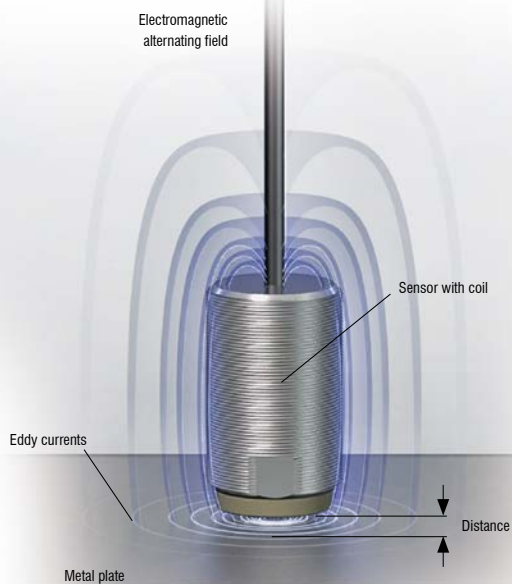
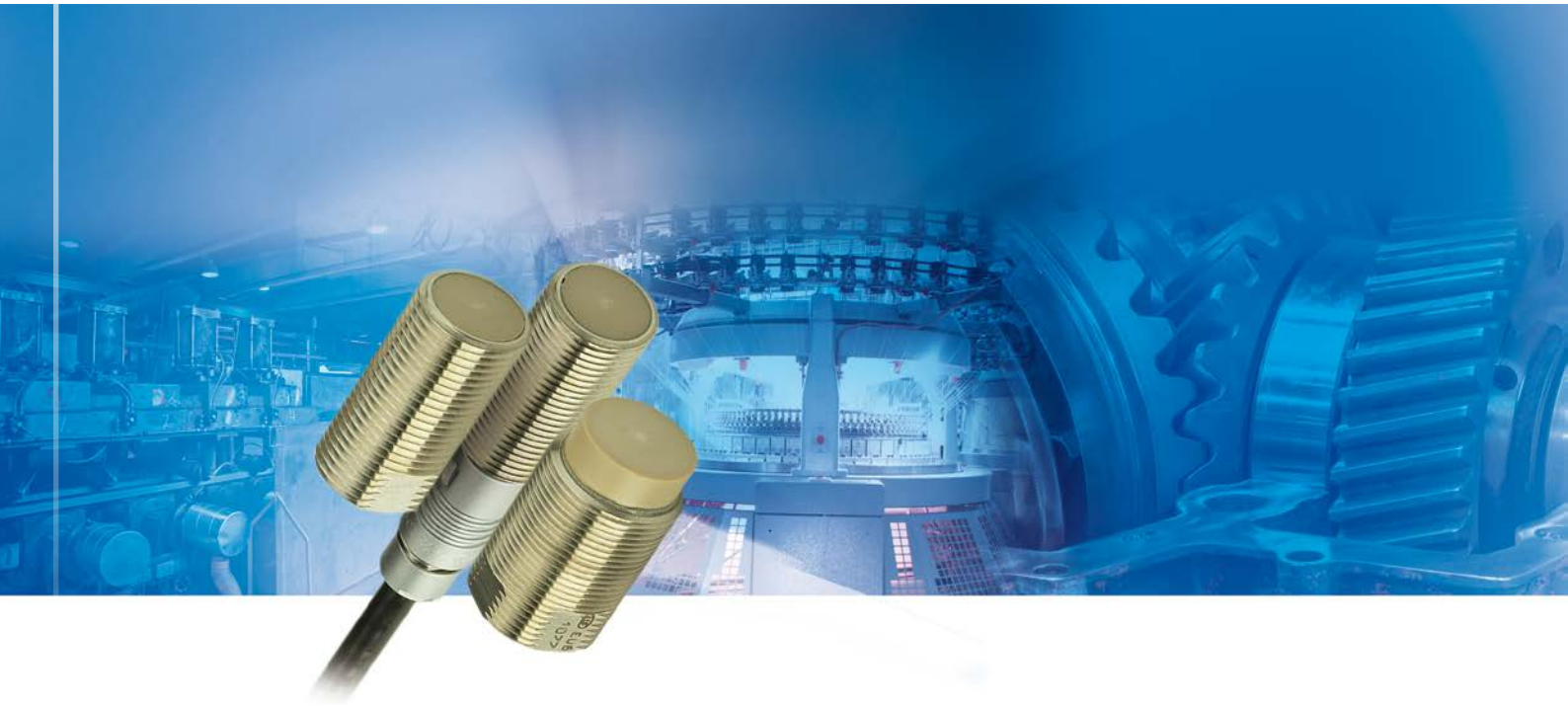




More Precision

eddyNCDT // Eddy current sensors for displacement and position





Measuring principle

The eddy current principle occupies a unique position amongst inductive measuring methods. The measuring principle is based on the extraction of energy from an oscillating circuit. This energy is required for the induction of eddy currents in electrically-conductive materials. Here, a coil is supplied with an alternating current, causing a magnetic field to form around the coil. If an electrically conducting object is placed in this magnetic field, eddy currents are induced which form a field according to Faraday's induction law.

This field acts against the field of the coil, which also causes a change in the impedance of the coil. The impedance can be calculated by the controller by looking at the change in the amplitude and phase position of the sensor coil.

Eddy current sensors

For many years, Micro-Epsilon has been a pioneer in displacement measurement using eddy current technology. Eddy current sensors from Micro-Epsilon are designed for non-contact measurement of displacement, distance, position, oscillation and vibrations. Eddy current sensors from Micro-Epsilon are extremely robust and precise.

