MICRO-EPSILON

More Precision

eddyNCDT // Inductive sensors based on eddy currents

Robust eddy current measuring system for industrial series applications
eddyNCDT 3020

- Extremely high temperature resistance and stability up to 105 °C
- Analog / RS485 / PROFINET / EtherNet/IP, EtherCAT
- High resolution and 3-point linearization
- Frequency response 5 kHz (-3dB)
- Measuring rate 80 kSa/s
- Configurable via sensorTOOL
- Switching output (NPN, PNP, TTL, HTL)

Robust and precise for industrial series applications

The eddyNCDT 3020 is an inductive eddy current measuring system for precise displacement and position measurements. The powerful controller offers high resolution and detects fast movements reliably and with high precision. Its robust, compact design, and flexible connection and configuration options make it particularly suitable for industrial environments and machine integration. The system is used, for example, for distance measurement in welding applications, steel rolling processes or in die casting systems.

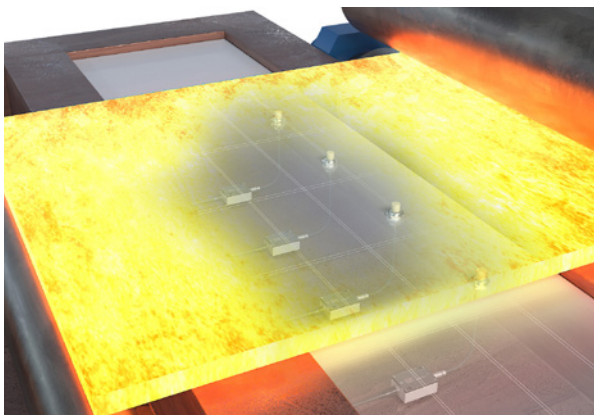
Due to the extremely high temperature resistance of the sensor (up to 200 °C) and controller (up to 105 °C), the complete measuring channel can be used at high ambient temperatures, which reduces temperature influences on the cable and increases measuring accuracy. Digital or analog interfaces also transmit the processed signal over long distances.

Wide sensor portfolio and simple setup

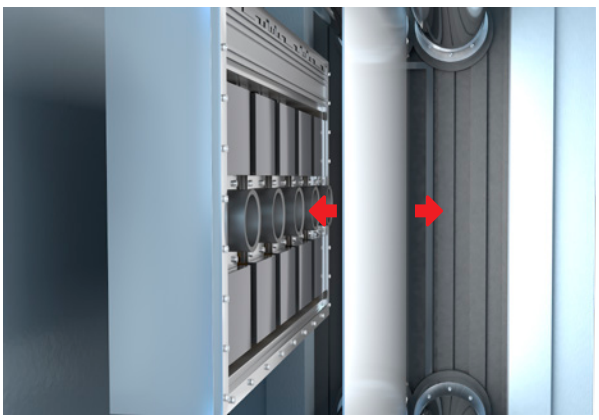
The combination of this controller and the extensive sensor portfolio covers measuring ranges from 1 to 80 mm.

The system can be configured very easily using the sensorTOOL, which offers great flexibility in use thanks to numerous setting options:

- Customizable scaling of analog output and measuring range
- Wide range of options for Condition Monitoring (limit value monitoring via switching output)
- Data processing through averaging, mastering or data reduction
- 3-point linearization for customer-specific installation situations



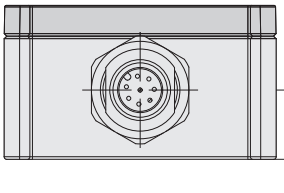
Flatness measurement during flat rolling of crude steel

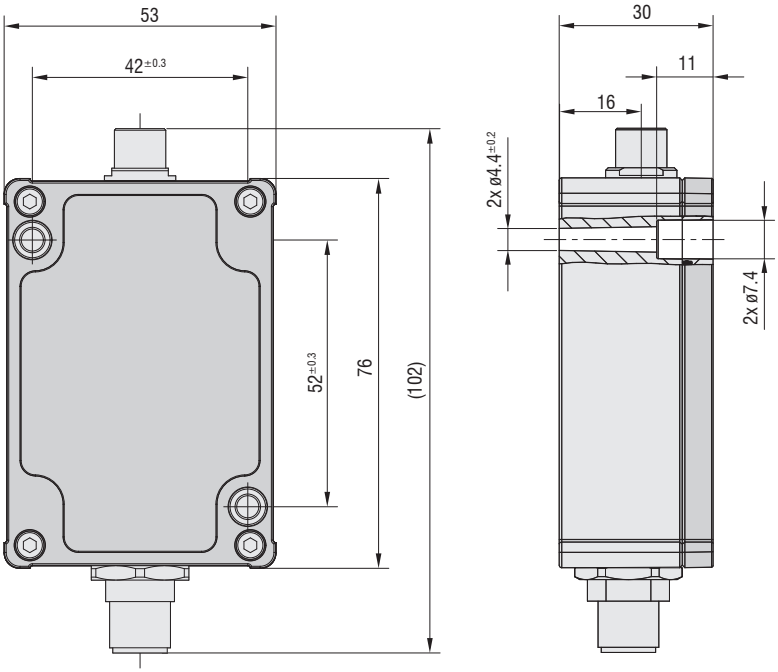


Distance measurement for stabilizing metal strips, e.g. in the galvanizing process

