION CERTIFICATE

Formtracer Extreme
CS-5000CNC/CS-H5000CNC
SERIES 525 — CNC Surface Roughness and Contour Measuring Systems

- High-accuracy stylus type CNC Surface Measuring System that allows batch measurement of surface roughness and form/contour.
- The X1 and Z2 axes have maximum drive speeds of 40 mm/s and 200 mm/s, respectively. This permits high-speed positioning that can potentially result in a large increase in the throughput of multiple-profile/multiple-workpiece measurement tasks.
- The high resolution linear encoder is incorporated in the X1 and Z1 axes so that high resolution is achieved and batch measurement of form/contour and surface roughness can be made.
- The active control method is employed for the Z1-axis detector to implement a wide-range measurement capability wherein the variation in dynamic measuring force is restricted.
- Since the Z1-axis detector incorporates an anti-collision safety device, the detector unit will automatically stop if it touches a workpiece or fixture.
- For models with the α axis, it is possible to perform continuous measurement over horizontal and inclined surfaces by power-tilting the X1 axis. (**CS-5000CNC** only)
- For models with the Y-axis table, it is possible to expand the measuring range for multiple workpieces through positioning in the Y-axis direction.
- Optional external control function (Ext I/O) through bidirectional communication (RS-232C) with the PLC (programmable logic controller) is available.

CS-H5000CNC
(with Y-axis table)



Wide-range detector employing active control technology

SPECIFICATIONS

Model No.			CS-5000CNC	CS-H5000CNC
X1 axis	Measuring range		200 mm	
	Resolution		0.005 µm	
	Scale type		Transmission-type linear encoder	
	Drive speed	CNC mode	Max. 40 mm/s	
		Joystick mode	0 to 40 mm/s	
	Measuring speed		0.02, 0.05, 0.1, 0.2 mm/s (surface roughness), 0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0 mm/s (form/contour)	
	Measuring direction		Forward/backward	
	Straightness	with standard stylus	(0.1+0.0015L) µm L: traverse length (mm)	(0.05+0.0003L) µm L: traverse length (mm)
		with 2X-long stylus	(0.2+0.0015L) µm L: traverse length (mm)	(0.1+0.0015L) µm L: traverse length (mm)
	Accuracy (20 °C)		±(0.3+0.002L) µm L: traverse length (mm)	±(0.16+0.001L) µm L: traverse length (mm)
α axis	Inclination range		-45° (CCW), +10° (CW)	—
Z1 axis (Detector)	Measuring range	with standard stylus	12 mm	
		with 2X-long stylus	24 mm	
	Resolution	with standard stylus	0.0008 µm	
		with 2X-long stylus	0.0016 µm	
	Vertical movement of the stylus		Arc motion	
	Scale type		Transmission-type linear encoder	
	Accuracy (20 °C)		±(0.3+|0.02H|) µm H: probing height (mm)	±(0.07+|0.02H|) µm H: probing height (mm)
	Measuring force	with standard stylus	4 mN (Fixed)	
		with 2X-long stylus	0.75 mN (Fixed)	
	Traceable angle		Ascent: 60°, Descent: 60° (Depends on the surface texture.)	
	Stylus tip shape	Standard stylus	Tip radius: 5 µm, Tip angle: 40°, Diamond	
		Standard ball stylus	Tip ball radius: 0.25 mm, Sapphire	
		2X-long stylus	Tip radius: 5 µm, Tip angle: 40°, Diamond	
		2X-long stylus	—	Tip radius: 2 µm, Tip angle: 60°, Diamond tip
		2X-long ball stylus	Tip ball radius: 0.25 mm, Sapphire	
	Face of stylus		Downward	
Z2 axis (Column)	Travel range	Z2 axis (column, type S)	300 mm	
		Z2 axis (column, type H)	500 mm	
	Resolution		0.05 µm	
	Scale type		Reflective-type linear encoder	
	Drive speed	CNC mode	Max. 200 mm/s	
		Joystick mode	0 to 50 mm/s	
Base	Base size (W×D)		750×600 mm	
	Base material		Granite	

Note: While the appearance of the natural stone base varies according to the source, the high stability for which this material is known can always be relied upon.

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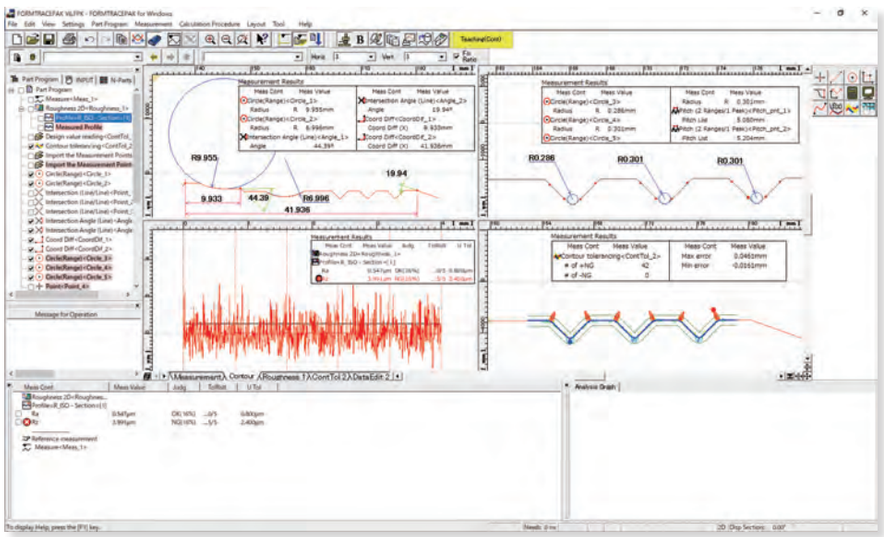
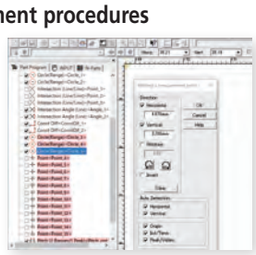
Surface Roughness/Contour Analysis Program FORMTRACEPAK



- **FORMTRACEPAK** functions offer total support for controlling the measurement system, surface roughness analysis, contour analysis, contour tolerancing, and inspection report creation.

• Editing measurement procedures

The items displayed in the measurement procedure window can be directly modified. You can, for example, perform new analyses by modifying the evaluation setup or roughness standard.



• Operation messaging

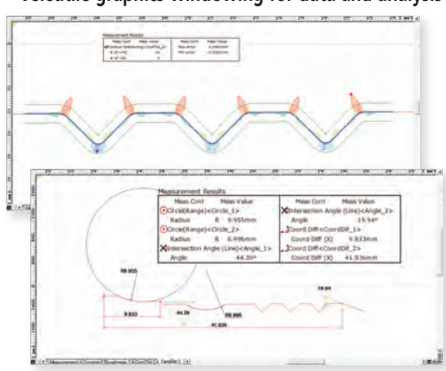
The operation message window for explaining the next step is incorporated.

• Measurement control

To make only a single measurement, you can create a part program in the single mode. To measure multiple workpieces of an identical shape, you can use the teaching mode. Since you can embed the entire flow, from making measurement to printing a report, into a part program, you can efficiently make measurements, analyze data, and output a report. A function is also provided that enables you to insert comments accompanied with photographs at desired timings, enabling you to embed the roles described in a measurement procedure document that specifies important points such as work settings.

To make immediate measurements, you can use the pull-down menu to easily select and call up the desired operating procedure.

• Versatile graphics windowing for data and analysis

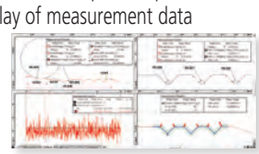


Tab-selection graphics window

Just select a tab to display the measurement data required, such as contour, roughness, or tolerancing results.

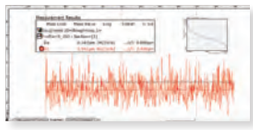
Dividing the screen into two or four windows

The screen can be divided into two, or four, windows for the convenient display of measurement data (for contour and roughness), analysis results, and contour tolerancing data, as required.



Displaying the results in the graphics window

You can paste the graphics obtained from measurements, as well as measurement values (including pass/fail results) and an analysis graph, into the graphics window. This enables you to check the graphics and measurement results at a glance using the graphics window alone.



Refer to the **FORMTRACEPAK** Brochure (**E15018**) for more details.

• **Online help functions**

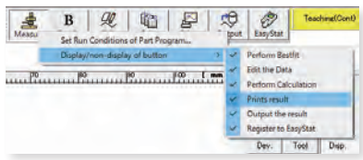
Online help that can be viewed any time is incorporated into the software. In addition to index and keyword searches, a status-saving help button, which displays menus and Windows help with a click of the mouse, is provided.

• **Multiple language support (18 languages)**

You can switch the language to be used in the measurement, analysis, and layout windows. After measurements have been made, you can switch to another language and create a report in that language. This function can be used worldwide.

• **Button-editing function**

You can hide buttons that are not used frequently. For example, you can choose to display only those buttons that are used frequently and increase the size of the displayed graphics window, thereby customizing the window to suit your needs.



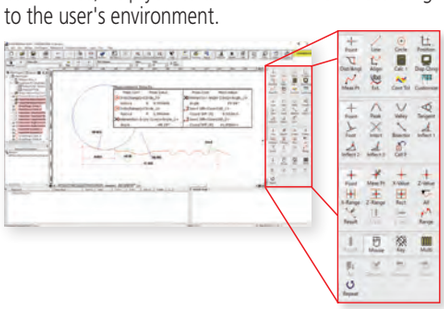
• **Simple statistical commands**

You can perform statistical calculations of roughness parameters and contour analysis results without using a separate program such as Excel.

Contour measurement

• **Contour analysis**

A wide variety of commands, which form the basic elements for analysis, are provided, including those for points (10 types), lines (6 types) and circles (6 types). A rich set of commands that combine these elements to calculate angles, pitches and distances as well as performing contour tolerancing and design value generation are also provided as standard features. These functions, combined with the function that enables you to customize the calculation command buttons by hiding less frequently used commands, help you to tailor the window according to the user's environment.

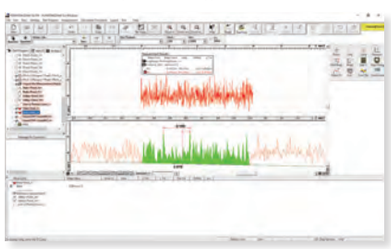


• **Contour-tolerancing as a standard feature**
• **Design value generation**
• **Data combination**
• **Simple pitch calculation**

Surface roughness measurement

• **Surface roughness analysis**

FORMTRACEPAK can perform surface roughness analyses that conform to various standards such as ISO, JIS, ANSI and VDA. For comparing measurement values with the tolerance limits, you can use the 16% rule or the maximum value rule. Furthermore, since **FORMTRACEPAK** comes with parameter calculation functions as well as a rich set of graphic analysis functions, it can be widely utilized for everything from routine quality control to R&D applications. It also includes many other functions such as the function for eliminating (compensating) shapes, such as slopes and radiused surfaces (R-surfaces), and data deletion.



• **Micro contour analysis**
• **Simple input using drawing symbols**
• **Multiple-point measurement**
• **Analysis using multiple-point measurements**
• **Reference length dialog box**
• **Analysis condition modification with preview**
• **R-surface automatic measurement**

Refer to the **FORMTRACEPAK** Brochure (**E15018**) for more details.

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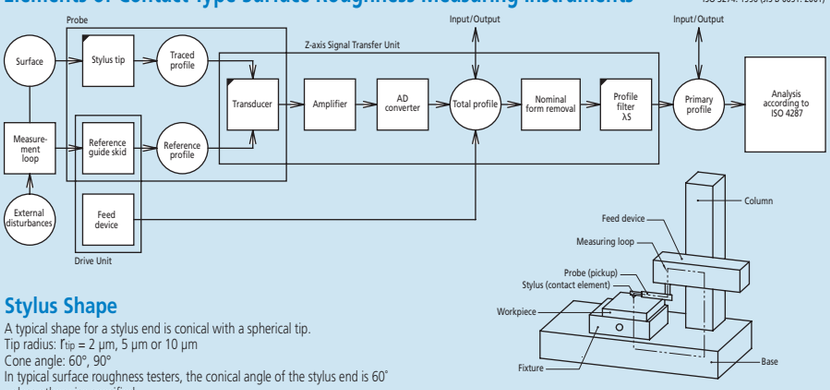
Quick Guide to Precision Measuring Instruments

Surftest (Surface Roughness Testers)

ISO 4287: 1997 Geometrical Product Specifications (GPS) – Surface Texture: Profile method– Terms, definitions, and surface texture parameters
ISO 4288: 1996 Geometrical Product Specifications (GPS) – Surface Texture: Profile method– Rules and procedures for the assessment of surface texture
ISO 3274: 1996 Geometrical Product Specifications (GPS) – Surface Texture: Profile method– Nominal characteristics of contact (stylus) instruments
ISO 11562: 1996 Geometrical Product Specifications (GPS) – Surface texture: Profile method– Metrological characteristics of phase correct filters

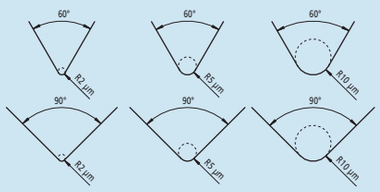
Elements of Contact Type Surface Roughness Measuring Instruments

ISO 3274: 1996 (JIS B 0651: 2001)



Stylus Shape

A typical shape for a stylus end is conical with a spherical tip.
Tip radius: r_{tip} = 2 µm, 5 µm or 10 µm
Cone angle: 60°, 90°
In typical surface roughness testers, the conical angle of the stylus end is 60° unless otherwise specified.



Static Measuring Force

Nominal radius of curvature of stylus tip: µm	Static measuring force at the mean position of stylus: mN	Tolerance on static measuring force variations: mN/µm
2	0.75	0.035
5	0.75 (4.0) *	0.2
10		

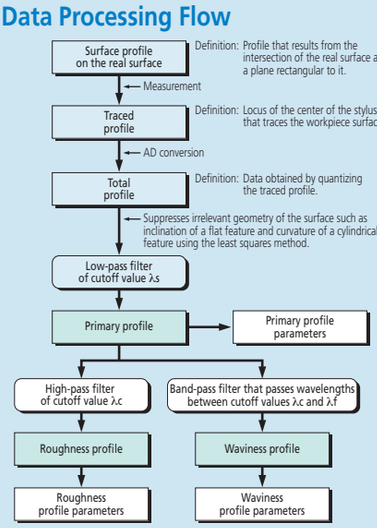
* The maximum value of static measuring force at the average position of a stylus is to be 4.0 mN for a probe with a special structure including a replaceable stylus.

Metrological Characterization of Phase Correct Filters

ISO 11562: 1996 (JIS B 0632: 2001)

A profile filter is a phase-correct filter without phase delay (cause of profile distortion dependent on wavelength).
The weight function of a phase-correct filter shows a normal (Gaussian) distribution in which the amplitude transmission is 50% at the cutoff wavelength.