Advantages

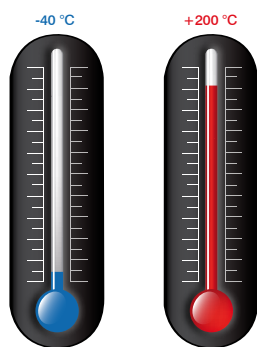
- Wear-free and non-contact measurement
- High precision and resolution
- High temperature stability
- Ferromagnetic and non-ferromagnetic materials
- For demanding, industrial environments: dirt, pressure, temperature
- Fast measurements up to 100kHz

eddyNCDT: Robust sensors with unmatched precision

Eddy current sensors from Micro-Epsilon are often used in applications where harsh ambient conditions are present and where maximum precision is required. Immunity to dirt, pressure and extreme temperature are distinctive features. The many designs of eddy current sensors enable engineers to select the optimal sensor for their particular application.

Custom sensors for automation and OEMs

Application examples are often found where the standard versions of the sensors and the controller are performing at their limits. For these special tasks, the measuring systems can be modified according to a customer's specific individual requirements. Changes requested include, for example, modified designs, target calibration, mounting options, individual cable lengths, modified measuring ranges or sensors with integrated controller.



Ideal for temperature fluctuations

- Active temperature compensation of sensor, cable and controller
- Temperature range -40°C to 200°C and higher



Robust sensors

- Robust and reliable sensors IP67
- Pressure-resistant models up to 2,000 bar
- Resistant to oil, dust & dirt



Comprehensive product range

- More than 400 sensor models
- Miniature sensors smaller than 2mm
- Custom sensors and OEMs

Eddy current sensor with integrated electronics Page 4 - 5 eddyNCDT 3001

- Measuring range 2 / 4mm
- Resolution 4µm
- Bandwidth 5kHz

Robust eddy current sensor system Page 10 - 13 eddyNCDT 3010

- Measuring range 0.5 - 15mm
- Resolution $\geq 0.025\mu\text{m}$
- Bandwidth 25kHz

High precision eddy current sensor system Page 18 - 25 eddyNCDT 3300

- Measuring range 0.4 - 80mm
- Resolution $\geq 0.02\mu\text{m}$
- Bandwidth up to 100kHz

Spindle Growth System Page 30 - 31 eddyNCDT SGS4701

- Measuring range 500µm
- Resolution $\geq 0.5\mu\text{m}$
- Bandwidth 2kHz

Compact eddy current sensor system Page 6 - 9 eddyNCDT 3005

- Measuring range 1 - 6mm
- Resolution $\geq 0.5\mu\text{m}$
- Bandwidth 5kHz

Flexible eddy current sensor system Page 14 - 17 eddyNCDT 3100

- Measuring range 0.5 - 15mm
- Resolution $\geq 0.025\mu\text{m}$
- Bandwidth 25kHz

Turbocharger speed sensors Page 26 - 29 turboSPEED DZ140

- Measuring range 0.5 - 1mm
- Speed range 200 RPM to 400,000 RPM
- Operating temperature up to 285°C

Application examples/Accessories Page 32 - 33

Technical information Page 34 - 39



- Compact M12 sensor design with integrated controller
- Bandwidth 5kHz (-3dB)
- Sensor for ferro- and non-ferromagnetic targets
- Temperature compensation up to 70°C
- Easy to use (plug & play)
- Robust design to IP67
- Ideal for OEM applications

Robust miniature eddy current sensor

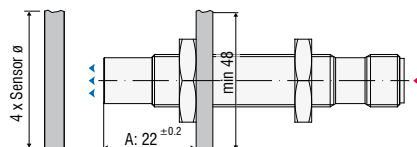
The eddyNCDT 3001 is a completely new high performance eddy current sensor platform. Although it is a similar size to currently available proximity and inductive sensors, the measuring performance is much greater. With integrated electronics including active temperature compensation, the sensor provides high measurement stability even in fluctuating temperature environments. Combined with an extremely competitive pricing structure, this is an ideal OEM solution. The device can be supplied in single quantities for evaluation

and can be modified if required for higher volume applications.

The sensor is factory calibrated with both ferrous and non-ferromagnetic materials, which eliminates the need for onsite linearisation of the sensor. The robust construction, combined with true eddy current measurement principle, enables measurements in harsh industrial environments (oil, pressure, dirt). Additionally, the eddy NCDT 3001 is also suitable for offshore and marine applications (saltwater resistant).

Installation instructions

The relative size of the measurement object to the sensor and the position of the mounting nut have effects on the linearity deviation for eddy current sensors.



Please note:

- Depending on the sensor model, the measurement object geometry shall be 4 times the sensor diameter.
- The mounting nut should not exceed the indicated dimension A.