Model		DT3020
Resolution [1]	Static	0.004 % FSO
	Dynamic	0.01 % FSO
Frequency response (-3dB) [2]		9 adjustable stages: 10 Hz ... 5 kHz
Measuring rate	Analog output	80 kSa/s
	Digital output	10 kSa/s
Linearity [3]		< ±0.2 % FSO
Temperature stability [4]		< 0.025 % FSO / K
Temperature compensation		10 ... 105 °C
Target material [5]		Steel, aluminum
No. of characteristic curves		1
Supply voltage		12 ... 32 VDC
Power consumption		< 1.7 W
Digital interface [6]		RS485 / USB / Ethernet / EtherCAT / PROFINET / EtherNet/IP
Analog output		4 ... 20 mA (max. 500 Ω load, freely scalable 0 ... 20 mA)
Digital outputs		Selectable: NPN, PNP, push-pull
Connection		Sensor: plug connector triaxial socket; supply/signal: 8-pole M12 connector
Mounting		Through-bores (Ø 4.4 mm)
Temperature range	Storage	-20 … 105 °C (non-condensing)
	Operation	-20 … 105 °C (non-condensing)
Shock (DIN EN 60068-2-27)		15 g / 6 ms in 3 axes, 2 directions and 1000 shocks each
Vibration (DIN EN 60068-2-6)		5 g / 10 … 500 Hz in 3 axes, 2 directions and 10 cycles each
Protection class (DIN EN 60529)		IP67 (plugged)
Material		Aluminum die-cast
Weight		approx. 190 g
Control and indicator elements [7]		Configurable via sensorTOOL software: 3-point linearization, scaling of the analog output, filter & averaging, interface selection

[1] FSO = Full Scale Output, RMS noise relates to the mid of the measuring range, static: 20 Hz, dynamic: 5 kHz
[2] Factory setting 5 kHz
[3] Value valid with 3-point linearization
[4] Value valid within the temperature-compensated range
[5] Steel: St37 1.0037; aluminum: AlMg3 3.3535
[6] Connection via an interface module is required for USB, Ethernet, EtherCAT, PROFINET and EtherNet/IP
[7] Access to sensorTOOL requires connection to a PC via an interface module

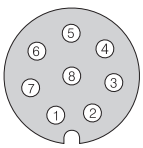




Pin assignment for power supply and signal

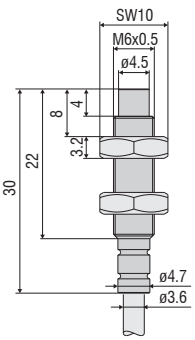
Pin	Assignment	Color (Cable: PC5/8-M12/105)
1	Not assigned	White
2	Supply: +24 V	Brown
3	Digital outputs	Green
4	RS485 A/+	Yellow
5	RS485 B/-	Gray
6	GND analog output	Pink
7	GND supply	Blue
8	Analog output $I_{Displacement}$	Red

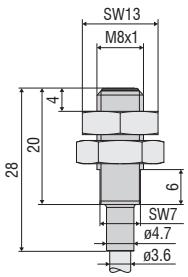
8-pole M12x1 housing connector
View on pin side

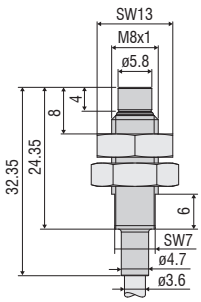


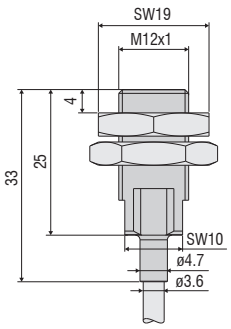
Standard sensors
eddyNCDT 3020 / 3060

Measurement direction





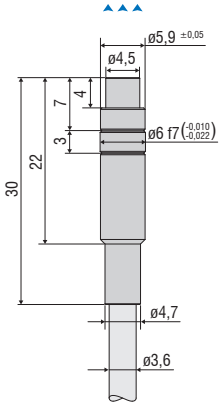




Model		ES-U1	ES-S1	ES-U2	ES-S2
Measuring range		1 mm	1 mm	2 mm	2 mm
Start of measuring range		0.1 mm	0.1 mm	0.2 mm	0.2 mm
Resolution [1] [2] [3]		0.02 µm	0.02 µm	0.04 µm	0.04 µm
Linearity [1] [4]		< ±1µm	< ±1µm	< ±2 µm	< ±2 µm
Temperature stability [1] [2]		< 0.15 µm / K	< 0.15 µm / K	< 0.3 µm / K	< 0.3 µm / K
Temperature compensation		+10 … +180 °C	+10 … +180 °C	+10 … +180 °C	+10 … +180 °C
Sensor type		unshielded	shielded	unshielded	shielded
Min. target size (flat)		Ø 18 mm	Ø 12 mm	Ø 24 mm	Ø 18 mm
Connection		integrated cable, axial, standard length 3 m; optionally 1 m, 6 m, 9 m [5]			
Mounting		Screw connection (M6)	Screw connection (M8)	Screw connection (M8)	Screw connection (M12)
Temperature range	Storage	-20 … +180 °C	-20 ... +200°C	-20 … +200 °C	-20 … +200 °C
	Operation	-20 … +180 °C	-20 ... +200°C	-20 … +200 °C	-20 … +200 °C
Pressure resistance		20 bar (front & rear)			
Shock (DIN EN 60068-2-27)		15 g / 6 ms in 3 axes, 2 directions and 1000 shocks each			
Vibration (DIN EN 60068-2-6)		15 g / 49.85 … 2000 Hz in 3 axes ±3 mm / 10 … 49.85 Hz in 3 axes			
Protection class (DIN EN 60529)		IP68 (plugged)			
Material		Stainless steel and plastic			
Weight [6]		approx. 2.4 g	approx. 2.4 g	approx. 4.7 g	approx. 11 g

[1] Valid for operation with DT306x, referenced to the nominal measuring range
[2] Relates to the mid of the measuring range within the compensated temperature range
[3] RMS value of the signal noise, static (20 Hz)
[4] Only with DT3061 controller and 5-point linearization
[5] Length tolerance cable: nominal value - 0 % / + 30 %
[6] Weight of sensor only, without nuts or cables

Additional design: ES-U1-T



ES-Ux-T design:

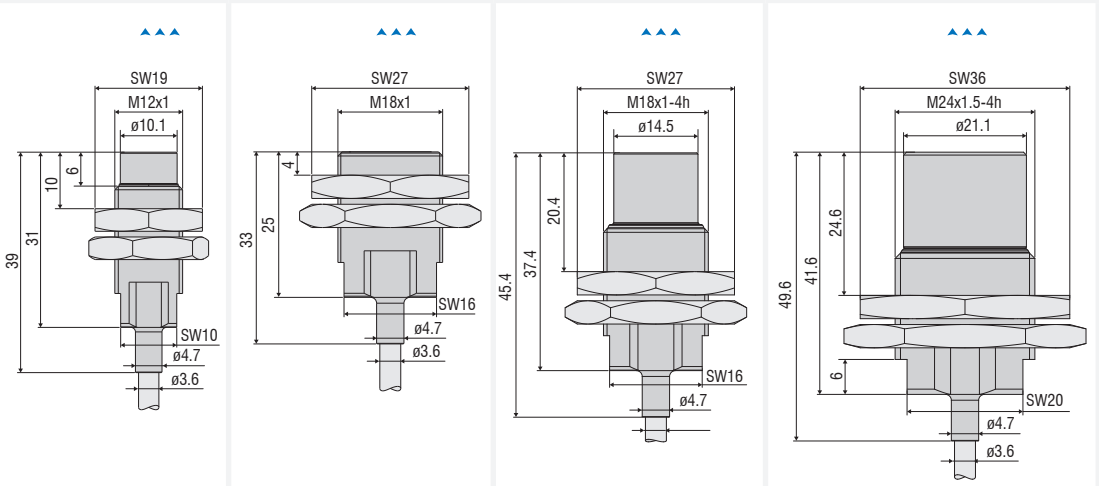
Sensors without threads

The ES-Ux-T design are sensors without threads.

These offer additional advantages for installation and temperature stability.

- Thanks to clamp mounting, the cable is not subjected to torsional stress, which prevents damage.
- The sensor has a defined clamping point, which minimizes thermal expansion in the measuring direction and enables high temperature stability.

▲▲▲ Measurement direction



Model	ES-U3	ES-S4	ES-U6	ES-U8
Measuring range	3 mm	4 mm	6 mm	8 mm
Start of measuring range	0.3 mm	0.4 mm	0.6 mm	0.8 mm
Resolution [1] [2] [3]	0.06 µm	0.08 µm	0.12 µm	0.16 µm
Linearity [1] [4]	< ±3 µm	< ±4 µm	< ±6 µm	< ±8 µm
Temperature stability [1] [2]	< 0.45 µm / K	< 0.6 µm / K	< 0.9 µm / K	< 1.2 µm / K
Temperature compensation	+10 … +180 °C	+10 … +180 °C	+10 … +180 °C	+10 … +180 °C
Sensor type	unshielded	shielded	unshielded	unshielded
Min. target size (flat)	Ø 36 mm	Ø 27 mm	Ø 54 mm	Ø 72 mm
Connection	integrated cable, axial, standard length 3 m; optionally 1 m, 6 m, 9 m [5]			
Mounting	Screw connection (M12)	Screw connection (M18)	Screw connection (M18)	Screw connection (M24)
Temperature range – Storage	-20 … +200 °C	-20 … +200 °C	-20 … +200 °C	-20 … +200 °C
Temperature range – Operation	-20 … +200 °C	-20 … +200 °C	-20 … +200 °C	-20 … +200 °C
Pressure resistance	20 bar (front & rear)			
Shock (DIN EN 60068-2-27)	15 g / 6 ms in 3 axes, 2 directions and 1000 shocks each			
Vibration (DIN EN 60068-2-6)	15 g / 49.85 … 2000 Hz in 3 axes ±3 mm / 10 … 49.85 Hz in 3 axes			
Protection class (DIN EN 60529)	IP68 (plugged)			
Material	Stainless steel and plastic			
Weight [6]	approx. 12 g	approx. 30 g	approx. 33 g	approx. 62 g

[1] Valid for operation with DT306x, referenced to the nominal measuring range
[2] Relates to the mid of the measuring range within the compensated temperature range
[3] RMS value of the signal noise, static (20 Hz)
[4] Only with DT3061 controller and 5-point linearization
[5] Length tolerance cable: nominal value - 0 % / + 30 %
[6] Weight of sensor only, without nuts or cables

Additional design: ES-U3-T

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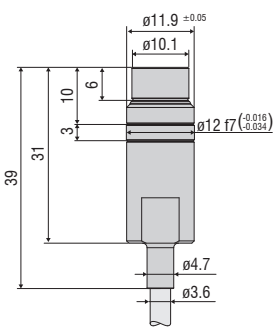
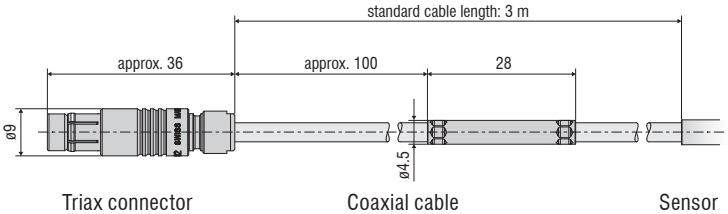


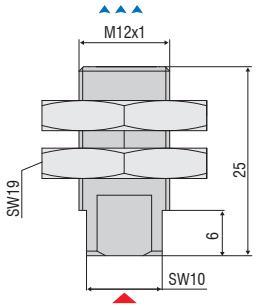
Connection of sensors with integrated cable:



Special sensors
eddyNCDT 3020 / 3060

Measurement direction

Connector side



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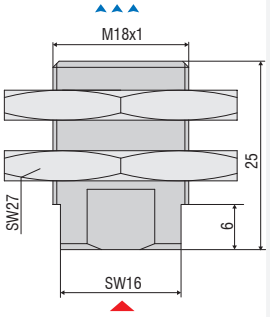

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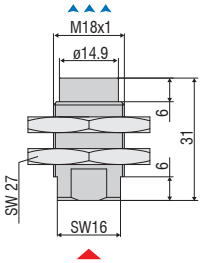

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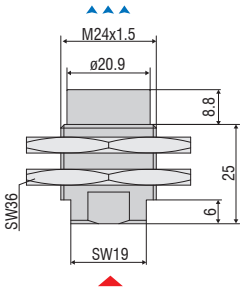