Data Processing Flow



Relationship between Cutoff Value and Stylus Tip Radius

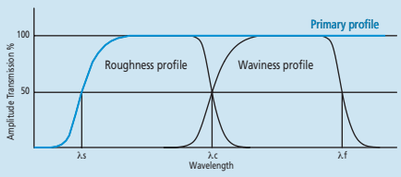
The following table lists the relationship between the roughness profile cutoff value λc, stylus tip radius r_{tip}, and cutoff ratio λc/λs.

λc mm	λs µm	λc/λs	Maximum r_{tip} µm	Maximum sampling length µm
0.08	2.5	30	2	0.5
0.25	2.5	100	2	0.5
0.8	2.5	300	2 *1	0.5
2.5	8	300	5 *2	1.5
8	25	300	10 *2	5

*1 For a surface with *Ra*>0.5 µm or *Rz*>3 µm, a significant error will not usually occur in a measurement even if r_{tip} = 5 µm.
*2 If a cutoff value λs is 2.5 µm or 8 µm, attenuation of the signal due to the mechanical filtering effect of a stylus with the recommended tip radius appears outside the roughness profile pass band. Therefore, a small error in stylus tip radius or shape does not affect parameter values calculated from measurements. If a specific cutoff ratio is required, the ratio must be defined.

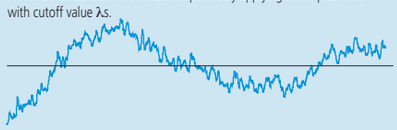
Surface Profiles

ISO 4287:1997 (JIS B 0601: 2013)



Primary Profile

Profile obtained from the measured profile by applying a low-pass filter with cutoff value λs.

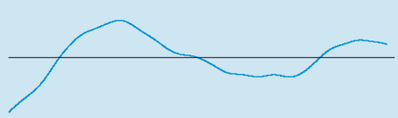


Roughness Profile

Profile obtained from the primary profile by suppressing the longer wavelength components using a high-pass filter of cutoff value λc.

Waviness Profile

Profile obtained by applying a band-pass filter to the primary profile to remove the longer wavelengths above λf and the shorter wavelengths below λc.



Roughness sampling length for non-periodic profiles

ISO 4288: 1996 (JIS B 0633: 2001)

Table 1: Sampling lengths for aperiodic profile roughness parameters (*Ra*, *Rq*, *Rsk*, *Rku*, *RΔq*), material ratio curve, probability density function, and related parameters

Ra µm	Sampling length *lr* mm	Evaluation length *ln* mm
(0.006)<*Ra*≤0.02	0.08	0.4
0.02 <*Ra*≤0.1	0.25	1.25
0.1 <*Ra*≤2	0.8	4
2 <*Ra*≤10	2.5	12.5
10 <*Ra*≤80	8	40

Table 2: Sampling lengths for aperiodic profile roughness parameters (*Rz*, *Rv*, *Rp*, *Rc*, *Rt*)

Rz *Rz*1max. µm	Sampling length *lr* mm	Evaluation length *ln* mm
(0.025)<*Rz*, *Rz*1max.≤0.1	0.08	0.4
0.1 <*Rz*, *Rz*1max.≤0.5	0.25	1.25
0.5 <*Rz*, *Rz*1max.≤10	0.8	4
10 <*Rz*, *Rz*1max.≤50	2.5	12.5
50 <*Rz*, *Rz*1max.≤200	8	40

1) *Rz* is used for measurement of *Rz*, *Rv*, *Rp*, *Rc*, and *Rt*.
2) *Rz*1max. only used for measurement of *Rz*1max., *Rv*1max., *Rp*1max., and *Rc*1max..

Table 3: Sampling lengths for measurement of periodic roughness profile roughness parameters and periodic or aperiodic profile parameter *RSm*

RSm mm	Sampling length *lr* mm	Evaluation length *ln* mm
0.013 <*RSm*≤0.04	0.08	0.4
0.04 <*RSm*≤0.13	0.25	1.25
0.13 <*RSm*≤0.4	0.8	4
0.4 <*RSm*≤1.3	2.5	12.5
1.3 <*RSm*≤4	8	40

Procedure for determining a sampling length if it is not specified

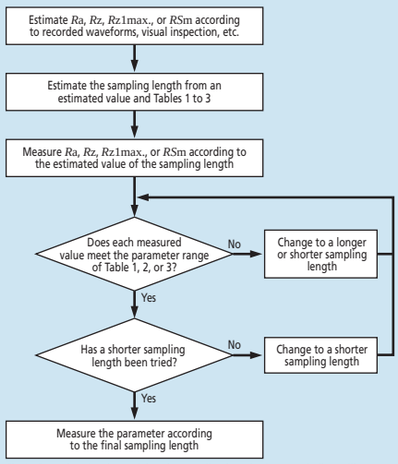


Fig.1 Procedure for determining the sampling length of an aperiodic profile if it is not specified.

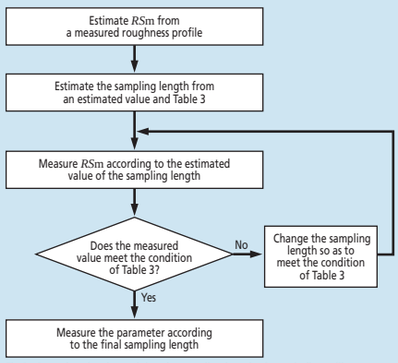


Fig.2 Procedure for determining the sampling length of a periodic profile if it is not specified.

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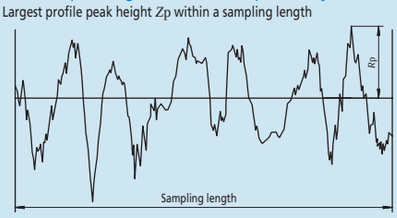
Definition of Parameters

ISO 4287: 1997, Amd. 1: 2009 (JIS B 0261: 2013)

Amplitude Parameters (peak and valley)

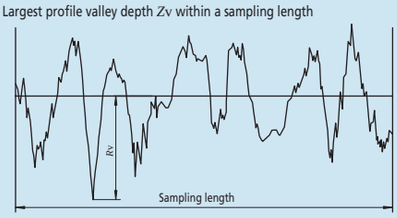
Maximum peak height of the primary profile Pp
Maximum peak height of the roughness profile Rp
Maximum peak height of the waviness profile Wp

Largest profile peak height Zp within a sampling length



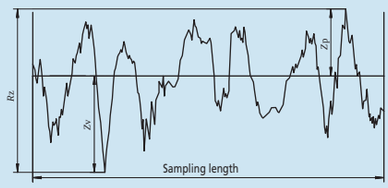
Maximum valley depth of the primary profile Pv
Maximum valley depth of the roughness profile Rv
Maximum valley depth of the waviness profile Wv

Largest profile valley depth Zv within a sampling length



Maximum height of the primary profile Pz
Maximum height of the roughness profile Rz
Maximum height of the waviness profile Wz

Sum of height of the largest profile peak height Zp and the largest profile valley depth Zv within a sampling length

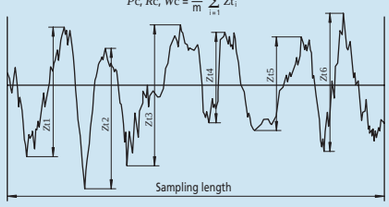


In the old JIS and ISO 4287-1: 1984, **Rz** was used to indicate the "ten point height of irregularities". Care must be taken because differences between results obtained according to the existing and old standards are not always negligibly small. (Be sure to check whether the drawing instructions conform to existing or old standards.)

Mean height of the primary profile elements Pc
Mean height of the roughness profile elements Rc
Mean height of the waviness profile elements Wc

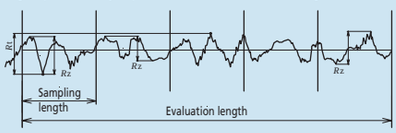
Mean value of the profile element heights Zt within a sampling length

$$Pc, Rc, Wc = \frac{1}{m}\sum_{i=1}^{m} Zt_i$$



Total height of the primary profile Pt
Total height of the roughness profile Rt
Total height of the waviness profile Wt

Sum of the height of the largest profile peak height Zp and the largest profile valley depth Zv within the evaluation length



Amplitude Parameters (average of ordinates)

Arithmetical mean deviation of the primary profile Pa
Arithmetical mean deviation of the roughness profile Ra
Arithmetical mean deviation of the waviness profile Wa

Arithmetic mean of the absolute ordinate values Z(x) within a sampling length

$$Pa, Ra, Wa = \frac{1}{l}\int_0^l |Z(x)|dx$$

with l as lp, lr, or lw according to the case.

Root mean square deviation of the primary profile Pq
Root mean square deviation of the roughness profile Rq
Root mean square deviation of the waviness profile Wq

Root mean square value of the ordinate values Z(x) within a sampling length

$$Pq, Rq, Wq = \sqrt{\frac{1}{l}\int_0^l Z^2(x)dx}$$

with l as lp, lr, or lw according to the case.

Skewness of the primary profile Psk
Skewness of the roughness profile Rsk
Skewness of the waviness profile Wsk

Quotient of the mean cube value of the ordinate values Z(x) and the cube of Pq, Rq, or Wq respectively, within a sampling length

$$Rsk = \frac{1}{Rq^3}\left[\frac{1}{lr}\int_0^{lr} Z^3(x)dx\right]$$

The above equation defines **Rsk**. **Psk** and **Wsk** are defined in a similar manner. **Psk**, **Rsk**, and **Wsk** are measures of the asymmetry of the probability density function of the ordinate values.

Kurtosis of the primary profile Pku
Kurtosis of the roughness profile Rku
Kurtosis of the waviness profile Wku

Quotient of the mean quartic value of the ordinate values Z(x) and the fourth power of Pq, Rq, or Wq respectively, within a sampling length

$$Rku = \frac{1}{Rq^4}\left[\frac{1}{lr}\int_0^{lr} Z^4(x)dx\right]$$

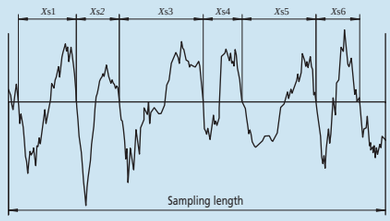
The above equation defines **Rku**. **Pku** and **Wku** are defined in a similar manner. **Pku**, **Rku**, and **Wku** are measures of the sharpness of the probability density function of the ordinate values.

Spacing Parameters

Mean width of the primary profile elements PSm
Mean width of the roughness profile elements RSm
Mean width of the waviness profile elements WSm

Mean value of the profile element widths Xs within a sampling length

$$PSm, RSm, WSm = \frac{1}{m}\sum_{i=1}^{m} Xs_i$$



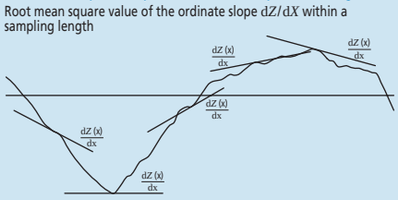
Peak count number based on the primary profile elements PPc
Peak count number based on the roughness profile elements RPc
Peak count number based on the waviness profile elements WPc

$$RPc = \frac{1}{RSm}$$

Hybrid Parameters

Root mean square slope of the primary profile $P\Delta q$
Root mean square slope of the roughness profile $R\Delta q$
Root mean square slope of the waviness profile $W\Delta q$

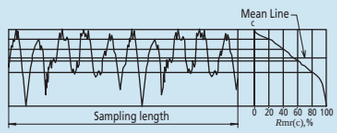
Root mean square value of the ordinate slope dZ/dX within a sampling length



Curves, Probability Density Function, and Related Parameters

Material ratio curve of the profile (Abbott-Firestone curve)

Curve representing the material ratio of the profile as a function of section level c



Material ratio of the primary profile $Pmr(c)$
Material ratio of the roughness profile $Rmr(c)$
Material ratio of the waviness profile $Wmr(c)$

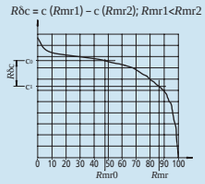
Ratio of the material length of the profile elements $Ml(c)$ at a given level c to the evaluation length

$$Pmr(c), Rmr(c), Wmr(c) = \frac{Ml(c)}{ln}$$

Section height difference of the primary profile $P\delta c$
Section height difference of the roughness profile $R\delta c$
Section height difference of the waviness profile $W\delta c$

Vertical distance between two section levels of a given material ratio

$$R\delta c = c(Rmr1) - c(Rmr2);\ Rmr1 < Rmr2$$



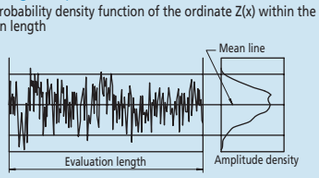
Relative material ratio of the primary profile Pmr
Relative material ratio of the roughness profile Rmr
Relative material ratio of the waviness profile Wmr

Material ratio determined at a profile section level $R\delta c$ related to the reference section level c_0

$$Pmr, Rmr, Wmr = Pmr(c_1), Rmr(c_1), Wmr(c_1)$$
where $c_1 = c_0 - R\delta c\ (P\delta c, W\delta c)$
$c_0 = c\ (Pm0, Rmr0, Wmr0)$

Probability density function
(profile height amplitude distribution curve)

Sample probability density function of the ordinate Z(x) within the evaluation length

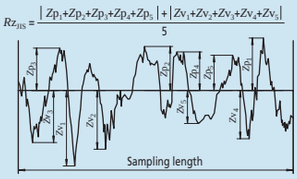


JIS Specific Parameters

Ten-point height of irregularities, Rz_{JIS}

Sum of the absolute mean height of the five highest profile peaks and the absolute mean depth of the five deepest profile valleys, measured from the mean line within the sampling length of a roughness profile. This profile is obtained from the primary profile using a phase-correct band-pass filter with cutoff values of lc and ls.

$$Rz_{JIS} = \frac{|Zp_1+Zp_2+Zp_3+Zp_4+Zp_5| + |Zv_1+Zv_2+Zv_3+Zv_4+Zv_5|}{5}$$



Symbol	Used profile
Rz_{JIS82}	Surface profile as measured
Rz_{JIS94}	Roughness profile derived from the primary profile using a phase-correct high-pass filter

Arithmetic mean deviation of the profile Ra_{75}

Arithmetic mean of the absolute values of the profile deviations from the mean line within the sampling length of the roughness profile (75%). This profile is obtained from a measurement profile using an analog high-pass filter with an attenuation factor of 12db/octave and a cutoff value of λc.

$$Ra_{75} = \frac{1}{ln}\int_0^{ln} |Z(x)|dx$$

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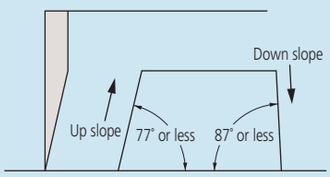
Quick Guide to Precision Measuring Instruments

Contracer (Contour Measuring Instruments)

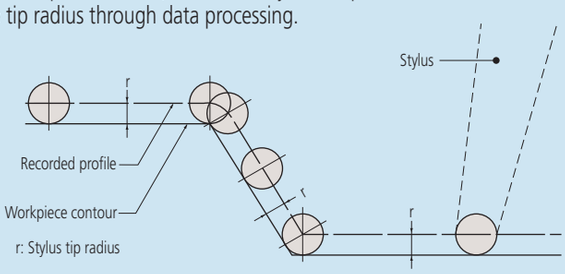
Traceable Angle



The maximum angle at which a stylus can trace upwards or downwards along the contour of a workpiece, in the stylus travel direction, is referred to as the traceable angle. A one-sided sharp stylus with a tip angle of 12° (as in the above figure) can trace a maximum 77° of up slope and a maximum 87° of down slope. For a conical stylus (30° cone), the traceable angle is smaller. An up slope with an angle of 77° or less overall may actually include an angle of more than 77° due to the effect of surface roughness. Surface roughness also affects the measuring force.