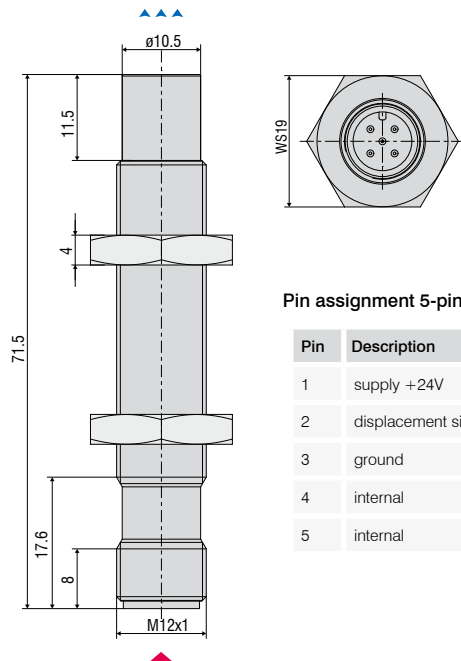
Model	DT3001-U2A-SA	DT3001-U2M-SA	DT3001-U4A-SA	DT3001-U4M-SA	DT3001-U4A-Cx	DT3001-U4M-Cx
Measurement object ¹⁾	aluminium	steel	aluminium	steel	aluminium	steel
Measuring range	2mm		4mm			
Offset distance	0.4mm					
Linearity	28μm					
Resolution ²⁾	4μm					
Bandwidth	5kHz (-3 dB)					
Temperature stability	0.03% FSO / °C					
Temperature compensation range	0°C ... +70°C					
Ambient temperature	0°C ... +70°C					
Installation	unshielded					
Recommended measurement object geometry (flat)	48mm					
Connection	connector 5-pin M12				integrated cable, 5-pin, length 3/6/9m	
Output	0.5 ... 9.5V				0.5 ... 4.5V	
Power supply	12V ... 32V					
Protection class	IP67 (connected)				IP67	
Weight	25g				60g (3m) 100g (6m) 140g (9m)	

FSO = of full scale output

¹⁾ Steel: ST37 DIN 1.0037 / aluminium: AlCuMgPb3.1645

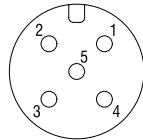
²⁾ RMS noise relates to centre of measuring range with a bandwidth of 5kHz

DT3001-SA

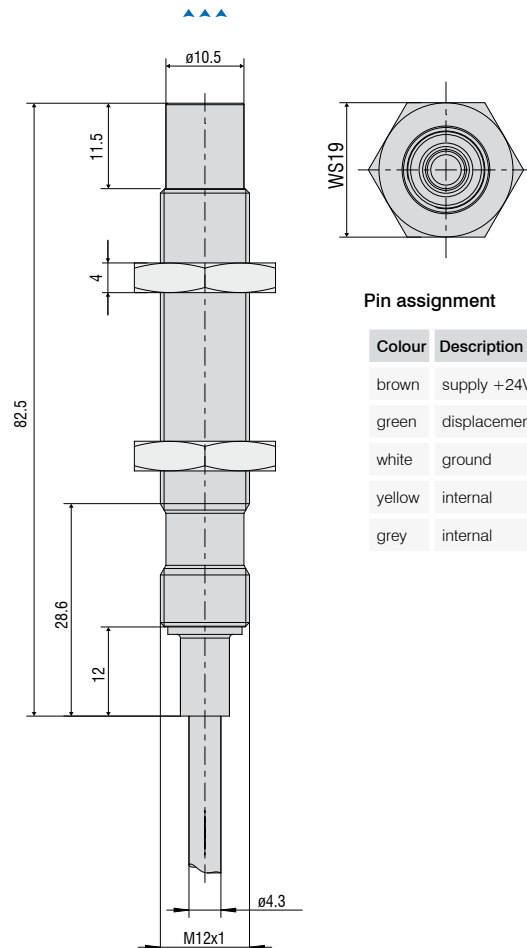


Pin assignment 5-pin M12-connector

Pin	Description
1	supply +24V
2	displacement signal
3	ground
4	internal
5	internal

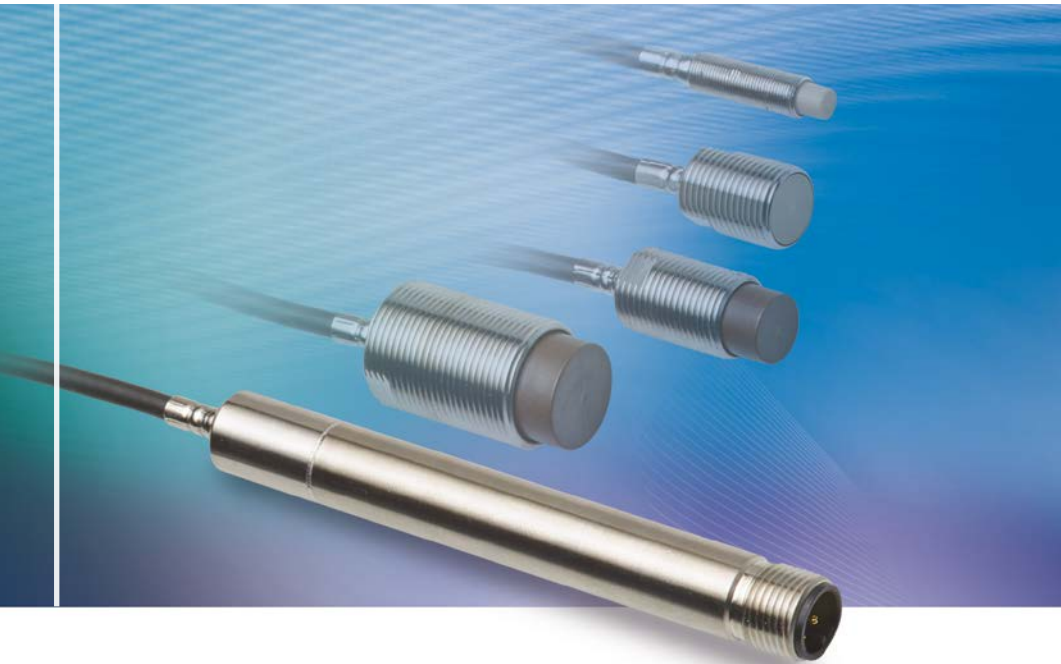


DT3001-Cx



Pin assignment

Colour	Description
brown	supply +24V
green	displacement signal
white	ground
yellow	internal
grey	internal



- Compact and robust design
- Temperature compensation up to 180°C
- High precision measurement accuracy
- High bandwidth
- Sensor for ferro- and non-ferromagnetic targets
- Easy to use (plug & play)
- Perfect for machine integration

Eddy current displacement measurement

Eddy current sensors from Micro-Epsilon are designed for displacement, distance, movement and position measurements, but also for detecting oscillations and vibrations. Non-contact operating eddy current sensors from Micro-Epsilon are renowned for their extreme precision, and are even used for micrometre-accuracy measurements.