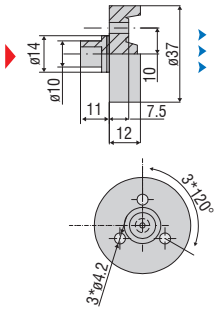
1:2

Model	ES2	ES4	EU6	EU8
Measuring range	2 mm	4 mm	6 mm	8 mm
Start of measuring range	0.2 mm	0.4 mm	0.6 mm	0.8 mm
Resolution [1] [2] [3]	0.04 µm	0.08 µm	0.12 µm	0.16 µm
Linearity [1] [4]	< 2 µm	<4 µm	6 µm	8 µm
Temperature stability [1] [2] [4]	0.5 µm / K	1 µm / K	1.5 µm / K	2 µm / K
Temperature compensation [4]	0 ... +150 °C	0 … +150 °C	0 … +150 °C	0 … +150 °C
Sensor type	shielded	shielded	unshielded	unshielded
Min. target size (flat)	Ø 18 mm	Ø 27 mm	Ø 54 mm	Ø 72 mm
Connection	Plug connection via triaxial socket	Plug connection via triaxial socket	Plug connection via triaxial socket	Plug connection via triaxial socket
Mounting	Screw connection (M12)	Screw connection (M18)	Screw connection (M18)	Screw connection (M24)
Temperature range – Storage	-20 ... +150 °C	-20 ... +150 °C	-20 ... +150 °C	-20 ... +150 °C
Temperature range – Operation	-20 … +150 °C	0 … +150 °C	-20 … +150 °C	0 … +150 °C
Pressure resistance	20 bar (front)	20 bar (front)	20 bar (front)	20 bar (front)
Protection class (DIN EN 60529)	IP64 (plugged)	IP50 (plugged)	IP64 (plugged)	IP64 (plugged)
Material	Stainless steel and plastic	Stainless steel and plastic	Stainless steel and plastic	Stainless steel and plastic

Operation with DT3020/306x requires special calibration (LC)
[1] Valid for operation with DT306x referenced to the nominal measuring range
[2] Relates to mid of measuring range
[3] RMS value of the signal noise, static (20 Hz)
[4] Only with DT3061 controller and 5-point linearization

Measurement direction

Connector side



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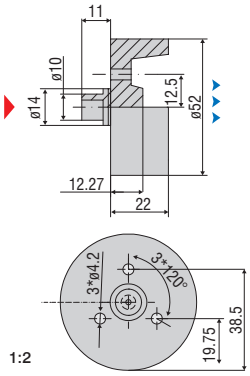

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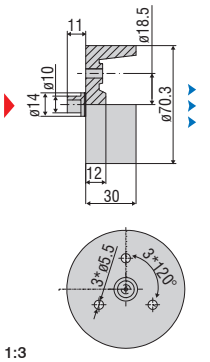

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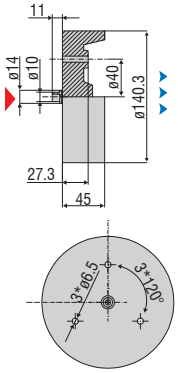


1:8

Model	EU15	EU22	EU40	EU80
Measuring range	15 mm	22 mm	40 mm	80 mm
Start of measuring range	1.5 mm	2.2 mm	4 mm	8 mm
Resolution [1] [2] [3]	0.3 µm	0.44 µm	0.8 µm	1.6 µm
Linearity [1] [4]	< ±15 µm	< ±22 µm	< ±40 µm	< ±80 µm
Temperature stability [1] [2] [4]	< 3.75 µm / K	< 5.5 µm / K	< 10 µm / K	< 20 µm / K
Temperature compensation [4]	0 … +150 °C	0 … +150 °C	0 … +150 °C	0 … +150 °C
Sensor type	unshielded	unshielded	unshielded	unshielded
Min. target size (flat)	Ø 111 mm	Ø 156 mm	Ø 210 mm	Ø 420 mm
Connection	Plug connection via triaxial socket	Plug connection via triaxial socket	Plug connection via triaxial socket	Plug connection via triaxial socket
Mounting	3 x through-holes	3 x through-holes	3 x through-holes	3 x through-holes
Temperature range – Storage	-20 ... +150 °C	-20 ... +150 °C	-20 ... +150 °C	-20 ... +150 °C
Temperature range – Operation	0 … +150 °C	0 … +150 °C	0 … +150 °C	0 … +150 °C
Protection class (DIN EN 60529)	IP64 (plugged)	IP64 (plugged)	IP64 (plugged)	IP64 (plugged)
Material	Epoxy	Epoxy	Epoxy	Epoxy

Operation with DT3020/306x requires special calibration (LC)