Compensating for Stylus Tip Radius

A recorded profile represents the locus of the center of the ball tip rolling on a workpiece surface. (A typical radius is 0.025 mm.) Obviously this is not the same as the true surface profile so, in order to obtain an accurate profile record, it is necessary to compensate for the effect of the tip radius through data processing.

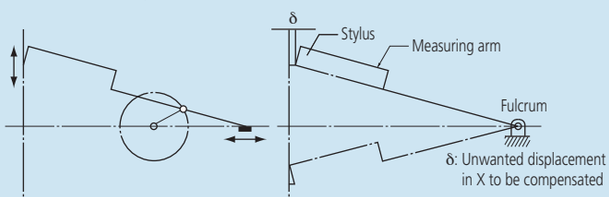


If a profile is read from the recorder through a template or scale, it is necessary to compensate for the stylus tip radius beforehand according to the applied measurement magnification.

Compensating for Arm Rotation

When the stylus traces through a circular-arc, error arises in the X-axis direction of the recorded profile. Possible methods for compensating for this effect are as follows:

1) Mechanical compensation
2) Electrical compensation



3) Software processing. To measure a workpiece contour that involves a large displacement in the vertical direction with high accuracy, one of these compensation methods needs to be implemented.

Accuracy

As the detector units of the X-and Z-axes incorporate scales, the magnification accuracy is displayed not as a percentage but as the linear displacement accuracy for each axis.

Overload Safety Cutout

If an excessive force (overload) is exerted on the stylus tip due, perhaps, to the tip encountering a too-steep slope on a workpiece feature, or a burr, for example, a safety device automatically stops operation and sounds an alarm buzzer. This type of instrument is commonly equipped with separate safety devices for the tracing direction (X axis) load and vertical direction (Z axis) load.

Circular-Arc / Linear Tracing

The locus traced by the stylus tip during vertical stylus movement can be a circular arc or a straight line. Ensuring a straight-line locus entails complex mechanics, while in the case of a circular-arc locus, if the amplitude of stylus displacement is large in the vertical direction, an error (δ) in the recorded profile in the horizontal direction arises. (See figure at lower left)

Z-axis Measurement Methods

Though the X-axis measurement method commonly adopted is by means of a digital scale, the Z-axis measurement divides into analog methods (using a differential transformer, for example) and digital scale methods.
Analog methods vary in Z-axis resolution depending on the measurement magnification and measuring range. Digital scale methods have fixed resolution.
Generally, a digital scale method provides higher accuracy than an analog method.

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Contour analysis methods

You can analyze the contour with one of the following two methods after completing the measurement operation.

Data processing section and analysis program

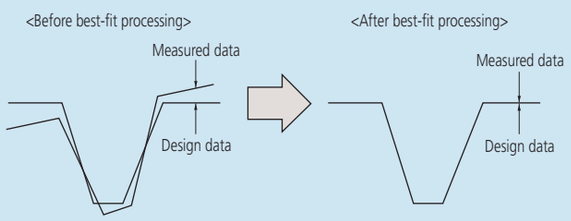
The measured contour is input into the data processing section in real time and a dedicated program performs the analysis using the mouse and/or keyboard. The angle, radius, step, pitch and other data are directly displayed as numerical values. Analysis combining coordinate systems can be easily performed. The graph that goes through stylus radius correction is output to the printer as the recorded profile.

Tolerancing with Design Data

Measured workpiece contour data can be compared with design data in terms of actual and designed shapes rather than just analysis of individual dimensions. In this technique each deviation of the measured contour from the intended contour is displayed and recorded. Also, data from one workpiece example can be processed so as to become the master design data to which other workpieces are compared. This function is particularly useful when the shape of a section greatly affects product performance, or when its shape has an influence on the relationship between mating or assembled parts.

Best-fitting

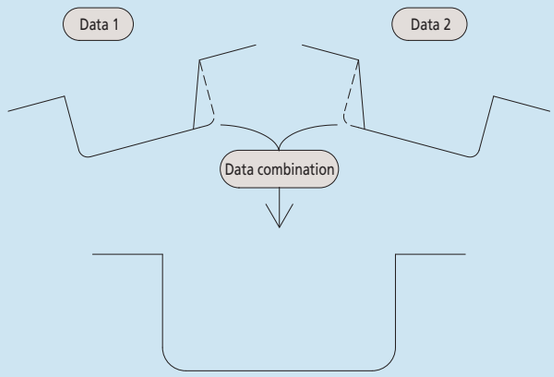
If there is a standard for surface profile data, tolerancing with design data is performed according to the standard. If there is no standard, or if tolerancing only with shape is desired, best-fitting between design data and measurement data can be performed.



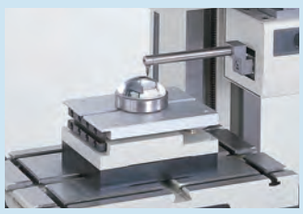
The best-fit processing algorithm searches for deviations between both sets of data and derives a coordinate system in which the sum of squares of the deviations is a minimum when the measured data is overlaid on the design data.

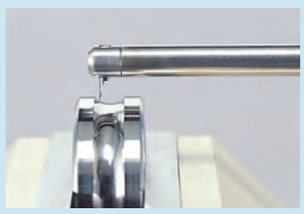
Data Combination

Conventionally, if tracing a complete contour is prevented by stylus traceable-angle restrictions then it has to be divided into several sections that are then measured and evaluated separately. This function avoids this undesirable situation by combining the separate sections into one contour by overlaying common elements (lines, points) onto each other. With this function the complete contour can be displayed and various analyses performed in the usual way.



Measurement Examples

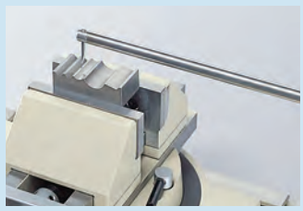

Aspheric lens contour


Inner/outer ring contour of a bearing


Internal gear teeth


Female thread form


Male thread form


Gage contour

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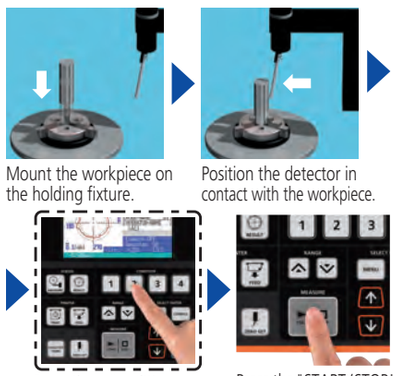
Roundtest RA-10
SERIES 211 — Roundness Measuring Instrument

RA-10

Simple measurement procedure



Mount the workpiece on the holding fixture.

Position the detector in contact with the workpiece.

Press the "Condition" button as required.

Press the "START/STOP" button.

SPECIFICATIONS

Model No.			RA-10
Turntable	Rotational accuracy (JIS B 7451-1997)	Radial direction	(0.04 + 6H/10000) μm H: Probing height (mm)
		Axial direction	(0.04 + 6X/10000) μm X: distance from the center of rotation (mm)
	Maximum probing diameter		ø100 mm
	Maximum loading mass		10 kg
Vertical movement	Vertical travel		117 mm
X axis	Travel range		75 mm (-25 mm to 50 mm from the rotation center)
Detector*	Measuring range		±1000 μm

* Only the standard length stylus is applicable to this detector. The long type cannot be used.

A cost-effective compact instrument that enables full-scale roundness evaluation.

- Offers easy operation for anyone.
  A large, simple key arrangement is used.
- User-friendly operation.
  Measurement results and recorded profiles are easy to view with the large LCD, and can then be printed by the built-in thermal line printer. Furthermore, optional functions to improve usability can be offered.

Refer to the Roundtest **RA-10** Brochure (**E15019**) for more details.

Roundtest RA-120/120P
SERIES 211 — Roundness Measuring Instruments

RA-120

RA-120P

The analysis capabilities for the various models (**RA-120**/**120P**/**10**) vary. For details, refer to page L-26.

SPECIFICATIONS

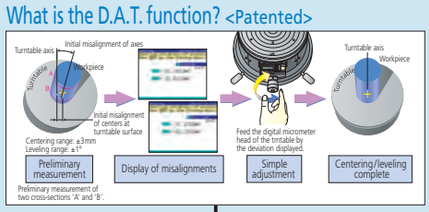
Model No.			RA-120	RA-120P
Turntable	Rotational accuracy (JIS B 7451-1997)	Radial direction	(0.04 + 6H/10000) μm H: Probing height (mm)	
		Axial direction	(0.04 + 6X/10000) μm X: distance from the center of rotation (mm)	
	Maximum probing diameter*1		ø280 mm (ø380 mm: for the vertical position when detector holder is installed reversely, the maximum probing height is up to 50 mm from the table top.)	
	Maximum loading mass		25 kg	
Vertical movement	Vertical travel		280 mm	
X axis	Travel range		165 mm (-25 mm to 140 mm from the rotation center)	
Detector*2	Measuring range		±1000 μm	

*1 Auxiliary stage for a low-height workpiece (optional) is required for the measurement 20 mm or less in the radial direction from the center point of the table and 20 mm or less from the table top.
*2 Only the standard length stylus is applicable to this detector. The long type cannot be used.

Easy operation, compact and outstanding cost/performance ratio, designed for use on the shop-floor right beside the production line.

- D.A.T. (Digimatic Adjustment Table) function aids adjustments such as centering and leveling, and substantially reduces the time required for preliminary setup operations.

What is the D.A.T. function? <Patented>



Dedicated analysis unit type (RA-120)

- Compact, lightweight design from incorporating electronic components inside the main unit.

Data analysis by PC (RA-120P)

- **ROUNDPAK**, a data analysis program employs Windows OS and archived higher level of analysis.

Refer to the Roundtest **RA-120/120P** Brochure (**E15008**) for more details.

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- Compact body and a wide measuring range assures precision that compares well with that of higher-grade models.
- D.A.T. (Digital Adjustment Table) function aids manual workpiece centering and leveling.
- Safety mechanism provided in the detection section as a standard feature.
- A sliding mechanism (optional sliding detector holder) can be installed in the detector holder. It enables one-touch measurement of a workpiece with a deep hole having a thick wall, which has been difficult with the standard detector.

Refer to the Roundtest **RA-1600** Brochure (**E15000**) for more details.

Achieved the world's highest level of accuracy for this class of machine. A high-performance automatic system equipped with a high-speed automatic centering/leveling function.

- High-speed automatic centering/leveling function contributes to a significant reduction in the man-hours required for setups.
- A fully automatic system which performs processing automatically from part program calling, centering/leveling, measurement, calculation, all the way through to printing.
- Capable of continuous inside/outside diameter measurement without changing the detector orientation (up to 50 mm ID).
- The automatic positioning function of the turntable enables automatic measurement in combination with table rotation and slider/column movement.
- Advanced graphical analysis such as power spectrum chart is available.
- A sliding mechanism is incorporated in the detector holder part.

Refer to the Roundtest **RA-2200** Series Brochure (**E15001**) for more details.

Roundtest RA-1600
SERIES 211 — Roundness/Cylindricity Measuring System

Detector safety mechanism

RA-1600

SPECIFICATIONS

Model No.			RA-1600
Turntable	Rotational accuracy (JIS B 7451-1997)	Radial direction	(0.02 + 6H/10000) µm H: Probing height (mm)
		Axial direction	(0.02 + 6X/10000) µm X: Distance from the center of rotation (mm)
	Maximum loading mass		25 kg
	Maximum probing diameter		ø280 mm
Vertical movement (Z-axis column unit)	Vertical travel		300 mm
X axis	Travel range		165 mm (-25 mm to +140 mm from the rotation center)
Detector	Measuring range	Standard	±400 µm/±40 µm/±4 µm
		Tracking	±5 mm

Roundtest RA-2200
SERIES 211 — Roundness/Cylindricity Measuring System

RA-2200AH
System vibration isolator (with side table)

RA-2200AH
System vibration isolator (monitor arm type)*
* Printer table (provided by the customer) not shown.

SPECIFICATIONS

Model No.			RA-2200AS	RA-2200DS	RA-2200AH	RA-2200DH
Turntable	Rotational accuracy (JIS B 7451-1997)	Radial direction	(0.02 + 3.5H/10000) µm H: Probing height (mm)			
		Axial direction	(0.02 + 3.5X/10000) µm X: Distance from the center of rotation (mm)			
	Maximum loading mass		30 kg			
	Maximum probing diameter		ø300 mm			
Vertical movement (Z-axis column unit)	Vertical travel		300 mm		500 mm	
X axis	Travel range		175 mm (-25 mm to +150 mm from the rotation center)			
Detector	Measuring range	Standard	±400 µm/±40 µm/±4 µm			
		Tracking	±5 mm			

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Roundtest RA-H5200
SERIES 211 — Roundness/Cylindricity Measuring System

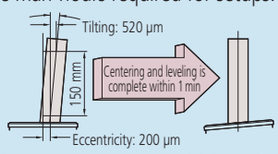
RA-H5200AS
with side table

SPECIFICATIONS

Model No.			RA-H5200AS	RA-H5200AH
Turntable	Rotational accuracy (JIS B 7451-1997)	Radial direction	(0.02 + 3.5H/10000) µm H: Probing height (mm)	
		Axial direction	(0.02 + 3.5X/10000) µm X: Distance from the center of rotation (mm)	
	Maximum loading mass		80 kg (On auto-centering: 65 kg)	
	Maximum probing diameter		ø400 mm	
Vertical movement (Z-axis column unit)	Vertical travel		350 mm	550 mm
X axis	Travel range		225 mm (-25 mm to +200 mm from the rotation center)	
Detector	Measuring range	Standard	±400 µm/±40 µm/±4 µm	
		Tracking	±5 mm	

A high-performance automatic system equipped with a high-speed automatic centering/leveling function achieves the world's highest-level of accuracy.

- High-speed automatic centering/leveling function contributes to a significant reduction in the man-hours required for setups.



- A fully automatic system which performs processing automatically from part program calling, centering/leveling, measurement, calculation, all the way through to printing.
- Capable of continuous inside/outside diameter measurement without changing the detector orientation (up to 50 mm ID).
- The automatic positioning function of the turntable enables automatic measurement in combination with table rotation and slider/column movement.
- Advanced graphical analysis such as a power spectrum chart is available.
- A sliding mechanism is incorporated in the detector holder.