Robust eddy current measurement system

The eddyNCDT 3005 is a new, powerful eddy current measurement system for fast, high precision displacement measurements. The system comprises a compact controller, a sensor and an integrated cable and is factory-calibrated for ferromagnetic and non-ferromagnetic materials.

As sensor and controller are temperature-compensated, high measurement accuracies can be achieved even in fluctuating temperatures. The sensors are designed for ambient temperatures up to max. +125°C but can optionally be custom engineered for temperatures from -30°C to +180°C. The measurement system is pressure-resistant up to 10 bar and so is ideally suited to machine integration.

Ideal for integration into plant and machinery

The eddyNCDT 3005 provides ease of use and high measurement accuracy, offering an outstanding price/performance ratio. Therefore, the sensor is ideally suited to OEM integration and mechanical engineering applications. Particularly where pressure, dirt, oil and high temperatures are present, the eddyNCDT 3005 is suitable. Where high volume orders are required, customer-specific designs can be tailored to suit individual requirements.

Multi-channel operation without mutual interference

If two or more systems operate next to one another, there is no need for synchronisation. For operating several systems, a new frequency separation is provided, which enables to operate these systems in parallel without influencing one another. Tuning via synchronisation cable is not necessary.



Compact design

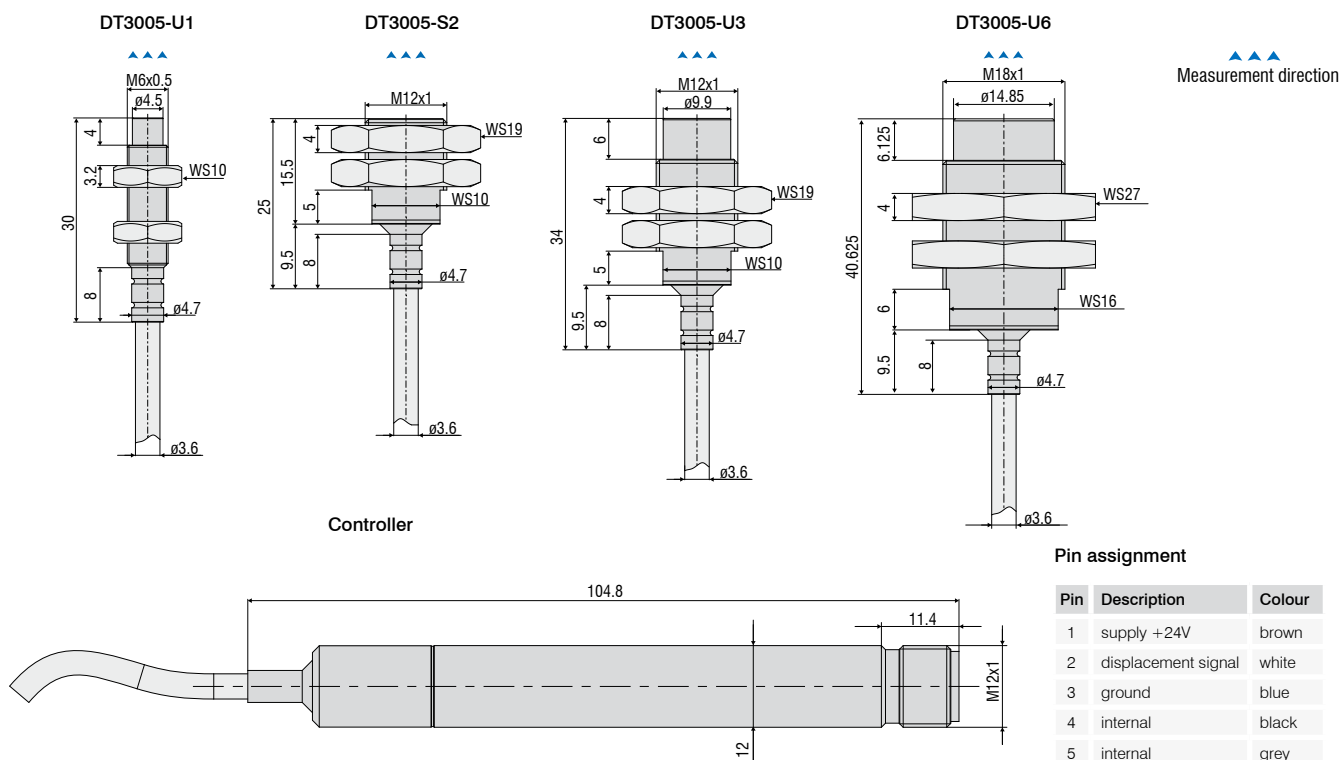
Model		DT3005- U1-A-C1	DT3005- U1-M-C1	DT3005- S2-A-C1	DT3005- S2-M-C1	DT3005- U3-A-C1	DT3005- U3-M-C1	DT3005- U6-A-C1	DT3005- U6-M-C1
Measurement object ¹⁾		aluminium	steel	aluminium	steel	aluminium	steel	aluminium	steel
Measuring range		1mm		2mm		3mm		6mm	
Offset distance		0.1mm		0.2mm		0.3mm		0.6mm	
Linearity	≤0.25% FSO	2.5µm		5µm		7.5µm		15µm	
Resolution ²⁾	≤0.05% FSO	0.5µm		1µm		1.5µm		3µm	
Repeatability		≤0.05% FSO							
Max. sensitivity deviation		≤1%							
Bandwidth		5kHz(-3dB)							
Temperature stability (MMR)		0.025% FSO / °C							
Temperature compensation range	sensor	10°C ... +125°C (optional -30°C ... 180°C)							
	controller	10°C ... +60°C							
Ambient temperature	sensor	-30°C ... +125°C (optional -30°C ... 180°C)							
	controller	-20°C ... +70°C							
Design		unshielded		shielded		unshielded		unshielded	
Recommended measurement object geometry (flat)		ø24mm		ø24mm		ø48mm		ø72mm	
Sensor cable length		1m							
Connection		connector 5-pin M12							
Output		0.5 ... 9.5V							
Power supply		12V ... 32V							
Protection class		IP67							
Pressure resistance		10bar (sensor, cable and controller)							
Weight		70g		75g		77g		95g	