[1] Valid for operation with DT306x referenced to the nominal measuring range

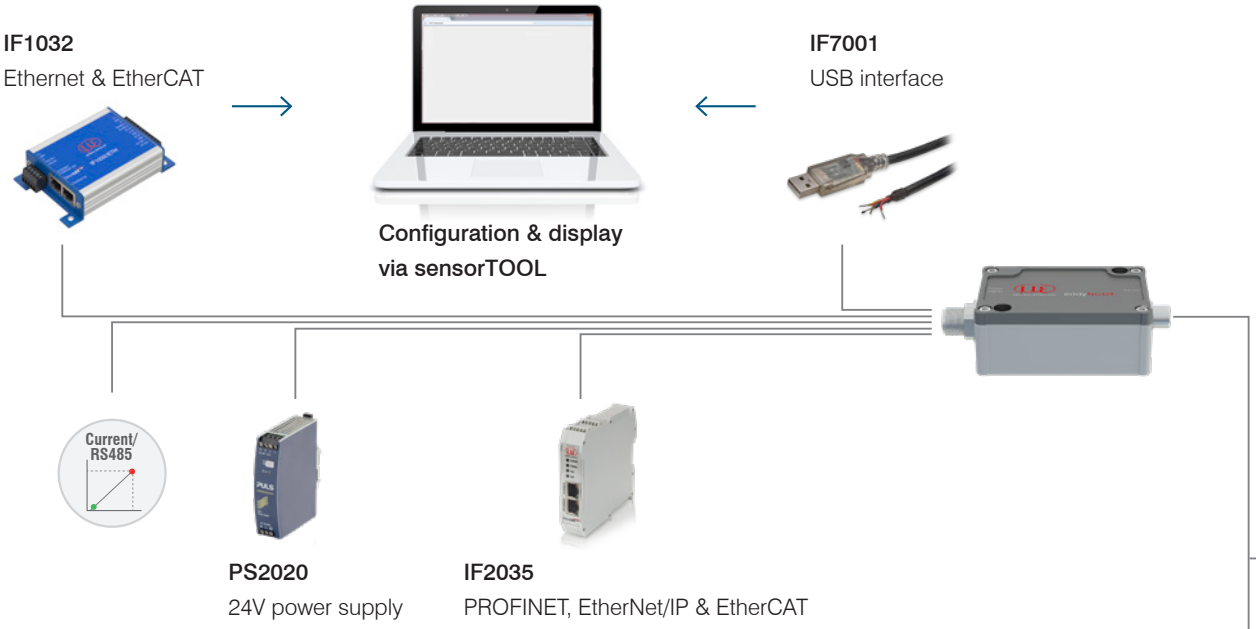
[2] Relates to mid of measuring range

[3] RMS value of the signal noise, static (20 Hz)

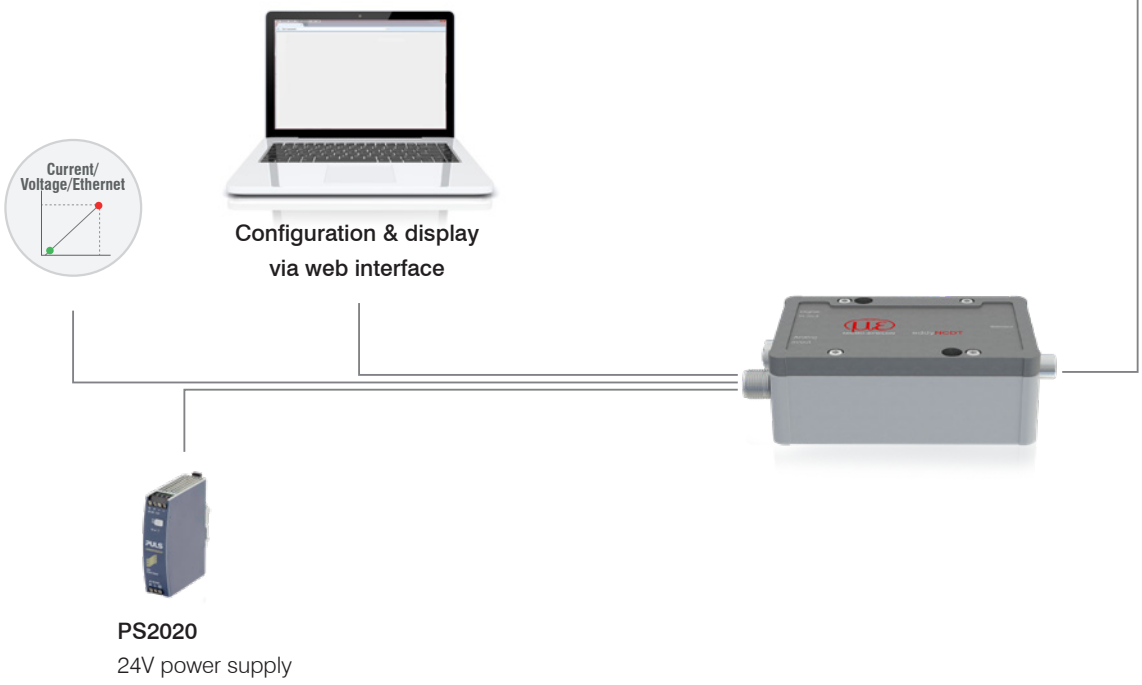
[4] Only with DT3061 controller and 5-point linearization

Connection possibilities
eddyNCDT 3020 / 3060

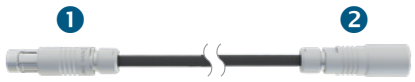
Connection possibilities DT3020



Connection possibilities DT3060



Extension cable (optional):
ECE-x/fB0/mB0



Sensors with integrated cable:
ES-xx

Coaxial cable with Viton sheath
Cable diameter: 3.6 mm
Minimum bending radius: static approx. 27 mm / dynamic approx. 54 mm
Temperature resistance: up to 200 °C
Available lengths: 1 m / 3 m / 6 m (9 m on request)

Adapter cable: EC-x/mB0/mB0

Sensors with socket: ESxx / EUxx

Connector mB0
Outer diameter: 9 mm
Mating length: 26 mm
Temperature resistance: up to 200 °C

Socket fB0
Outer diameter: 10 mm
Mating length: 35 mm
Temperature resistance: up to 200 °C

Accessories
eddyNCDT

Item	Description	DT3001	DT3005	DT3020	DT3060	DT3070	DZ140	SGS
PCx/5-M12	**Power supply and signal cable** 5-pole with M12 connector Standard length: 5 m Optionally available: 10 m/20 m/40 m/80 m as drag-chain suitable variant	x	x					
PCx/8-M12	**Power supply and signal cable** 8-pole with M12 connector Standard length: 3 m Optionally available: 5 m/ 10 m /15 m / 10 m also as drag-chain suitable variant			x	x	x		
PC5/8-M12/105	**Power supply and signal cable** Increased temperature resistance up to 105 °C 8-pole with M12 connector Length: 5 m as drag-chain suitable variant			x	x	x		
PC4701-x	**Power supply and signal cable** 8-pole with M12 connector Standard length: 10 m Optionally available: 15 m 10 m also available as drag chain–suitable variant							x
SCD2/4/RJ45	**Ethernet cable** 4-pole with M12 connector on RJ45 connector Standard length: 2 m				x	x		
PC140-x	**Power supply and signal cable** 8-pole connector Standard length: 3 m Optionally available: 6 m						x	
PS2020	**Power supply unit** Input 100-240 VAC Output 24 VDC / 2.5 A; installation on symmetrical standard rail 35 mm x 7.5 mm, DIN 50022	x	x	x	x	x	x	x
IF2035	**Interface module for Industrial Ethernet connection** Connection of RS422 or RS485 interfaces to PROFINET / Ethernet/IP / EtherCAT 2 network connections for different network topologies Ideal for confined spaces due to a compact housing and DIN rail mounting		x	x				
IF1032	**Interface module for Ethernet/EtherCAT connection** 1x RS485 2x analog-in (14 bit, max. 4 ksps), voltage 1x analog-in, (14 bit, max. 4 ksps), current		x	x				
IF7001	**Single-channel converter cable from RS485 to USB** Conversion from RS485 to USB Easy sensor connection via USB Integration into plant and machinery		x	x				