Roundtest RA-2200 PLUS
SERIES 211 — Roundness/Cylindricity Measuring System

RA-2200AH PLUS
System vibration isolator (with side table)

- The turntable with automatic centering and leveling function is equipped as standard, which frees operators from manual centering and leveling operations.
- Automatic control of holder arm posture (vertical/horizontal) and the rotation feature of the detector (rotates in 1° increments in the range of 0 to 270°) enables continuous measurement of various feature combinations, such as OD/ID and/or top/bottom plane measurements.
- A Mitutoyo linear scale is used in the X-axis drive unit to directly detect the position of the drive unit. It guarantees the highly precise positioning vital for automatic measurement.
- A roughness detector (optional) is supported.

SPECIFICATIONS

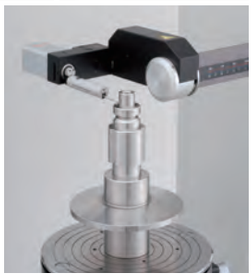
Model No.			RA-2200AS PLUS	RA-2200AH PLUS
Turntable	Rotational accuracy (JIS B 7451-1997)	Radial direction	(0.02 + 3.5H/10000) µm H: Probing height (mm)	
		Axial direction	(0.02 + 3.5X/10000) µm X: Distance from the center of rotation (mm)	
	Maximum loading mass		30 kg	
	Maximum probing diameter		ø256 mm	
Vertical movement (Z-axis column unit)	Vertical travel		300 mm	500 mm
X axis	Travel range		175 mm (-25 mm to +150 mm from the rotation center)	
Detector	Measuring range	Standard	±400 µm/±40 µm/±4 µm	
		Tracking	±5 mm	

Refer to the Roundtest **RA-2200** Series Brochure (**E15001**) for more details.

MeasurLink® ENABLED
Data Management Software by Mitutoyo

PROPRIETARY INSPECTION CERTIFICATE

Roundtest RA-H5200 PLUS
SERIES 211 — Roundness/Cylindricity Measuring System



RA-H5200AS PLUS
with side table

A fully automated machine with highest-level accuracy that can greatly improve productivity and efficiency.

- The turntable with automatic centering and leveling function is equipped as standard, which frees operators from manual centering and leveling operations.
- Automatic control of holder arm posture (vertical/horizontal) and the rotation feature of the detector (rotates in 1° increments in the range of 0 to 270°) enables continuous measurement of various feature combinations, such as OD/ID and/or top/bottom plane measurements.
- A Mitutoyo linear scale is used in the X-axis drive unit to directly detect the position of the drive unit. It guarantees the highly precise positioning vital for automatic measurement.
- A roughness detector (optional) is supported.

Refer to the Roundtest **RA-H5200** Series Brochure (**E4392**) for more details.

SPECIFICATIONS

Model No.			RA-H5200AS PLUS	RA-H5200AH PLUS
Turntable	Rotational accuracy (JIS B 7451-1997)	Radial direction	(0.02 + 3.5H/10000) µm H: Probing height (mm)	
		Axial direction	(0.02 + 3.5X/10000) µm X: Distance from the center of rotation (mm)	
	Maximum loading mass		80 kg (On auto-centering: 65 kg)	
	Maximum probing diameter		ø356 mm	
Vertical movement (Z-axis column unit)	Vertical travel		350 mm	550 mm
X axis	Travel range		225 mm (-25 mm to +200 mm from the rotation center)	
Detector	Measuring range	Standard	±400 µm/±40 µm/±4 µm	
		Tracking	±5 mm	

Roundtest Extreme RA-6000 CNC
SERIES 211 — CNC Roundness/Cylindricity Measuring System

RA-6000 CNC

MeasurLink® ENABLED
Data Management Software by Mitutoyo

The best accuracy achieved in the class of large cylindricity measuring machine.

- Loading capacity is 350 kg, and the highest rotational accuracy in the class is achieved. Besides roundness and cylindricity, the flatness can be measured in high accuracy. The workpiece that requires high accuracy measurement such as large and heavy cylindrical parts can be measurement.
- For the ID measurement of a deep hole, such as a main shaft of machine tool, a deep hole measuring unit (specially made, without CNC functions) is available.
- A Mitutoyo linear scale is used in the X-axis drive unit to directly detect the position of the drive unit. It guarantees the highly precise positioning vital for automatic measurement.

SPECIFICATIONS

Model No.			RA-6000 CNC
Turntable	Rotational accuracy *1*2 (JIS B 7451-1997)	Radial direction	(0.05 + 6H/10000) µm H: Probing height (mm)
		Axial direction	(0.05 + 6X/10000) µm X: Distance from the center of rotation (mm)
	Maximum loading mass		350 kg
	Maximum probing diameter		ø880 mm
Vertical movement (Z-axis column unit)	Vertical travel		1050 mm
X axis	Travel range		465 mm (-25 mm travel available from the rotation center)
Detector	Measuring range		±400 µm

*1 The temperature at which the accuracy can be guaranteed is 20 °C.
*2 The rotational accuracy has been obtained when load is applied to the rotation center.

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Mitutoyo

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PROPRIETARY INSPECTION CERTIFICATE

ROUNDTRACER EXTREME
SERIES 211 — CNC Roundness/Cylindricity Measuring System

RTX-0605-A

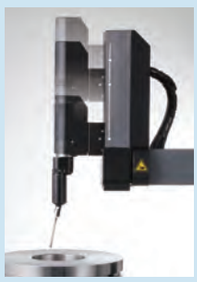
SPECIFICATIONS

Model No.			RTX-0605-A
Turntable	Rotational accuracy (JIS B 7451:1997)	Radial direction	(0.02 + 3.5H/10000) µm H: Probing height (mm)
		Axial direction	(0.02 + 3.5R/10000) µm R: Measuring radius (mm)
	Maximum loading mass		60 kg
	Maximum probing diameter		ø680 mm
Vertical movement (Z-axis column unit)	Travel range		550 mm
X axis	Travel range		197 mm (-33 mm to 164 mm from the rotation center)*
Detectors	Measuring range		±400 µm/±40 µm/±3.6 µm

* Value when the measuring system is mounted with a roundness detector and a standard stylus, and is in the outside diameter measuring position with the stylus at 0°.

- ROUNDTRACER EXTREME models are triple-role CNC profile measuring systems that integrate the roundness and cylindricity measuring capabilities of our ROUNDTEST models and the contour and surface roughness measuring capabilities of our hybrid, dual-role FORMTRACER models to measure surface roughness, contour, roundness, and cylindricity.

- Measurement repeatability is improved as a result of the newly developed centring mechanism and optimized slider structure.
- A detector holder with motorized sliding function enables continuous inside and upper surface measurement of thick workpieces.

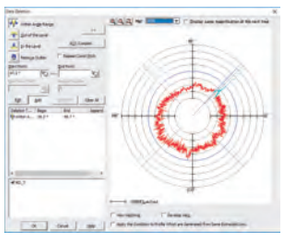


- Measurement throughput is improved as a result of the increased drive speeds of each axis and the addition of new functions and technologies.
- The incredibly high throughput is the result of reduced positioning time by CNC control, a highly rigid centring table, reduced waiting time until measurement start, and best-in class drive speeds.

Refer to the ROUNDTRACER EXTREME Brochure (**E15032**) for more details.

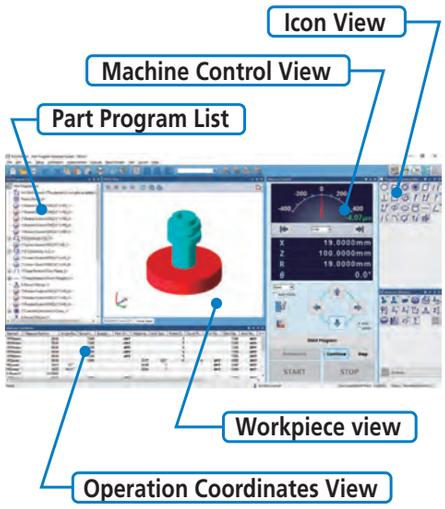
ROUNDPAK
Roundness/Cylindricity measurement/Analysis software

• A wide variety of parameters including those for roundness/cylindricity, as well as flatness and parallelism, are provided as standard features. You can visually select these parameters using icons.
ROUNDPAK also comes with specialized functions, such as the design value best-fit analysis function, the harmonic analysis function, and a function for recording the peak or trough points on a circumference. Data that has already been collected can be easily used for re-calculation, or deleted.

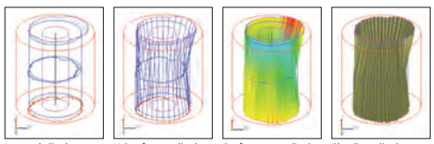


Data deletion

• The customer can create reports in custom formats by specifying how the analysis results will be displayed, as well as the sizes and positions of graphics. The analysis result window can be directly utilized as a layout window. Since the measurement procedure, including the layout information, is saved, the entire process, from measurement start, calculation, result saving, and finally to printing, can be automatically executed.



• Analysis results such as cylindricity and coaxiality can be visually expressed in 3D graphics.



Normal display | Wire-frame display | Surface-map display | Shading display

• An offline teaching function is provided to create a part program (measurement procedure) without an actual measurement target, enabling the user to virtually execute the measurement operation in a 3D simulation window.

Analysis type		Model	RTX-0605-A	RA-2200/H5200 RA-2200 PLUS/ H5200 PLUS/6000CNC	RA-1600	RA-120P	RA-120	RA-10
Roundness		○	✓	✓	✓	✓	✓	✓
Cylindricity		⌭	✓	✓	✓			
Concentricity		◎	✓	✓	✓	✓	✓	✓
Coaxiality	Axis element	◉	✓	✓	✓	✓	✓	✓
	Axis		✓	✓	✓	✓		
Flatness		▱	✓	✓	✓	✓	✓	✓
Parallelism		//	✓	✓	✓	✓	✓	
Perpendicularity		⊥	✓	✓	✓	✓	✓	
Radial deviation		⏢	✓	✓	✓			
Thickness deviation		⌀	✓	✓	✓	✓	✓	
Radial runout		↗	✓	✓	✓	✓	✓	✓
Total runout		⌰	✓	✓	✓			
Diameter measurement		ϕ	✓	✓	✓			
Straightness		—	✓	✓	✓			
Inclination		∠	✓	✓	✓			
Taper		/\	✓	✓	✓			
Diameter contour tolerancing		⌖	✓	✓	✓			
Rectilinear contour tolerancing		⌒	✓	✓	✓			
Width measurement (only CNC)		⌶	✓	✓ (only PLUS and CNC)				
Power spectrum		⫼	✓	✓	✓			
Harmonic analysis		⌯	✓	✓	✓	✓		
Profile operation		⏦	✓	✓	✓	✓		
Tapered surface analysis		⏢	✓	✓	✓			
Lead (twist) analysis		⫽	✓ (optional)					
3D surface property analysis		⌇	✓ (optional)					

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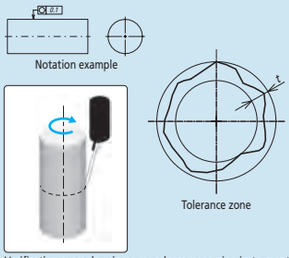
Quick Guide to Precision Measuring Instruments

Roundtest (Roundform Measuring Instruments)

Geometrical tolerances ISO/DIS 1101: 1996*1, ISO 5459*2

Roundness

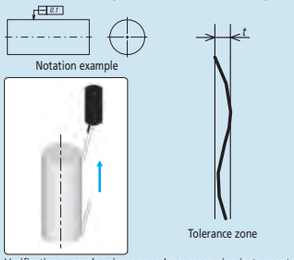
Any circumferential line must be contained within the tolerance zone formed between two coplanar circles with a difference in radii of t



Verification example using a roundness measuring instrument

Straightness

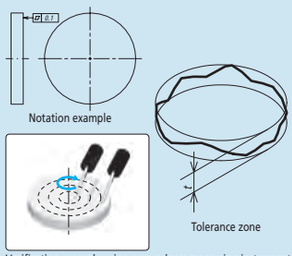
Any line on the surface must lie within the tolerance zone formed between two parallel straight lines a distance t apart and in the direction specified



Verification example using a roundness measuring instrument

Flatness

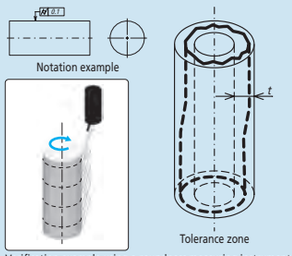
The surface must be contained within the tolerance zone formed between two parallel planes a distance t apart



Verification example using a roundness measuring instrument

Cylindricity

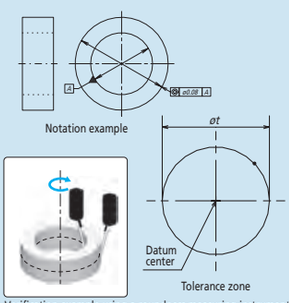
The surface must be contained within the tolerance zone formed between two coaxial cylinders with a difference in radii of t



Verification example using a roundness measuring instrument

Concentricity

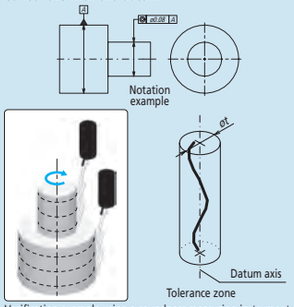
The center point must be contained within the tolerance zone formed by a circle of diameter t concentric with the datum



Verification example using a roundness measuring instrument

Coaxiality

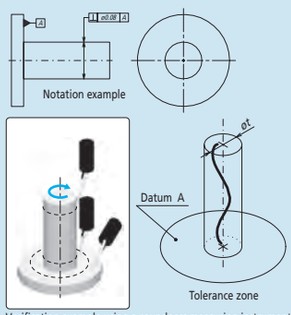
The axis must be contained within the tolerance zone formed by a cylinder of diameter t concentric with the datum



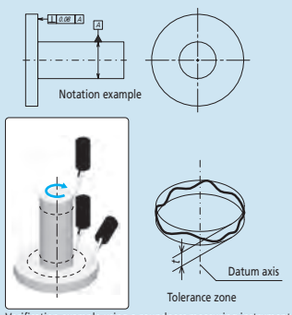
Verification example using a roundness measuring instrument

Perpendicularity

The line or surface must be contained within the tolerance zone formed between two planes a distance t apart and perpendicular to the datum



Verification example using a roundness measuring instrument

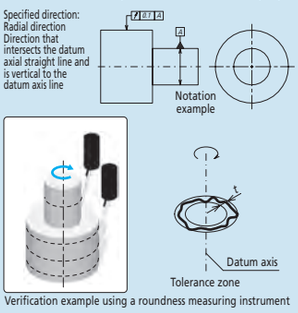


Verification example using a roundness measuring instrument

Circular Runout (Radial and Axial)