FSO = of full scale output

MMR = midrange

¹⁾ Steel: ST37 DIN 1.0037 / aluminium: AlCuMgPb3.1645

²⁾ RMS noise relates to centre of measuring range with a bandwidth of 5kHz

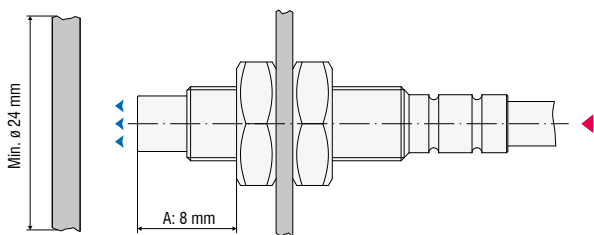
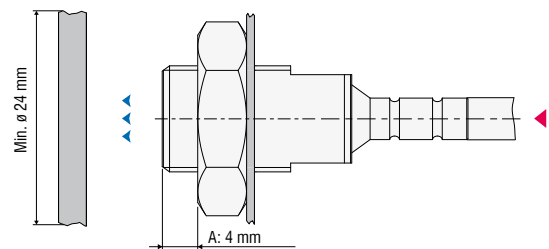
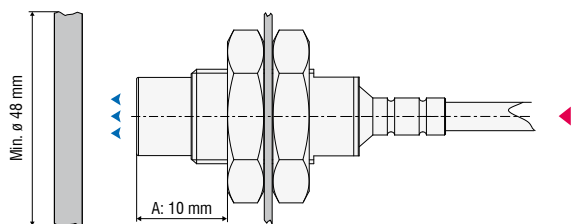
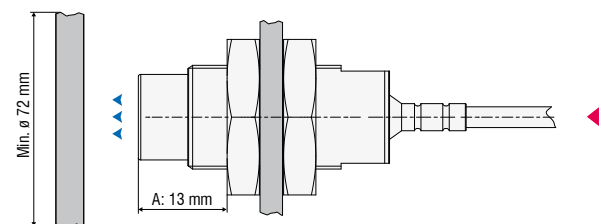


Installation instructions

The relative size of the measurement object to the sensor and the position of the mounting nut have effects on the linearity deviation for eddy current sensors.

Please note:

- Depending on the sensor model, the measurement object geometry shall be 2 or 4 times the sensor diameter.
- The mounting nut should not exceed the indicated dimension A.

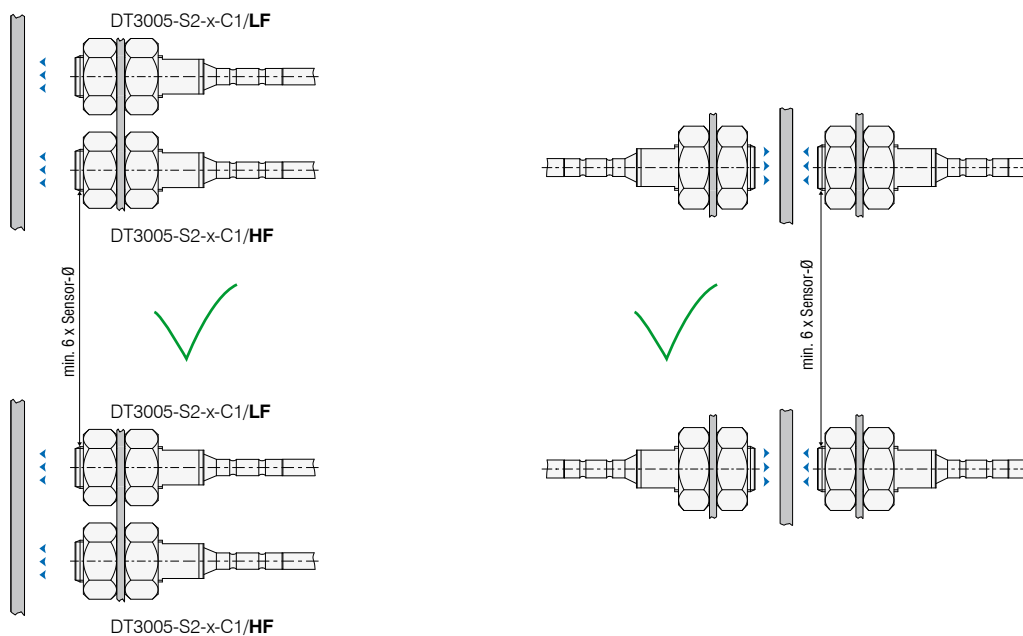
DT3005-U1-x-C1**DT3005-S2-x-C1****DT3005-U3-x-C1****DT3005-U6-x-C1**