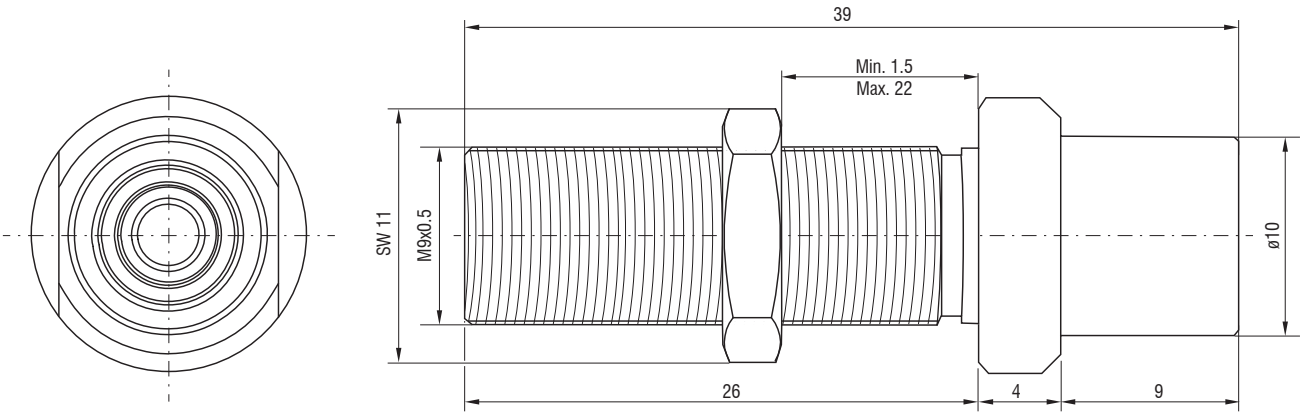
Plug system for vacuum applications
Vacuum feedthrough eddy/fB0/fB0/triax

The eddyNCDT series delivers high-precision measurement results even in airless rooms. The eddy/fB0/fB0/triax vacuum feedthrough also enables eddyNCDT products to be used in vacuum applications.

- Application in vacuums
- Application as a wall duct
- Pluggable version
- Compatible with all common eddyNCDT products

Vacuum feedthrough eddy/fB0/fB0/triax	
Housing material	CuZn39Pb3
O-ring material	FPM (Viton®)
Max. leakage rate (IEC standard 60068-2-17)	$<10^{-8}$ mbar*l/s
Operating temperature [1]	from -20 °C to 150 °C
Mating cycles (IEC 60512-5-9a)	10,000
Vibration (MIL-STD-202 Method 204 Condition B)	10 to 2,000 Hz, 1.5 mm or 15 g, 12 pass cycles per axis, 20 minutes per 10-2000-10 Hz pass cycle, no discontinuity >1 µs
Insulation resistance	10^{10} Ω

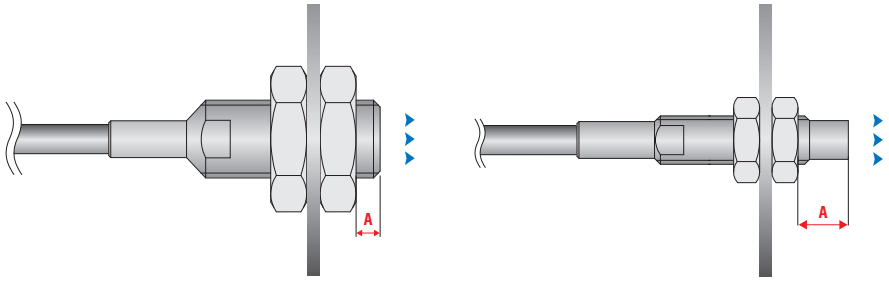
[1] Min. connection temperature: 0 °C



Standard installation situation

Distance between the nut and the measuring area

eddyNCDT sensors are mounted using the two mounting nuts included in the delivery. During the factory-calibration of the sensors, these were mounted in a defined distance A and included in the calibration. In order to achieve maximum linearity, the nut must be mounted in the defined distance indicated in the table.



Please note the respective distances recommended in the table below when mounting the sensors:

Series	Model	Distance A
DT3001-	U2-A-SA	22 mm (±0.2 mm)
	U2-M-SA	22 mm (±0.2 mm)
	U4-A-SA	22 mm (±0.2 mm)
	U4-M-SA	22 mm (±0.2 mm)
	U4-A-Cx	22 mm (±0.2 mm)
	U4-M-Cx	22 mm (±0.2 mm)
	U6-A-SA	22 mm (±0.2 mm)
	U6-M-SA	22 mm (±0.2 mm)
	U8-A-SA	22 mm (±0.2 mm)
	U8-M-SA	22 mm (±0.2 mm)
DT3005-	U1-A-C1	8 mm (±0.2 mm)
	U1-M-C1	8 mm (±0.2 mm)
	S2-A-C1	4 mm (±0.2 mm)
	S2-M-C1	4 mm (±0.2 mm)
	U3-A-C1	10 mm (±0.2 mm)
	U3-M-C1	10 mm (±0.2 mm)
	U6-A-C1	13 mm (±0.2 mm)
	U6-M-C1	13 mm (±0.2 mm)
DT3020 / DT3060	ES-U1	8 mm (±0.2 mm)
	ES-S1	4 mm (±0.2 mm)
	ES-U2	8 mm (±0.2 mm)
	ES-S2	4 mm (±0.2 mm)
	ES-U3	10 mm (±0.2 mm)
	ES-S4	4 mm (±0.2 mm)
	ES-U6	20.4 mm (±0.2 mm)
	ES-U8	24.6 mm (±0.2 mm)
	ES04	2.1 mm (±0.2 mm)
	EU05	5.5 mm (±0.2 mm)
	ES08	2.7 mm (±0.2 mm)
	ES1	4 mm (±0.2 mm)
	EU1	6.7 mm (±0.2 mm)
	ES2	4 mm (±0.2 mm)
	EU3	10 mm (±0.2 mm)
	ES4	4 mm (±0.2 mm)
	EU6	10.125 mm (±0.2 mm)
	EU8	12.8 mm (±0.2 mm)
DT3070-	ES-S04	2.4 mm (±0.2 mm)