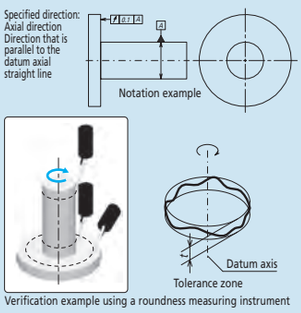
The line must be contained within the tolerance zone formed between two coplanar and/or concentric circles a distance t apart concentric with or perpendicular to the datum

Specified direction: Radial direction
Direction that intersects the datum axial straight line and is vertical to the datum axis line



Verification example using a roundness measuring instrument

Specified direction: Axial direction
Direction that is parallel to the datum axial straight line

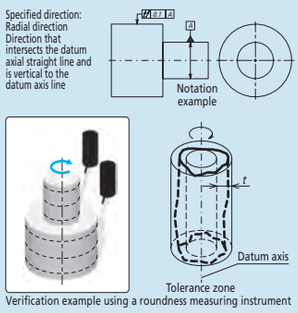


Verification example using a roundness measuring instrument

Total Runout (Radial and Axial)

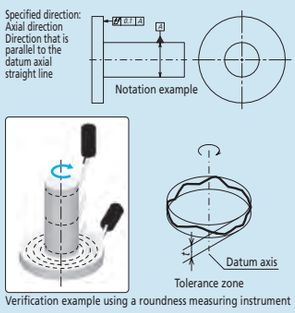
The surface must be contained within the tolerance zone formed between two coaxial cylinders with a difference in radii of t, or planes a distance t apart, concentric with or perpendicular to the datum

Specified direction: Radial direction
Direction that intersects the datum axial straight line and is vertical to the datum axis line



Verification example using a roundness measuring instrument

Specified direction: Axial direction
Direction that is parallel to the datum axial straight line

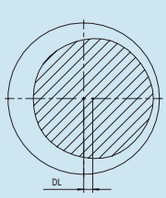


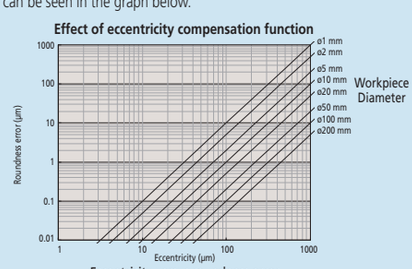
Verification example using a roundness measuring instrument

Adjustment prior to Measurement ISO 4291: 1985*3

Centering

A displacement offset (eccentricity) between the Roundtest's turntable axis and that of the workpiece results in distortion of the measured form (limaçon error) and consequentially produces an error in the calculated roundness value. The larger the eccentricity, the larger is the error in calculated roundness. Therefore the workpiece should be centered (axes made coincident) before measurement.
Some roundness testers support accurate measurement with a limaçon error correction function.
The effectiveness of this function can be seen in the graph below.

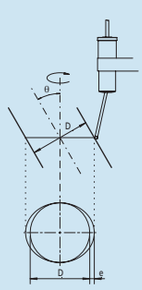


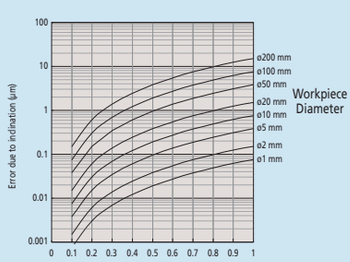


Eccentricity versus roundness error

Leveling

Any inclination of the axis of a workpiece with respect to the rotational axis of the measuring instrument will cause an elliptic error. Leveling must be performed so that these axes are sufficiently parallel.





Inclination versus elliptic error

Effect of Filter Settings on the Measured Profile ISO 12181-2: 2011*4

Profiles can be filtered in various ways to reduce or eliminate unwanted detail, with a cut-off value set in terms of undulations per revolution (upr). The effect of different upr settings is shown in the diagrams below, which illustrate how the measured roundness value decreases as lower upr settings progressively smooth out the line.

Filtering

	2CR filter	Gaussian filter
Standard	ISO 4291: 1985*3	ISO 12181-1: 2011*5
Attenuation rate	75%	50%

Terms and abbreviated terms ISO 12181-1: 2011*5

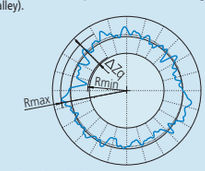
Abbreviated terms	Terms
LSCI	Least squares reference circle
LSCY	Least squares reference cylinder
LSLI	Least squares reference line
LSPL	Least squares reference plane
LCD	Local cylindricity deviation
LFD	Local flatness deviation
LRD	Local roundness deviation
LSD	Local straightness deviation
MICI	Maximum inscribed reference circle
MICY	Maximum inscribed reference cylinder
MCCI	Minimum circumscribed reference circle
MCCY	Minimum circumscribed reference cylinder
MZCI	Minimum zone reference circles
MZCY	Minimum zone reference cylinder
MZLI	Minimum zone reference lines
MZPL	Minimum zone reference planes
UPR	Undulations per revolution

Evaluating the Measured Profile Roundness ISO 12181-1: 2011*5, ISO 4291: 1985*3

Roundness testers use the measurement data to generate reference circles whose dimensions define the roundness value. There are four methods of generating these circles, as shown below, and each method has individual characteristics so the method that best matches the function of the workpiece should be chosen.
Each method results in a different center position for the reference circles and therefore affects the axial location of the circular feature measured.

Least Square Circle (LSC)

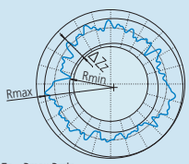
A circle is fitted to the measured profile such that the sum of the squares of the departure of the profile data from this circle is a minimum. The roundness figure is then defined as the difference between the maximum deviation of the profile from this circle (highest peak to the lowest valley).



ΔZq = Rmax-Rmin
ΔZq: A symbol indicating roundness value by LSC.

Minimum Zone Circles (MZC)

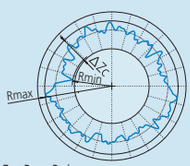
Two concentric circles are positioned to enclose the measured profile such that their radial difference is a minimum. The roundness figure is then defined as the radial separation of these two circles.



ΔZz = Rmax-Rmin
ΔZz: A symbol indicating roundness value by MZC.

Minimum Circumscribed Circle (MCC)

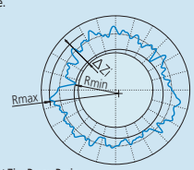
The smallest circle that can enclose the measured profile is created. The roundness figure is then defined as the maximum deviation of the profile from this circle. This circle is sometimes referred to as the 'ring gage' circle.



ΔZc = Rmax-Rmin
ΔZc: A symbol indicating roundness value by MCC.

Maximum inscribed Circle (MIC)

The largest circle that can be enclosed by the profile data is created. The roundness figure is then defined as the maximum deviation of the profile from this circle. This circle is sometimes referred to as the 'plug gage' circle.



ΔZi = Rmax-Rmin
ΔZi: A symbol indicating roundness value by MIC.

Parameters and abbreviated terms ISO 12181-1: 2011*5

Abbreviated terms	Parameter	Reference element*			
		Minimum zone	Least square	Minimum circumscribed	Minimum inscribed
CYLtt	Cylinder taper		✓		
STRsg	Generatrix straightness deviation		✓		
STRlc	Local generatrix straightness deviation		✓		
CYLp	Peak-to-reference cylindricity deviation		✓		
FLTp	Peak-to-reference flatness deviation		✓		
RONp	Peak-to-reference roundness deviation		✓		
STRp	Peak-to-reference straightness deviation		✓		
CYLt	Peak-to-valley cylindricity deviation	✓	✓	✓	✓
FLTt	Peak-to-valley flatness deviation	✓	✓		
RONt	Peak-to-valley roundness deviation	✓	✓	✓	✓
STRt	Peak-to-valley straightness deviation	✓	✓		
CYLv	Reference-to-valley cylindricity deviation		✓		
FLTv	Reference-to-valley flatness deviation		✓		
RONv	Reference-to-valley roundness deviation		✓		
STRv	Reference-to-valley straightness deviation		✓		
CYLq	Root-mean-square cylindricity deviation		✓		
FLTq	Root-mean-squareflatness deviation		✓		
RONq	Root-mean-square roundness deviation		✓		
STRq	Root-mean-square straightness deviation		✓		
STRsa	Straightness deviation of the extracted median line	✓	✓	✓	✓

* The reference elements to which the parameter can be applied.

*1 ISO/DIS 1101: 1996 Geometrical Product Specifications (GPS) - Geometrical tolerancing - Tolerancing of form, orientation, location and run-out
*2 ISO 5459 Technical drawings - Geometrical tolerancing - Datums and datum-systems for geometrical tolerances
*3 ISO 4291: 1985 Methods for the assessment of departure from roundness - Measurement of variations in radius
*4 ISO 12181-2: 2011 Geometrical Product Specifications (GPS) - Roundness - Part2: Specification operators
*5 ISO 12181-1: 2011 Geometrical Product Specifications (GPS) - Roundness - Part 1: Vocabulary and parameters of roundness

Shop-floor Type CNC Coordinate Measuring Machine MiSTAR 555

Refer to page N-3 for details.

CNC Coordinate Measuring Machine CRYSTA-Apex V Series

Refer to page N-4 for details.

Non-contact Line-Laser Probe SurfaceMeasure

Refer to page N-16 for details.

SMS Smart Measuring System

MeasurLink® ENABLED
Data Management Software by Mitutoyo

Shop-floor Type CNC Coordinate Measuring Machine MiSTAR 555

- Accuracy across a wide temperature range of 10 to 40 °C has been achieved thanks to a combination of technologies such as the symmetric guide structure, uniform material, and temperature compensation.
- Equipped with the newly developed environment-resistant ABS scale, the machine benefits from significantly enhanced contamination tolerance. This eliminates the need for initialization and improves work efficiency.
- The footprint is reduced to about 80% compared with that of the conventional moving bridge model by adopting the horizontal-arm structure and installing the CMM controller and PC under the measuring table.

Equipped with the **PH10MQ** probe head

MiSTAR 555

SPECIFICATIONS

Items \ Model		MiSTAR 555
Measuring range	X axis	570 mm
	Y axis	500 mm
	Z axis	500 mm
Maximum permissible length measurement error*1*2 ISO 10360-2: 2009 (18 to 22 °C) (Probe used SP25M)		2.2 + 3L/1000 µm
Drive speed		CNC MODE: 5 to 350 mm/s (max. combined speed 606 mm/s)
Drive acceleration		1556 mm/s^2 (max. combined acceleration 2695 mm/s^2)
Workpiece	Max. height	660 mm
	Max. loading	120 kg
Accuracy guaranteed temperature range		10 to 40 °C
Mass (including the controller and installation platform)		655 kg

*1 Specifications vary by configuration and thermal environment.
*2 L = Measuring length (unit: mm)
Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

Refer to the **MiSTAR 555** Brochure (**E16028**) for more details.

SMS Smart Measuring System
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Standard CNC CMM
CRYSTA-Apex V500/700/900 Series

- The **CRYSTA-Apex V500/700/900** Series, CNC CMMs deliver high accuracy (1.7 µm), high speed, and high acceleration. This series includes models suitable for small- to medium-sized workpieces.
- The temperature compensation system supplied as standard can deliver accuracy across a wide temperature range of 16 to 26 °C.

CRYSTA-Apex V574

CRYSTA-Apex V776

CRYSTA-Apex V9106

The PH20 5-axis control touch-trigger probe is available. Excludes CRYSTA-Apex V9108, CRYSTA-Apex V9168 and CRYSTA-Apex V9208.

SPECIFICATIONS

Items \ Model		CRYSTA-Apex V544	CRYSTA-Apex V574	CRYSTA-Apex V776	CRYSTA-Apex V7106
Measuring range	X axis	500 mm		700 mm	
	Y axis	400 mm	700 mm	700 mm	1000 mm
	Z axis	400 mm		600 mm	

Items \ Model		CRYSTA-Apex V 9106	CRYSTA-Apex V 9108	CRYSTA-Apex V 9166	CRYSTA-Apex V 9168	CRYSTA-Apex V 9206	CRYSTA-Apex V 9208
Measuring range	X axis	900 mm					
	Y axis	1000 mm		1600 mm		2000 mm	
	Z axis	600 mm	800 mm	600 mm	800 mm	600 mm	800 mm

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

CRYSTA-Apex V Series Accuracy

Unit: µm

Series	Probe used	Length measurement error*1 ISO 10360-2: 2009
500/700/900 Series	**SP25M**	$E_{0, MPE} = 1.7 + 3L/1000$*2

*1 Specifications vary by configuration, size, and thermal environment.
*2 L = Measuring length (unit: mm)

Refer to the **CRYSTA-Apex V** Series Brochure (**E16026**) for more details.

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Standard CNC CMM
CRYSTA-Apex V1200/1600/2000 Series

- The **CRYSTA-Apex V1200/1600/2000** Series are large-sized CNC CMMs developed for supporting quality evaluation of large parts.
- The temperature compensation system supplied as standard can deliver accuracy across a wide temperature range of 16 to 26 °C.

CRYSTA-Apex V122010

CRYSTA-Apex V162012

SPECIFICATIONS

Items \ Model		CRYSTA-Apex V121210	CRYSTA-Apex V122010	CRYSTA-Apex V123010
Measuring range	X axis	1200 mm		
	Y axis		2000 mm	3000 mm
	Z axis		1000 mm	

Items \ Model		CRYSTA-Apex V 162012	CRYSTA-Apex V 162016	CRYSTA-Apex V 163012	CRYSTA-Apex V 163016	CRYSTA-Apex V 164012	CRYSTA-Apex V 164016
Measuring range	X axis	1600 mm					
	Y axis	2000 mm		3000 mm		4000 mm	
	Z axis	1200 mm	1600 mm	1200 mm	1600 mm	1200 mm	1600 mm

Items \ Model		CRYSTA-Apex V203016	CRYSTA-Apex V204016
Measuring range	X axis	2000 mm	
	Y axis	3000 mm	4000 mm
	Z axis	1600 mm	

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

CRYSTA-Apex V Series Accuracy

Unit: µm

Series	Probe used	Length measurement error*1 ISO 10360-2: 2009
1200 Series	**SP25M**	$E_{0,MPE}$=2.3 + 3L/1000*2
1600 Series		$E_{0,MPE}$=3.3 + 4.5L/1000 (4.5 + 5.5L/1000)*2 *3
2000 Series		$E_{0,MPE}$=4.5 + 8L/1000*2

*1 Specifications vary by configuration, size, and thermal environment.
*2 L = Measuring length (unit: mm)
*3 ( ) indicates Z: 1600 mm specification

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Standard CNC CMM
CRYSTA-Apex EX 1200R Series

- **CRYSTA-Apex EX 1200R** Series products are advanced CNC CMMs equipped with the REVO-2 probe head and a choice of probes to create a range of standard 5-axis measuring machines.
- 5-axis operation reduces the time required for probe repositioning movements and allows more flexible positioning. This also facilitates access to complex workpieces and saves time both during programming and measurement.
- Allows ultra high-speed 5-axis scanning (max. 500 mm/s), far surpassing conventional 3-axis control. Support for high-speed sampling of up to 4,000 points per second allows acquisition of densely spaced measurement points, even during fast scanning.
- Internal implementation of laser sensing technology ensures high-accuracy measurement, even with long styli (up to 500 mm*).