Multi-channel operation without mutual interference

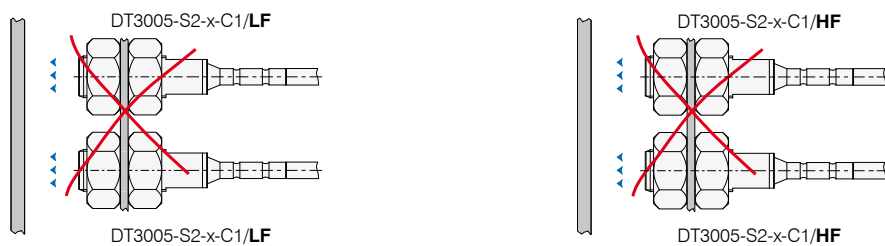
If two or more systems operate next to one another, there is no need for synchronisation using a synchronisation cable. For operating several systems, a new frequency separation is provided (LF/HF), which enables to operate these systems in parallel without influencing one another.

Please note:

- The LF/HF sensor arrangement enables to mount two sensors next to one another.
- The distance between two pairs of sensors must be at least 6 times the sensor diameter.
- However, it is not possible to place 2 LF sensors or 2 HF sensors next to one another.



Correct LF/HF arrangement



Arrangement not possible



- High accuracy and temperature stability
- Active temperature compensation
- Bandwidth 25kHz (-3dB)
- For integration in harsh, industrial environments
- Multi-channel applications by synchronisation

System structure

The eddyNCDT 3010 is a compact, single-channel system consisting of an eddy current sensor, a sensor connecting cable and an amplifier electronics (signal conditioning unit). The sensors are factory-calibrated for aluminium (non-ferromagnetic) or steel St37 (ferromagnetic). Using three-point linearisation, the user can also compensate on site for other materials.

Temperature compensation

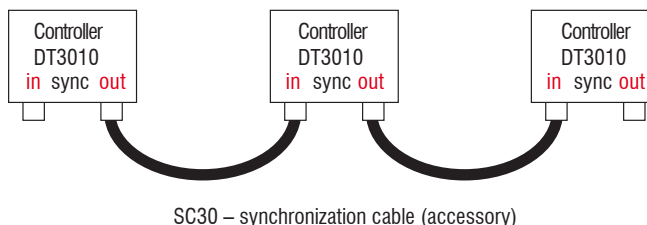
The eddyNCDT 3010 series is suitable in a wide temperature range. In the case of fluctuating ambient temperatures a stable output signal is very important for reliable measurements. Due to a patented temperature compensation method the eddyNCDT series 3010 offers a unique thermal stability, which no other system can offer.

The eddyNCDT 3010 is designed for industrial use in production plants, for machine control and for measuring and testing during in-process quality assurance.

Synchronisation

If several channels of series 3010 operate simultaneously close to one another, a mutual interference is possible because of slight differences in the oscillator frequencies.

This can be avoided by synchronisation. Two SMC connectors at the electronic box, one for oscillator signal output (sync out) and one for input (sync in) are standard equipment. The electronics operate independently as long as they are not interconnected. If connected together, they automatically switch to synchronised operation and are controlled by the first electronics (master). Any quantity of units can be synchronised by serial connection.



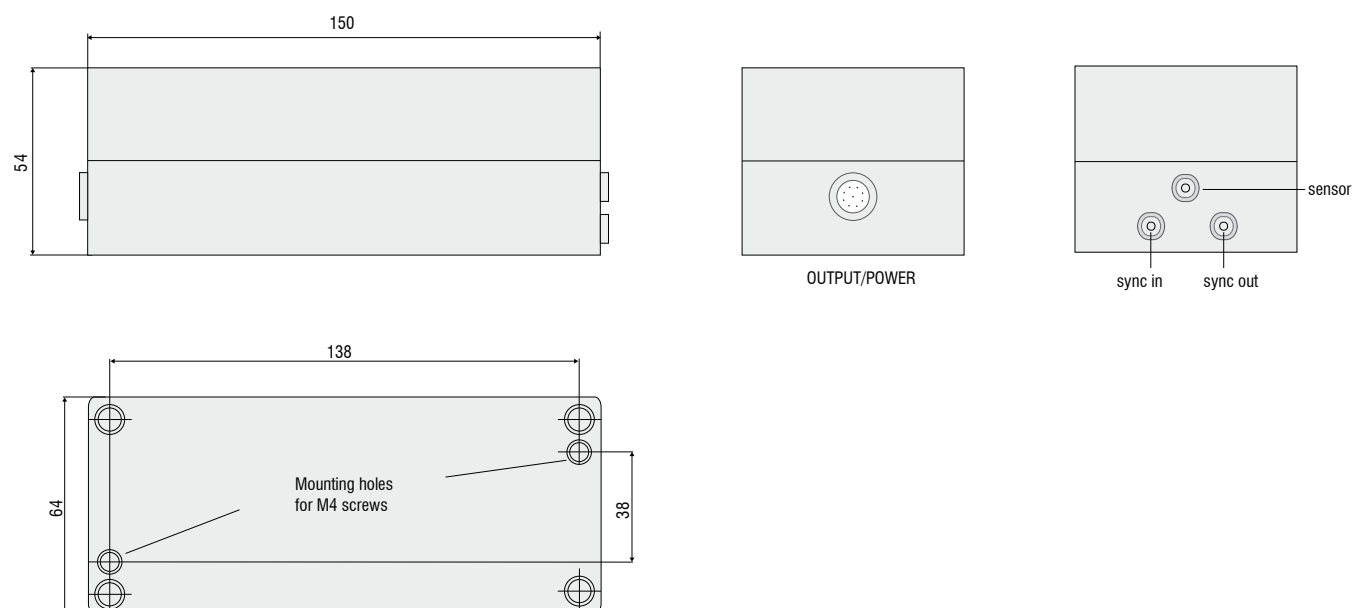
Controller	DT3010-A	DT3010-M
Material	non-ferromagnetic target	ferromagnetic target
Linearity	$\leq \pm 0.25\%$ FSO	
Resolution ¹⁾	0.005% FSO	
Repeatability	0.01% FSO	
Bandwidth	25kHz (-3dB)	
Temperature compensation range	standard: 10 to 65°C optional 0 to 90°C	
Temperature range controller	operation: 10 to 50°C	
	storage: -25 to 75°C	
Temperature stability controller (MMR)	$\leq 0.05\%$ FSO/°C	
Output	0 ... 10V / 10mA and 4 ... 20mA	
Power supply	24 VDC (9 ... 30V) / 205mA	
Electromagnetic compatibility (EMC)	acc. EN 50081-2 / EN 50082-2	
Synchronisation	with cable SC 30 (accessory)	
Protection class	controller	IP 54