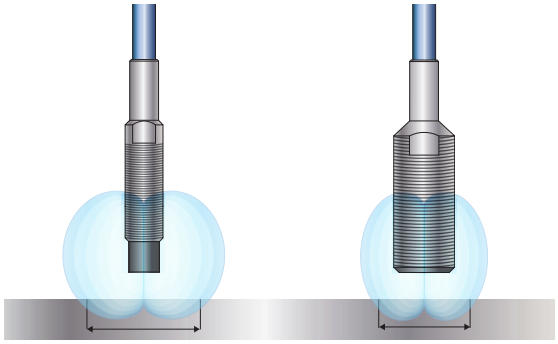
Influences on the measurement signal

Sensor installation

The notes mentioned under "Standard installation situation" for correct sensor installation affect the measurement signal.

Minimum diameter of the target (flat)

The relative size of the target has effects on the linearity deviation. Ideally, the target size with shielded sensors is at least 2 times the sensor diameter, with unshielded sensors it is 4 times the sensor diameter. From this size on, almost all field lines run from the sensor to the target. Here, nearly any field line penetrates the target via the front surface and therefore contributing to the formation of eddy currents. With smaller target diameters, field linearization is recommended.



Unshielded sensor
Measurement spot =
4x sensor diameter

Shielded sensor
Measurement spot =
2x sensor diameter

ø Target = 4x or 2x sensor diameter
recommended (no linearization is required)

ø Target = 3x or 1.5x sensor diameter
requires field linearization (DT306x / DT3300)

Minimum diameter of round targets

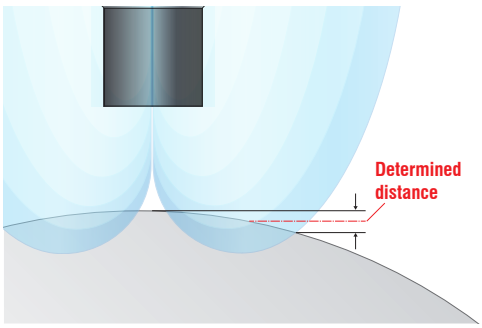
As well as the minimum size for flat geometries, a minimum diameter for round measuring objects is required.

Diameter > 10x sensor diameter
requires field linearization (DT306x / DT3300)

Diameter < 10x sensor diameter
requires factory calibration

Compensating the distance with curved measuring objects

When measuring on curved surfaces such as shafts, the sensors use the medium distance which results from the closest and the most distant field line range. However, this is not the distance between the vertex of the curved target and the sensor. For this reason, eddy current measuring systems from Micro-Epsilon enable the storage of the actual distance in the controller. This is how measurements can be performed on cylindrical objects such as rolls or shafts.



Material and thickness of the target

Stable measurement results require a certain target minimum thickness that depends on the target material used. For one-sided distance measurements, the following standard values are recommended:

Target material	Recommended target thickness
Aluminum	0.504 mm
Lead	1.377 mm
Gold	0.447 mm
Graphite	8.100 mm
Copper	0.402 mm
Magnesium	0.627 mm
Brass	0.747 mm
Nickel	0.081 mm
Permalloy	0.012 mm
Phosphor Bronze	0.906 mm
Silver	0.390 mm
Steel DIN 1.1141	0.069 mm
Steel DIN 1.4005	0.165 mm
Steel DIN 1.4301	2.544 mm

Tilt angle

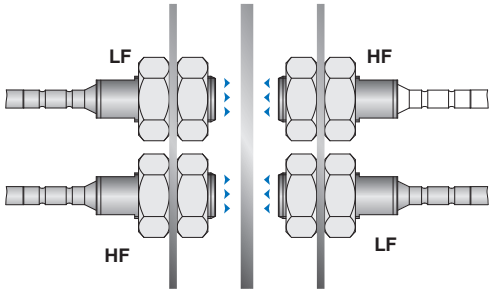
The high accuracy of the eddyNCDT sensors is only achieved with vertical sensor installation. When the sensor or the target are tilted, the measured results slightly deviate from those measured in the vertical position.

The extent of deviation differs from sensor to sensor. The tilt angle of ±3° can be neglected for most of the measurement tasks. With a tilt angle of larger than 6°, factory calibration is recommended. With a 3-point calibration, the tilt angle can be stored in the controller. This compensates for all influences affecting the signal.