* Distance from probe rotation center to stylus tip

CRYSTA-Apex EX 123010R

SPECIFICATIONS

Items \ Model		CRYSTA-Apex EX 121210R	CRYSTA-Apex EX 122010R	CRYSTA-Apex EX 123010R
Measuring range	X axis	1200 mm		
	Y axis	1200 mm	2000 mm	3000 mm
	Z axis	960 mm		

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

CRYSTA-Apex EX 1200R Series Accuracy

Unit: µm

Probe used	Length measurement error*1 ISO 10360-2: 2009
REVO + RSP2 + RSH250	$E_{0,MPE}$=2.9 + 4L/1000*2
REVO + RSP3-3 + RSH3-3	$E_{0,MPE}$=2.5 + 3L/1000*2

*1 Specifications vary by configuration, size, and thermal environment.
*2 L = Measuring length (unit: mm)

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High Accuracy CNC CMM STRATO-Apex Series

- The **STRATO-Apex** Series of CNC CMMs offer improved structural rigidity and guide systems to guarantee very high accuracy measurement. High drive speed and high acceleration provide lower cycle times in critical measurement applications.
- For position detection, the same ultra-high-precision length measuring unit (internally developed) as that used in the **LEGEX** series has been adopted. It enables excellent position detection for highly-accurate measurement. It also applies various other technologies, such as a high-speed control program, that enable high speed and accuracy.

STRATO-Apex 574

STRATO-Apex 7106

STRATO-Apex 9166

STRATO-Apex 162016

SPECIFICATIONS

Items \ Model		STRATO-Apex 574	STRATO-Apex 776	STRATO-Apex 7106
Measuring range	X axis	500 mm	700 mm	
	Y axis	700 mm	700 mm	1000 mm
	Z axis	400 mm	600 mm	

Items \ Model		STRATO-Apex 9106	STRATO-Apex 9166	STRATO-Apex 162012	STRATO-Apex 162016	STRATO-Apex 163012	STRATO-Apex 163016
Measuring range	X axis	900 mm		1600 mm			
	Y axis	1000 mm	1600 mm	2000 mm		3000 mm	
	Z axis	600 mm		1200 mm	1600 mm	1200 mm	1600 mm

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

STRATO-Apex Series Accuracy

Unit: µm

Series	Probe used	Length measurement error*1 ISO 10360-2: 2009
574 Series	**SP25M**	$E_{0,MPE} = 0.7 + 2.5L/1000$*2
700/**900** Series		$E_{0,MPE} = 0.7 + 2.5L/1000$*2
1600 Series		$E_{0,MPE} = 2.5 + 4.0L/1000$ (3.0 + 4.0L/1000)*2 *3

*1 Specifications vary by configuration, size, and thermal environment.
*2 L = Measuring length (unit: mm)
*3 ( ) indicates Z: 1600 mm specification

Refer to the **STRATO-Apex** Series Brochure (**E16001**) for more details.

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High-accuracy Separate Guide Type STRATO-Apex Series

- The **STRATO-Apex** Series are CNC CMMs that use Mitutoyo's standard structure for large machines which are designed to be used for measuring large and heavy workpieces with high accuracy. The measuring accuracy and drive speed are the world's highest in the X-axis measuring range of 2000 mm and 3000 mm.
- High-accuracy linear encoders (manufactured in-house) are built into the length measuring units used for position detection. Their excellent position detection capability is what makes the control of these high-accuracy devices possible. The series also applies a multitude of technologies regarding structure, control, component processing, assembly, and other aspects that enable large CMMs to deliver high-accuracy measurements.
- These series are equipped with a system to automatically restore accuracy deterioration (MOVAC) caused by foundation deformation as a standard feature.
- Equipped with a temperature compensation system that guarantees the specified accuracy within the wide range of 18 to 22 °C under certain environmental conditions, although high-accuracy CMMs should ideally be installed in a temperature controlled room.
- Safety devices such as a Z-axis beam sensor, tape switch, and area sensor are available as options.

STRATO-Apex 3000G Series

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SPECIFICATIONS

Items \ Model		STRATO-Apex 2000G Series	STRATO-Apex 3000G Series	STRATO-Apex 4000G Series
Measuring range	X axis	2000 mm	3000 mm	4000 mm
	Y axis	3000 mm/4000 mm/5000 mm/6000 mm		
	Z axis	1200 mm/1600 mm/2000 mm		

Note: For information on accuracy specifications, contact your local Mitutoyo sales office.

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Ultra-high Accuracy CNC CMM
LEGEX Series

- The **LEGEX** Series is an ultra-high precision CNC CMM with the world's highest level of accuracy, made possible by rigorous analysis of all possible error-producing factors and the elimination or minimization of their effects.
- The fixed bridge structure and precision air bearings running on highly rigid guideways ensure superior motion stability and ultra-high geometrical accuracy.
  It has been designed to minimize deformation affected by variable load, etc. by conducting in-depth stress analyses based on FEM structural analysis simulations. In addition, other technologies have been utilized in the structure of the drive unit, minimizing vibration, etc., to provide ultra-high accuracy.
- For position detection, it has adopted an ultra-high-precision length measuring unit (internally developed) created by combining an ultra-high-precision crystallized glass scale having a thermal expansion coefficient of 0 with a high-resolution, high-performance reflective linear encoder, thereby enabling excellent position detection for ultra-high-precision measurement.

LEGEX 9106

SPECIFICATIONS

Items \ Model		LEGEX 574	LEGEX 774	LEGEX 776	LEGEX 9106	LEGEX 12128*
Measuring range	X axis	500 mm	700 mm	700 mm	900 mm	1200 mm
	Y axis	700 mm	700 mm	700 mm	1000 mm	1200 mm
	Z axis	450 mm	450 mm	600 mm	600 mm	800 mm

* Custom-made model. For information about **LEGEX 12128**, contact your local Mitutoyo sales office.
Note: For measuring table, the standard specification is ceramic coating. A hand scraper version is available as a made-to-order item.

LEGEX Series Accuracy

Unit: µm

Probe used	Length measurement error*1 ISO 10360-2: 2009
MPP-310Q	$E_{0, MPE}$=0.28 + L/1000*2

*1 Specifications vary by configuration, size, and thermal environment.
*2 L = Measuring length (unit: mm)
Note: For **LEGEX 12128**, contact your local Mitutoyo sales office.

Refer to the **LEGEX** Series Brochure (**E16012**) for more details.

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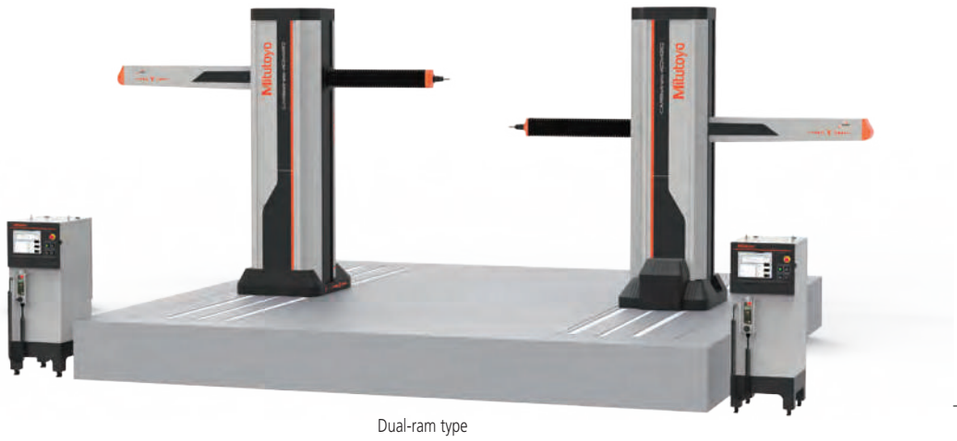
Car Body Measuring System CARBstrato Series

Measurement example for dual-ram type
(Simultaneous use of touch-trigger probe and line laser probe)

- The world's largest class of CMM
  The **CARBstrato** Series is a lineup of horizontal-ram type CNC CMMs, offering the world's largest measurement range that even makes it possible to measure car bodies.

- Single- & Dual-ram systems
  Single- and dual-ram types are available to suit the intended use.
  Single-ram type: Measures a workpiece using a single ram
  Dual-ram type: Measures a workpiece placed between two simultaneously controlled rams



Dual-ram type

Refer to the **CARB** Series Brochure (**E16014**) for more details.

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In-line Type CNC CMM MACH-3A Series

• In-line type CNC CMM (Horizontal-ram type) Incorporating the CMM controller and the host computer in the main unit results in a compact space-saving footprint for the shop floor. This series is designed for 24-hour operation with high stability and remarkable durability. Accuracy can be guaranteed within a temperature range of 5 to 40 °C.

MACH-3A 653
The indexing table shown is optional

SPECIFICATIONS

Items \ Model		MACH-3A 653
Measuring range	X axis	600 mm
	Y axis	500 mm
	Z axis	280 mm
Accuracy*1*2	19 to 21 °C	$E_{0, MPE} = 2.2 + 3.5L/1000\,\mu m$*3

*1 Specifications vary by configuration and thermal environment.
*2 For guaranteed accuracy within a temperature range other than 19 to 21 °C, please contact your local Mitutoyo sales office.
*3 L = Measuring length (unit: mm)

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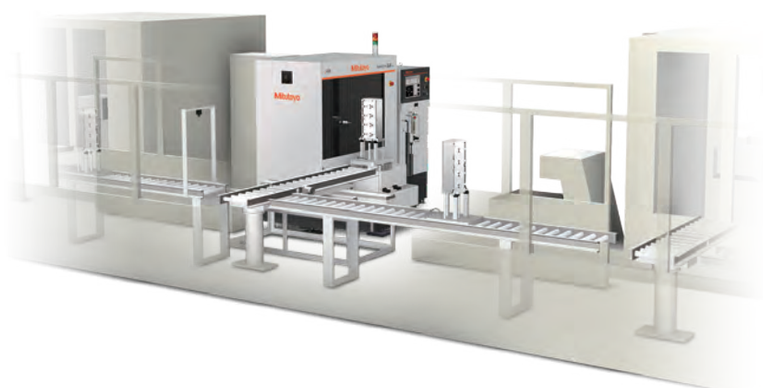

Refer to the **MACH** Series Brochure (**E16010**) for more details.

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In-line Type CNC CMM MACH-V9106

- This makes it possible to build a flexible measuring system to replace gage measurements on power train production lines. It also allows for high throughput thanks to high acceleration and high drive speed. In addition, its accuracy is guaranteed within the temperature range 5 to 35 °C.

MACH-V9106

SPECIFICATIONS

Items \ Model		MACH-V9106
Measuring range	X axis	900 mm
	Y axis	1000 mm
	Z axis	600 mm
Accuracy*1*2	19 to 21 °C	$E_{0, MPE} = 2.5 + 3.5L/1000\,\mu m$*3

*1 Specifications vary by configuration and thermal environment.
*2 For guaranteed accuracy within a temperature range other than 19 to 21 °C, please contact your local Mitutoyo sales office.
*3 L = Measuring length (unit: mm)

Refer to the **MACH** Series Brochure (**E16010**) for more details.

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CMM equipped with high-accuracy/ high-speed/flexible CNC measuring head MACH Ko-ga-me

- Can be used in standalone applications or integrated into work cells.
- If required, the system can measure workpiece features that exceed the **Ko-ga-me**'s X stroke by mounting the workpiece, or the **Ko-ga-me**, on an auxiliary X axis.
- Ideal for inspection of large or small workpieces and offers a wide choice of measuring probes including touch-trigger and scanning types. (Note: Probe choice may be restricted, depending on the application.)

KGM12128-C

Standalone system

Note: Stand, measuring table, etc. are options.

SPECIFICATIONS

Items \ Model		KGM12128-C
Measuring range	X axis	120 mm
	Y axis	120 mm
	Z axis	80 mm
Accuracy*1*2	19 to 21 °C	$E_{0,MPE}$ = 2.4 + 5.7L/1000 µm*3

*1 Specifications vary by configuration and thermal environment.
*2 For guaranteed accuracy within a temperature range other than 19 to 21 °C, please contact your local Mitutoyo sales office.
*3 L = Measuring length (unit: mm)

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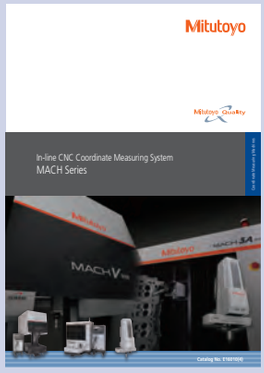


Refer to the **MACH** Series Brochure (**E16010**) for more details.

Software for Manual/CNC Coordinate Measuring Machines MCOSMOS

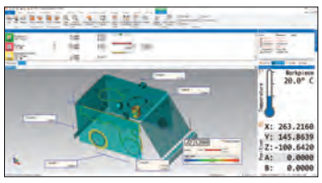
MCOSMOS software modules

	GEOPAK	CAT1000P	CAT1000S	SCANPAK
MCOSMOS-1	✓			
MCOSMOS-2	✓	✓	✓	
MCOSMOS-3	✓	✓	✓	✓

- **MCOSMOS** is the data processing program family for the CMM that runs on Windows.

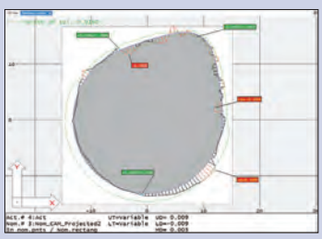
GEOPAK [General purpose measurement program]

For (online/offline) part program creation, using the measurement of geometric elements. Extensive tolerance comparisons and output functions are included.



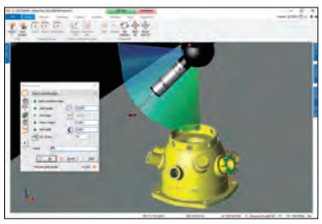
SCANPAK [Contour measurement program]

SCANPAK is a program for measuring/evaluating contours for profile requirements. Graphical display for reporting & output back to m/c tool and many other operations are possible.



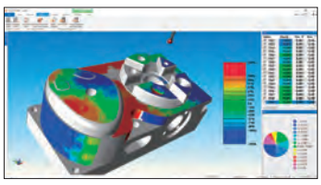
CAT1000P [Online/Offline teaching program]

For (online/offline) part program creation, using the measurement of geometric elements directly from the CAD model, with automatic collision avoidance.



CAT1000S [Curved surface evaluation program]

CAD model-based generation of surface measurement points, and comparison of actual/nominal data, with graphical output.

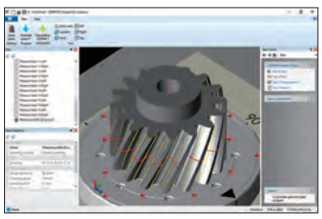


GEARPAK-Worm [Gear evaluation program]

This is a software for evaluation of tooth form based on worm measurement data obtained from CNC CMMs.