FSO = of full scale output

MMR = midrange

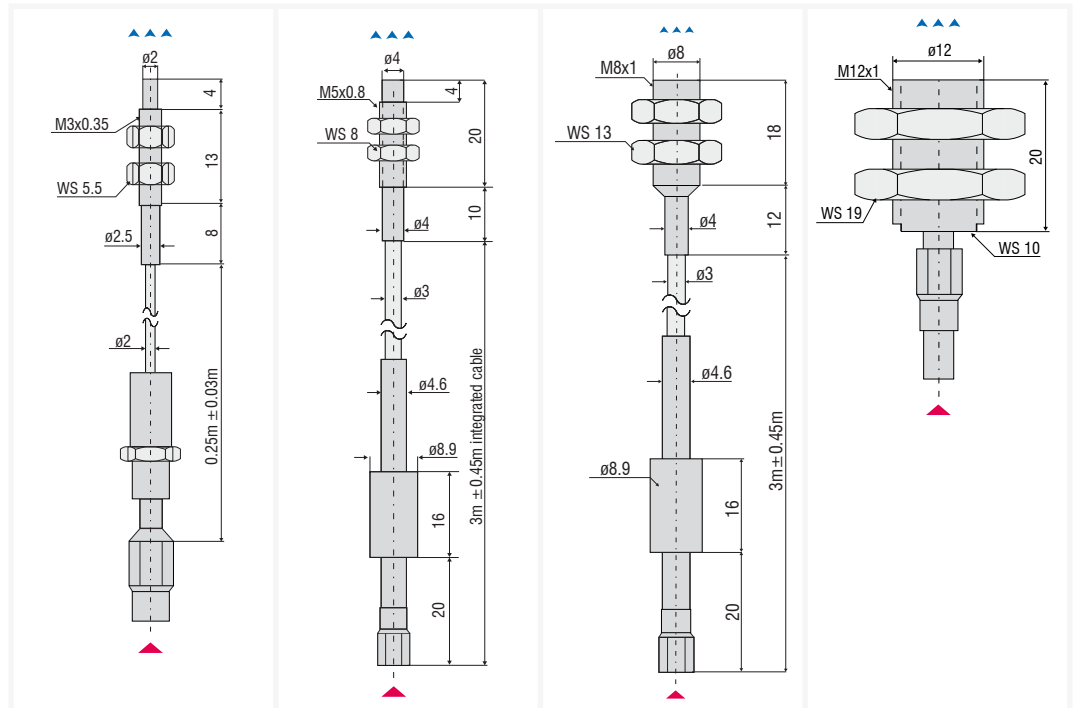
¹⁾ static resolution at midrange

Housing DT3010



▲▲▲▲
Measurement direction

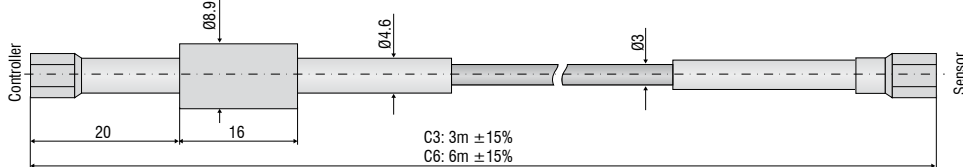
▲
Connector side



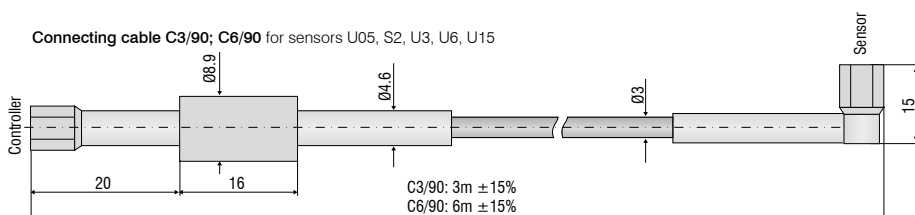
Sensor type	U05(09)	U1	S1	S2
Design	unshielded	unshielded	shielded	shielded
Measuring range	0.5mm	1mm	1mm	2mm
Offset distance	0.05mm	0.1mm	0.1mm	0.2mm
Linearity	$\leq \pm 1.25\mu\text{m}$	$\leq \pm 2.5\mu\text{m}$	$\leq \pm 2.5\mu\text{m}$	$\leq \pm 5\mu\text{m}$
Resolution	$0.025\mu\text{m}$	$0.05\mu\text{m}$	$0.05\mu\text{m}$	$0.1\mu\text{m}$
Repeatability	$0.05\mu\text{m}$	$0.1\mu\text{m}$	$0.1\mu\text{m}$	$0.2\mu\text{m}$
Temperature stability (MMR)	$\leq \pm 0.125\mu\text{m}/^\circ\text{C}$	$\leq \pm 0.25\mu\text{m}/^\circ\text{C}$	$\leq \pm 0.25\mu\text{m}/^\circ\text{C}$	$\leq \pm 0.5\mu\text{m}/^\circ\text{C}$
Integrated cable/ length	0.25m	3m	3m	-
Temperature sensor cable	180°C	180°C	180°C	-
Housing material	stainless steel and ceramic	stainless steel and plastic	stainless steel and plastic	stainless steel and plastic