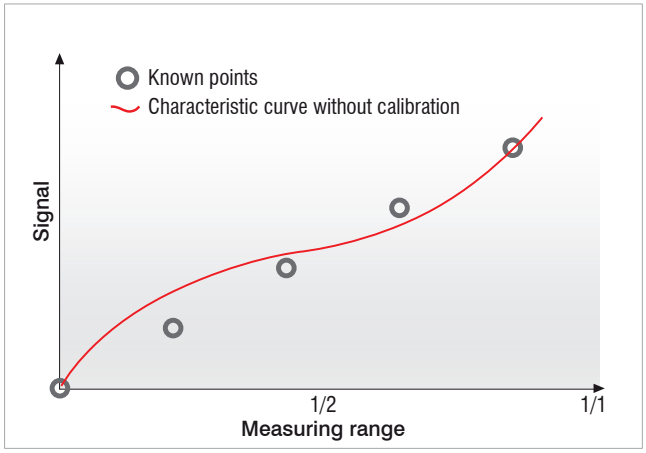
Terms
eddyNCDT

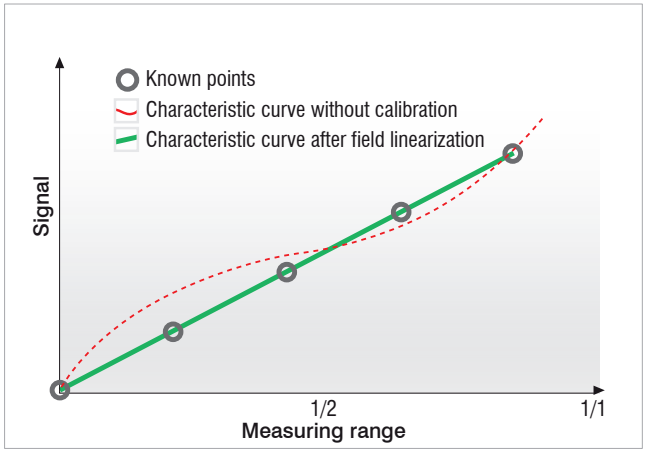
Frequency separation

For the simultaneous operation of several eddyNCDT measuring systems, these are available with a new type of frequency separation (LF/HF). The frequency separation enables multi-channel operation without mutual influence. This function makes a synchronization cable superfluous.



Field calibration



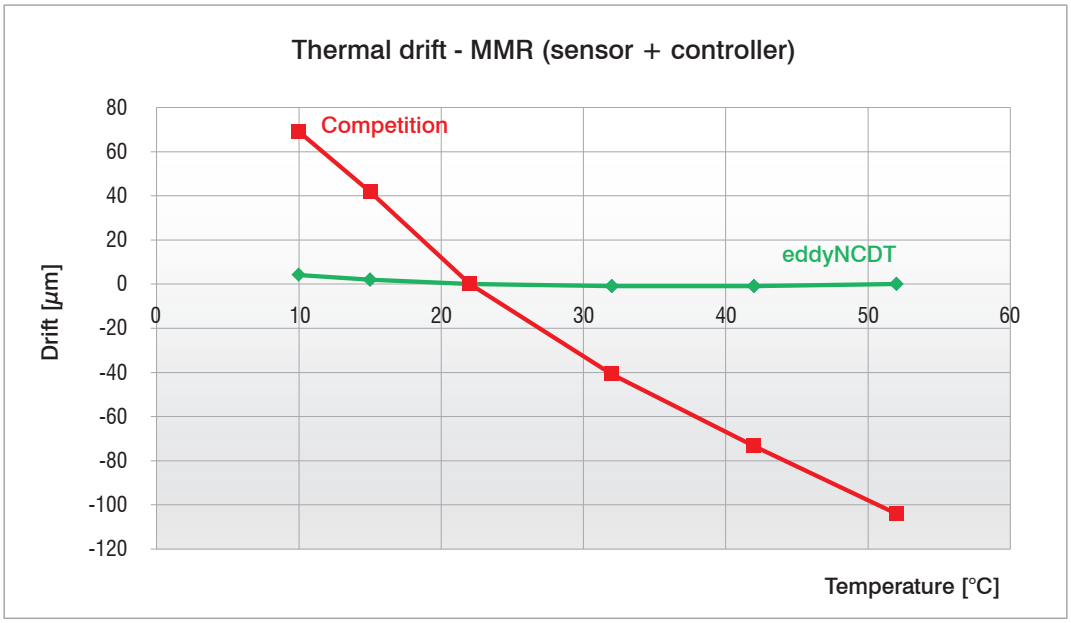


If the installation situation does not correspond to the standard installation conditions, field linearization is recommended (available with eddyNCDT 3060 and eddyNCDT 3300) This on-site calibration compensates for influences which result from the installation scenario or the target materials and shapes. Therefore, optimum measurement accuracies will always be achieved even in the case of difficult installation conditions.

For machine integration, linearization with 2 fixed points (start and end point) is sufficient in most cases. Using 3 or 5 points for linearization enables to increase the accuracy again.

For a linearization with 2 or more points, this applies only within the selected edge points. Outside this range, there may be larger linearity deviations.

Thermal drift of a Micro-Epsilon eddy current system compared with the competitors



All eddyNCDT sensors and controllers are actively temperature-compensated (sensors up to max. 180 °C, controllers up to max. 50 °C). This means that the temperatures of the sensor and the controller are recorded during operation and considered in the measurement result. This results in an extremely stable measurement signal.

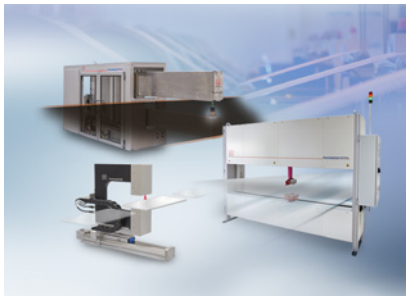
The figure shows a Micro-Epsilon sensor (green) compared with competing products (red). The maximum deviation over the entire temperature range is significantly below the 150 ppm/°C specified in the data sheet. Occasionally the deviation for the temperature increase of one degree amounts to a maximum of 150 ppm.

Conclusion: In order to keep precise measurement values in the µm range constant and reliable, the resolution to be achieved and the temperature influence are crucial factors. The temperature stability of the Micro-Epsilon system achieves such a high level that temperature fluctuations are actively compensated for. Due to the higher temperature influence of the competitor system, even daily temperature fluctuations of ±2.5 °C can cause a deviation of >20 µm. Measurements with micrometer accuracy are therefore not possible with the competitor system without active temperature compensation, even in normal environments.

Sensors and Systems from Micro-Epsilon

Sensors and systems for displacement, distance and position

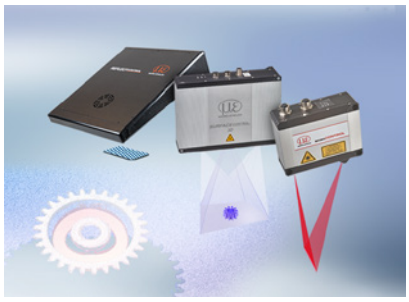
Sensors and measurement devices for non-contact temperature measurement



Measuring and inspection systems for metal strips, plastics and rubber

Optical micrometers and fiber optics, measuring and test amplifiers

Color recognition sensors, LED analyzers and inline color spectrometers



3D measurement technology for dimensional testing and surface inspection

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