GEARPAK Express [Gear evaluation program]

This is a program for evaluation of involute gear teeth obtained from CNC CMMs, and tooth profile based on cylindrical gear measurement data.

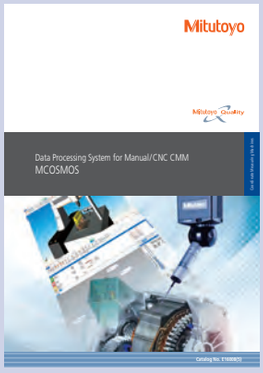


[Result drawing]

GEARPAK-Bevel/Hypoid [Gear production support/evaluation program]

This is a software for evaluation of tooth form, pitch error, etc., based on measurement data from bevel or hypoid gears obtained by CNC CMM.

[Result drawing]



Refer to the **MCOSMOS** Software Brochure (**E16008**) for more details.

FORMTRACEPAK-AP [Analysis program]

This software is used for minutely analyzing two-dimensional curved lines captured by **SCANPAK**.

SURFPAK-SP [Analysis program]

This is a software program as used for the **SURFTEST** roughness probe for a CMM. With this program, surface roughness analysis conforming to standards such as ISO, JIS, ANSI, and VDA are available. Cooperation with **MCOSMOS** enables fully automatic dimensional measurement and surface roughness measurement.

ROUNDPAK-CMM

The functionality of analysis software as used for roundness measuring machines is now available on **MCOSMOS**. As well as roundness and cylindricity evaluation, various filters are also available.

MAFIS Express [Blade measurement/Evaluation program]

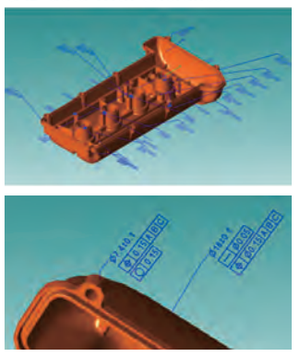
This software program enables creation of measurement programs and measurement and analysis of blades and blisks. A part program for measurement can be automatically created just by selecting required contents and evaluation conditions. The measurement results will be displayed in a report including 2D graphics.

Automatic measurement program generation software MiCAT Planner

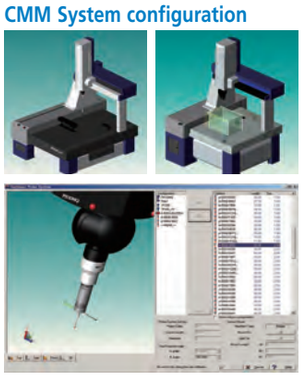
One-click programming that changes the relationship between people and precision measurement

- Identifies tolerance information included in 3D models with Product and Manufacturing Information (PMI), defines measurement locations and creates a measurement program fully automatically.
  Also, even with the 3D CAD model without PMI, the measurement program can be created automatically just by adding tolerance information on **MiCAT Planner**.
  This is more efficient than the conventional teaching model.
- Through its optimization function, the software estimates the shortest route for measurement with the minimum of probe repositioning and tool changing, and creates a program that enables measurement in the minimum possible time.
- Utilizing the rule editor function to set the measurement rules prevents variation in measurement quality between program writers.

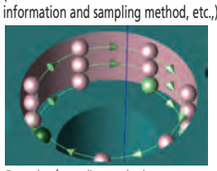
CAD data with tolerances



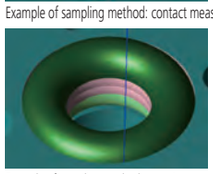
CMM System configuration



User-defined measurement rules
(number of locations to measure with tolerance information and sampling method, etc.,)

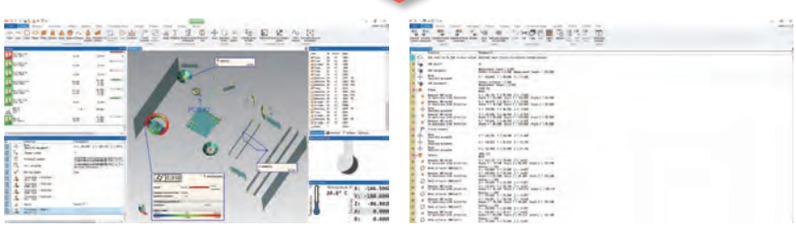


Example of sampling method: contact measurement



Example of sampling method: scanning measurement

Instantly and automatically creates a measurement program



Output a measurement program for MCOSMOS

Case study

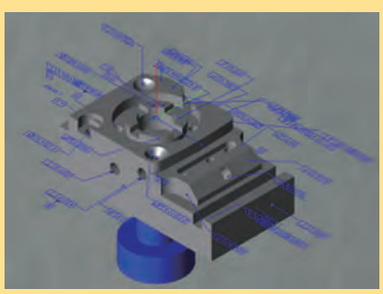
Compare the measurement part-programming time for a test piece.

1: Programming in 2D drawing: **approx. 45 to 60 minutes**

2: Programming using 2D drawing + 3D CAD: **approx. 15 to 20 minutes**

3: Create with **MiCAT Planner** (using 3D CAD model + PMI): **approx. 3 minutes!**

Note: The measurement rules are defined in advance.



Part-programming time
Reduced by up to 95% !!

Guarantee a
dramatically reduced development phase
and at the same time improve product quality.

Tolerance information add function

Lets you add tolerances in the software even for 3D CAD models containing no tolerance information. Automatically create optimal measuring programs based on the added tolerance specifications.

Supported languages

Available in 16 languages

Refer to the **MiCAT Planner** Brochure (**E16019**) for more details.

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• The flying spot type is capable of scanning difficult parts, such as this impeller, precisely and achieves highest scanning accuracy in the class (in the case of **SurfaceMeasure201FS**).

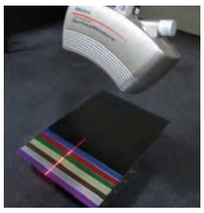
Non-contact type laser probe SurfaceMeasure

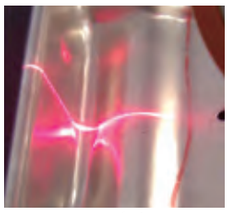
• Ultra-high speed data collection
The **SurfaceMeasure** probe works by emitting laser beams onto the workpiece to collect coordinate values from its surface, and can collect data at the ultra-high speed of 300,000 points/second.*
* When using **SurfaceMeasure1110**

• Advantages of non-contact type
Non-contact measurement enables measurement of materials that can be easily deformed by contact measurement, including plastics or thin, elastic parts.

• Powder-less measurement
Automatic configuration of the camera sensitivity and the laser intensity settings according to the environment and materials enable establishing a simple and comfortable laser-scanning environment since measurement is now powder and spray free.

• Evaluation cases
The collected point cloud data can be used by various optional software in a wide range of applications, such as editing, plane creation, comparison using CAD data and more.


Measurement of color sample plate


Measurement of glossy parts

403

1110

201FS

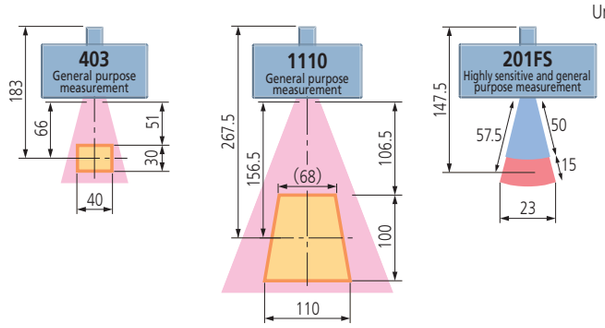
SPECIFICATIONS

		SurfaceMeasure 403	SurfaceMeasure 1110	SurfaceMeasure 201FS
Laser irradiation method		Line Laser		Flying spot
Max. scan width		40 mm	110 mm	23 mm
Max. scan depth		30 mm	100 mm	15 mm
Working distance		66 mm	156.5 mm	57.5 mm
Scanning error*		8 µm	9 µm	1.8 µm
Max. acquisition rate		60,000 points/sec	300,000 points/sec	25,000 points/sec
Mass		430 g	440 g	500 g
Laser Class	EN/IEC	Class2 [EN/IEC 60825-1 (2014)]		
	Laser Type	Red-light semiconductor		Semiconductor
Line Laser	Wave length	660 nm		670 nm
	Power output	4 mW	2.5 mW	1 mW

* According to Mitutoyo's acceptance procedure. (1σ /sphere measurement, probe alone.)

Measuring range

Unit: mm



Refer to the **SurfaceMeasure** Brochure (**E16000**) for more details.

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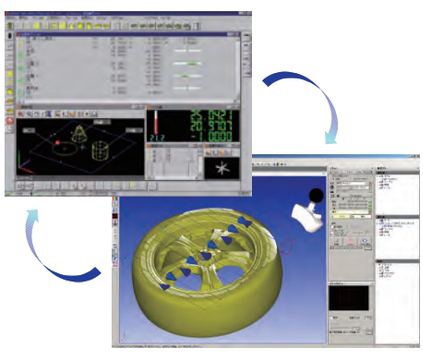
Mitutoyo

Point Cloud Processing Software for Coordinate Measuring Machines MSURF

- **MSURF** is a software program that enables users to perform operations from measurement to evaluation on the same platform when the non-contact line laser probe, **SurfaceMeasure**, is used. Eight software modules are provided according to the task.

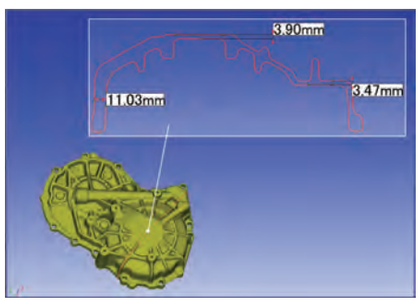
MSURF-S

Calculates point cloud data measured by CNC CMM with **SurfaceMeasure**. It generates scanning paths by defining the scanning start position, length, and width.

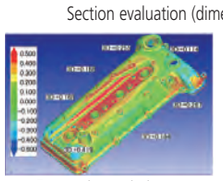


MSURF-I

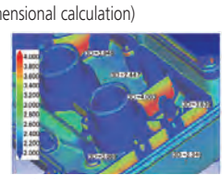
Conducts analysis or comparison verification of measured point cloud data in reference to nominal data (supporting CAD data import).



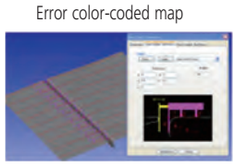
Section evaluation (dimensional calculation)



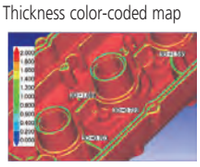
Error color-coded map



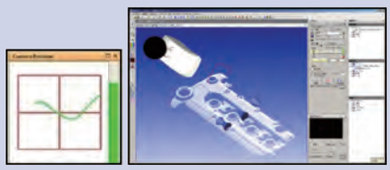
Thickness color-coded map



Evaluation of step/clearance



Surface curvature evaluation



Note: If not using the **ACR3** probe changer, probe replacement is performed manually.

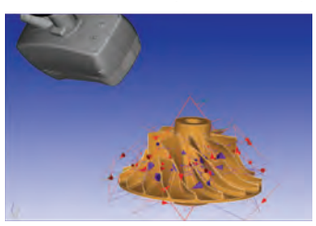
MSURF-MESH PRO

This software is provided with various functions such as filtering point cloud data and mesh data. The software is enhanced by adding functions to standard ones. It also enables functions such as mesh data thinning-out, highlighting, interpolation and outlier removal that are unavailable as standard.

Note: **MSURF-MESH PRO** has the optional functions of **MSURF-I**.

MSURF-PLANNER

MSURF-PLANNER is software to automatically create measurement macros (surface form, feature form) for the line laser probe from 3D CAD data.
Optimized data (travel path, number of probe head revolutions, etc.) of a measurement path will contribute to improvements in productivity.



Automatic generation of measurement macros by **MSURF-PLANNER**

MSURF-G

MSURF-G is the off-line version of **MSURF-S**. It allows users to create measurement programs in advance of actual measurements on a CMM by using CAD data. Therefore, users can start measurement immediately at the time a real workpiece is ready. Since **MSURF-S** is a standalone PC application, only requiring installation by the user, it helps preserve valuable CMM time exclusively for productive measurement.

Note: **MSURF-G** cannot be combined with **MSURF-S**.

N

SP25M

Compact high accuracy type scanning probe

This compact, multifunctional and highly accurate scanning probe is only 25 mm in diameter, which enables it to access shrouded workpiece features. Data collection is by scanning measurement, ultra-high precision point measurement and center alignment point measurement. The probe can be attached to a probe head (**PH10M**/**10MQ**) to automatically change the orientation allowing for maximum flexibility in measurement.

Scanning probes

MPP-310Q

Ultra-high accuracy and low measuring force scanning probe

This ultra-high precision scanning probe incorporates built-in XYZ scales for highest-accuracy performance. The compact size of this probe is ideal for low measuring force and high speed scanning. Data collection can be performed by scanning measurement, ultra-high precision point measurement and center alignment measurement.

SP80

High accuracy scanning probe (supports long styli)

A highly accurate stylus up to 500 mm in length (both horizontally and vertically) can be installed on this probe. This ultra-high precision scanning probe allows data collection by scanning measurement, ultra-high precision point measurement and center alignment point measurement.

MPP-10

Probe for effective thread-depth measurement

This is the only probe in the world that is dedicated to measure effective screw-thread depth on a CNC CMM. The probe can also attach to a probe head (**PH10M**/**10MQ**) to change the orientation to measure bores in various directions.

REVO-2

High speed 5-axis scanning head

This high-speed scanning head delivers high accuracy measurement while delivering high-throughput. Contact measurement with a stylus that can be up to 500 mm in length increases flexibility and makes simultaneous 5-axis measuring with non-step indexing possible.

Non-contact probes

SurfaceMeasure

Non-contact type laser probe

This compact, high accuracy, non-contact type laser probe is designed for use with CNC CMMs. The scanning probe automatically adjusts to workpiece surface characteristics to deliver highly efficient measurements. Automatic laser intensity and camera sensitivity adjust according to the environment and the workpiece material, for simpler and more comfortable laser scanning.

SurfaceMeasure403

SurfaceMeasure1110

SurfaceMeasure201FS

QVP

QUICK VISION probe

This CNC CMM Quick Vision Probe utilizes Mitutoyo's technology in a vision measuring machine for totally-automated video measurement.

CF20

Centering microscope for CMMs

This centering microscope enables measurement of small holes or elastic bodies that are very difficult to measure using a contact measurement method such as with a touch-trigger probe. It also allows a CMM to be used as a very large microscope.

CCTV Monitor System for CMM (optional)

A probe for roughness measurement

SURFTEST

Probe for surface roughness measurement

Mounting this probe on a CMM enables surface roughness measurement and analysis to be included in fully automatic CNC measurement cycles. This probe is compatible with an automatic probe changer, and therefore can be automatically replaced with another type of probe for 3D coordinate measurement. A wide variety of roughness analyses can be performed using the dedicated evaluation program.

Touch-trigger probes

TP7M

High accuracy touch-trigger probe

This high-accuracy touch-trigger probe has an excellent repeatability figure of of $2\sigma \leq 0.25$ µm. A long stylus, up to 150 mm in length, can be installed.

TP200

Compact high-accuracy touch-trigger probe

This compact, high accuracy, touch-trigger probe is only 13.5 mm in diameter, making it an ideal choice where high-accuracy measurement inside narrow or shrouded workpiece features is needed.
Styli auto-changing (optional) is supported.

TP20

Compact touch-trigger probe

This compact touch-trigger probe is only 13.2 mm in diameter, making it an ideal choice for probing deep inside narrow or shrouded workpiece features.
Styli auto-changing (optional) is supported when mounted on a CNC CMM.

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MH20i

Touch-trigger probe with manual probe head

This touch-trigger probe equipped with a manual probe head is designed for use with manual CMMs. The probe head may be manually indexed to 168 positions.

PH20

5-axis control touch-trigger system

Thanks to unique "head touches", it is possible to measure by movement of the probe head itself instead of moving the CMM elements. Also, measuring time can significantly be shortened by means of 5-axis concurrent movement and stepless positioning angle.

Probe heads

PH10M / 10MQ

Motorized probe heads

These heads allow automatic control of positioning (up to 720 directions) of the mounted probe. It is possible to mount not only a touch-trigger probe but also any scanning probe, vision probe, laser probe, screw-thread depth probe, etc.
Auto-changing is available (optional).

▲Mounting example of touch-trigger probe

PH1

Manual probe head

This manual probe head is designed for use with the **TP200**/**TP20** touch-trigger probes.
The attached probe is manually positioned in the desired orientation to suit the measuring task.

▲Mounting example of touch-trigger probe

PH6M

Fixed probe head

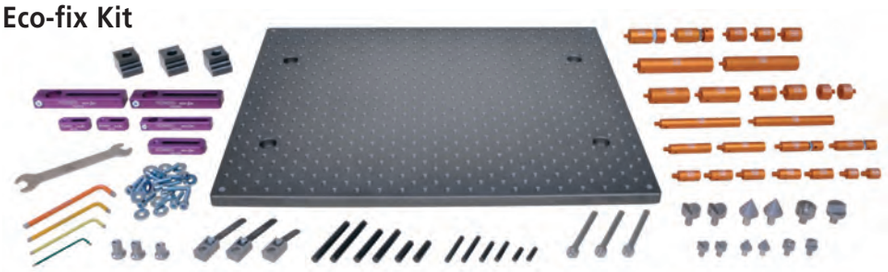
A fixed probe head with autojoint connector for use with **TP7M** or **SP25M**.

Refer to the Probes for Coordinate Measuring Machines Brochure (**E16005**) for more details.

Clamping System

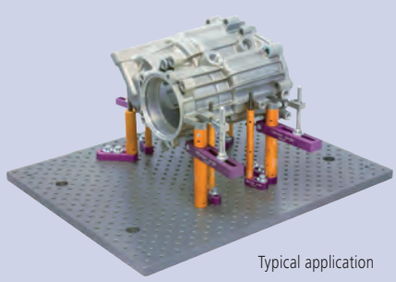
- A workpiece can be mounted on a CMM's measuring table using a variety of combinations of **Eco-Fix** clamping components. A dedicated fixturing jig is not necessary.
- Economical starter kits "**Eco-fix Kit S**" and "**Eco-fix Kit L**" are available as shown below.
- Using the optional receiver plate set relieves you of the trouble of positioning the workpiece.

Eco-fix Kit



Eco-fix Kit L

Receiver plate set (optional)



Typical application

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Performance Assessment Method of Coordinate Measuring Machines

Regarding the performance assessment method of CMM, a revision of ISO 10360 Series was issued in 2003, and was partially revised in 2009.
The following describes the standard inspection method including the revised content.

Table 1 ISO 10360 Series

	Item	ISO Standard No.	Year of issue
1	Terms	ISO 10360-1	2000
2	Length measurement	ISO 10360-2	2009
3	Rotary table equipped CMM	ISO 10360-3	2000
4	Scanning measurement	ISO 10360-4	2000
5	Single/Multi-styli measurement	ISO 10360-5	2010
6	Software inspection	ISO 10360-6	2001

Maximum Permissible Length Measurement Error $E_{0,MPE}$ [ISO 10360-2: 2009]

Using the standard CMM with specified probe, measure 5 different calibrated lengths 3 times each in 7 directions within the measuring volume (as indicated in Figure 1), making a total of 105 measurements.
If these measurement results, including the allowance for the uncertainty of measurement, are equal to or less than the values specified by the manufacturer, then it proves that the performance of the CMM meets its specification. The result of OK/NG is required to be judged considering the uncertainties.
The maximum permissible error (standard value) of the test may be expressed in any of the following three forms (unit: µm).

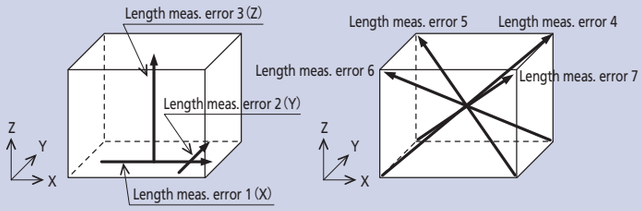


Figure 1 Measauring directions to obtain length measurement error

$$E_{0,MPE}\ (MPE_E) = A + L/K \leq B$$
$$E_{0,MPE}\ (MPE_E) = A + L/K$$
$$E_{0,MPE}\ (MPE_E) = B$$

A: Constant (µm) specified by the manufacturer
K: Dimensionless constant specified by the manufacturer
L: Measured length (mm)
B: Upper limit value (µm) specified by the manufacturer

Note: ISO 10360-2: 2009 requires measurement in 4 different directions and recommends measurement parallel to each axis, while ISO 10360-2: 2001 specified the measurement "in 7 arbitrary directions."

The following error definitions were added in ISO 10360-2: 2009.

Maximum Permissible Length Measurement Error / Length Measurement Error when stylus offset is 150 mm $E_{150,MPE}$ [ISO 10360-2: 2009]

In addition to length measurement in 7 directions, ISO 10360-2: 2009 specifies measuring in 2 lines over the diagonal YZ or XZ plane with probe offset as shown in Figure 2.

Note: The stylus offset is set at 150 mm as default.

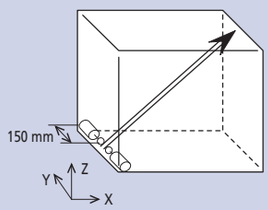


Figure 2 Length measurement error when Z-axis stylus offset is 150 mm

Maximum Permissible Limit of the Repeatability Range of Length Measurement $R_{0,MPL}$ [ISO 10360-2: 2009]

Calculate the maximum value from the results of three repeated measurements.

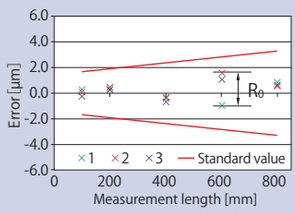


Figure 3 Repeating range of length measurement

Maximum Permissible Radial Four-Axis Error MPE_{FR}, Maximum Permissible Tangential Four-Axis Error MPE_{FT}, and Maximum Permissible Axial Four-Axis Error MPE_{FA} [ISO 10360-3: 2000]

The test procedure under this standard is to place two standard spheres on the rotary table as shown in Figure 4. Rotate the rotary table to a total of 15 positions including 0°, 7 positions in the plus (+) direction, and 7 positions in the minus (-) direction and measure the center coordinates of the two spheres in each position. Then, add the uncertainty of the standard sphere shape to each variation (range) of radial direction elements, connecting direction elements, and rotational axis direction elements of the two standard sphere center coordinates. If these calculated values are less than the specified values, the evaluation test is passed.

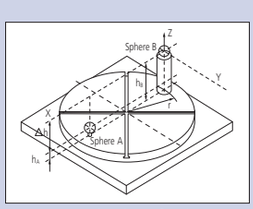


Figure 4 Evaluation of a CMM with a rotary table

Maximum Permissible Scanning Probing Error MPE_{THP} [ISO 10360-4: 2000]

This is the accuracy standard for a CMM if equipped with a scanning probe. The test procedure under this standard is to perform a scanning measurement in 4 planes on the standard sphere and then, for the least squares sphere center calculated using all the measurement points, calculate the radial range (dimension 'A' in Figure 5) within which all measurement points exist. Based on the least squares sphere center calculated above, calculate the radial distance between the calibrated standard sphere radius and the maximum measurement point and the minimum measurement point, and take the larger distance (dimension 'B' in Figure 5). Add an extended uncertainty that combines the uncertainty of the stylus tip shape and the uncertainty of the standard test sphere shape to each A and B dimension. If both calculated values are less than the specified values, this scanning probe test is passed.

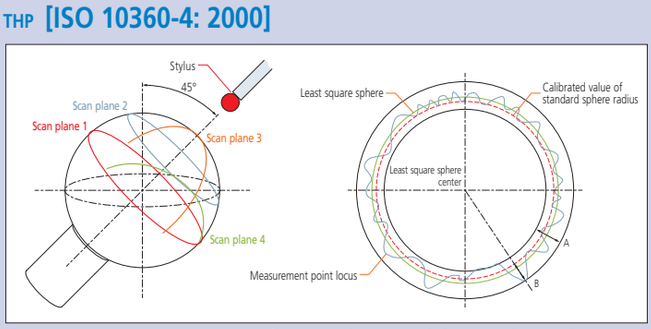


Figure 5 Target measurement planes for the maximum permissible scanning probing error and its evaluation concept

Maximum Permissible Single Stylus Form Error $P_{FTU, MPE}$ [ISO 10360-5: 2010]

This measurement was included in the dimensional measurement in ISO 10360-2: 2001. However, it is specified as "CMMs using single and multiple stylus contacting probing systems" in ISO 10360-5: 2010.
The measurement procedure has not been changed, and the following procedure should be performed.
Measure the defined target points on a standard sphere (25 points, as in Figure 6) and use all the results to calculate the center position of the sphere by the least squares method.
Then, calculate the radial distance from the center position of the sphere by the least squares method for each of the 25 measurement points, and obtain the radial difference Rmax - Rmin. If this difference, to which a compound uncertainty of forms of the stylus tip and the standard test sphere are added, is equal to or less than the specified value, it can be judged that the probe has passed the test.

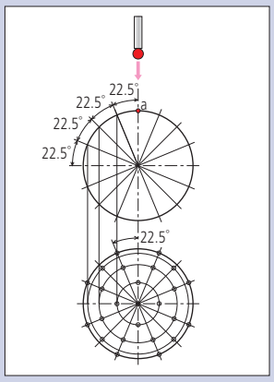
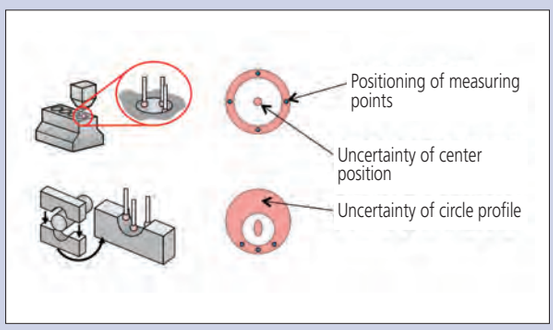


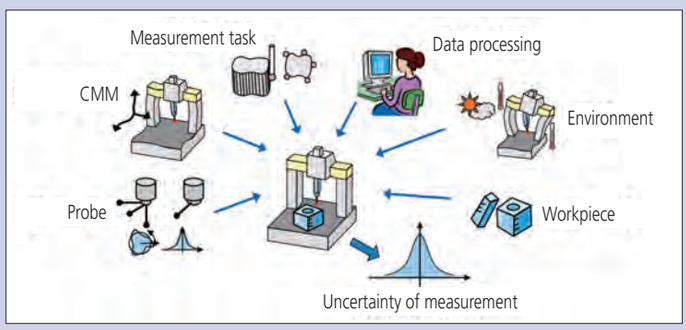
Figure 6 Target points of measurement for Single Stylus Form Error

Measurement Uncertainty of the CMM

Measurement uncertainty is an indication used for evaluating reliability of measurement results.
In ISO 14253-1: 1998, it is proposed to consider the uncertainty when evaluating the measurement result in reference to the specification.
However, it is not easy to estimate the uncertainty of the measurement performed by a CMM.
To estimate the uncertainty of the measurement, it is necessary to quantify each source of uncertainty, and determine how it propagates to the measurement result. The CMM is subject to all types of settings that determine how the measurement should be performed, such as measurement point distribution, or datum definition, according to the drawing instruction or operator's intention. This fact makes it harder to detect the sources of uncertainty influencing the result. Taking circle measurement as an example, just a difference of one measurement point and its distribution causes the necessity of recalculation of the uncertainty.
Also, there are many sources of uncertainty to be considered with the CMM and their interactions are complex.
Because of the above, it is almost impossible to generalize on how to estimate measurement uncertainty of the CMM.



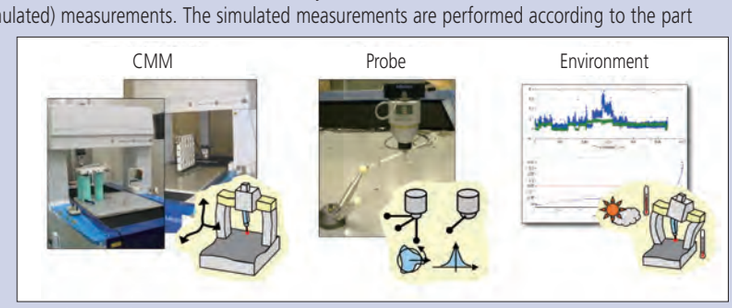
Example of circle measurement by CMM



Major contributions that cause uncertainty in CMM measurement results

Measurement uncertainty of the CMM and the Virtual CMM software

The Virtual CMM software* enables straightforward, automated estimation of the measurement uncertainty of a CMM. The software simulates a CMM on a PC based on its machine characteristics and performs virtual (simulated) measurements. The simulated measurements are performed according to the part program created by the machine operator. The machine's performance is evaluated from experimental values based on geometrical characteristics of the actual machine, probing characteristics, and temperature environment, etc., and the measurement uncertainty of the CMM is estimated by the software package.
ISO15530 Part 4 (ISO/TS 15530-4 (2008)) defines how to verify the validity of task-specific measurement uncertainty using computer simulations.
Virtual CMM conforms to this specification.



Quantification of CMM uncertainty elements by experiment

* Virtual CMM is a software package originally developed by PTB (Physikalisch-Technische Bundesanstalt).

Relevant parts of ISO 15530: Geometrical Product Specifications (GPS) – Coordinate measuring machines (CMM): Technique for determining the uncertainty of measurement –

Part 3: Use of calibrated workpieces or measurement standards
Part 4: Evaluating task-specific measurement uncertainty using simulation [Technical Specification]