MMR = midrange

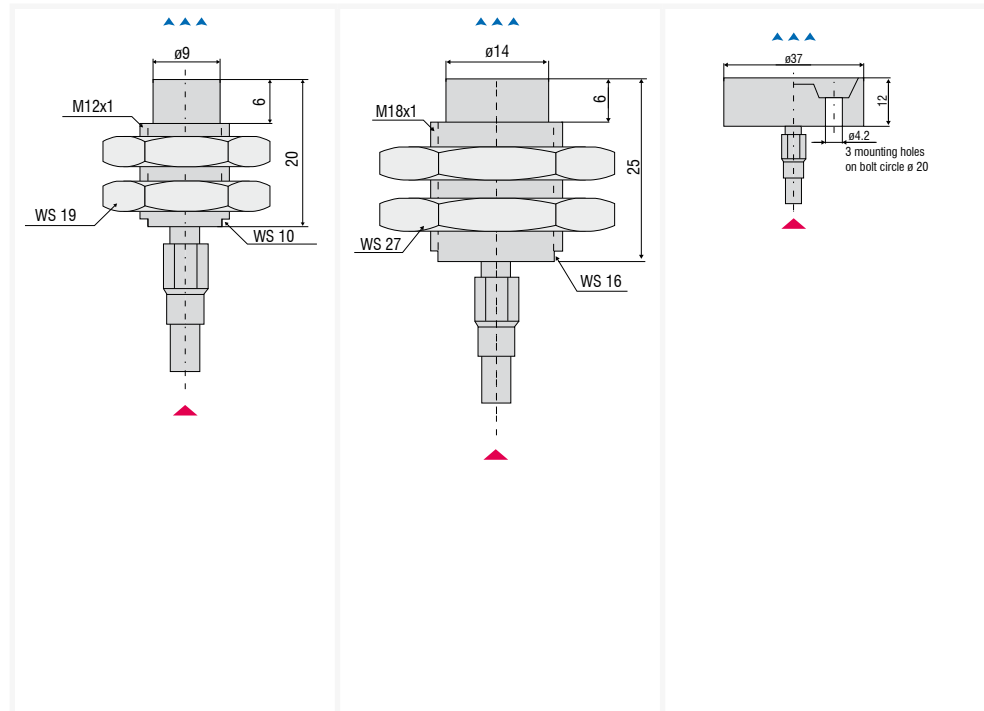
Connecting cable C3; C6 for sensors U05, S2, U3, U6, U15



Connecting cable C3/90; C6/90 for sensors U05, S2, U3, U6, U15

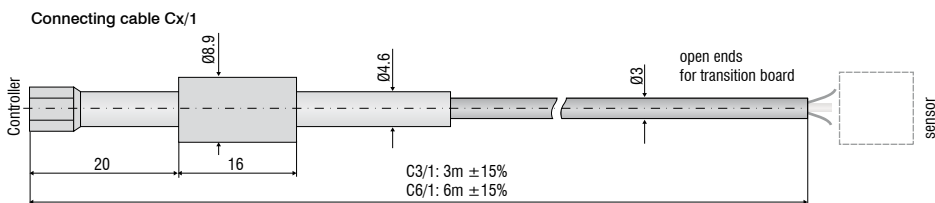


▲▲▲▲
Measurement direction
▲
Connector side



Sensor type	U3	U6	U15
Design	unshielded	unshielded	unshielded
Measuring range	3mm	6mm	15mm
Offset distance	0.3mm	0.6mm	1.5mm
Linearity	$\leq \pm 7.5\mu\text{m}$	$\leq \pm 15\mu\text{m}$	$\leq \pm 37.5\mu\text{m}$
Resolution	$0.15\mu\text{m}$	$0.3\mu\text{m}$	$0.75\mu\text{m}$
Repeatability	$0.3\mu\text{m}$	$0.6\mu\text{m}$	$1.5\mu\text{m}$
Temperature stability (MMR)	$\leq \pm 0.75\mu\text{m}/^\circ\text{C}$	$\leq \pm 1.5\mu\text{m}/^\circ\text{C}$	$\leq \pm 3.75\mu\text{m}/^\circ\text{C}$
Integrated cable/ length	-	-	-
Temperature sensor cable	-	-	-
Housing material	stainless steel and plastic	stainless steel and plastic	epoxy

MMR = midrange



Cable Cx / Cx1 / Cx/90

Cable design
Sheath material
Temperature resistance
Outer diameter
Bending radius

coaxial with sheath wire
FEP/Flour-Thermoplast
-50°C to +200°C
2.95mm $\pm 0.05\text{mm}$
one-time bending during installation: 2 x cable diameter
minimum bending radius for movement: 5 x cable diameter
optimum bending radius at continuous movement: 10 x cable diameter
no

Suitable for use with robots

Plug

Type
Locking method
Protection class
Temperature resistance
Material housing
Mechanical service life

Sensor side/Controller side

female connector, coaxial, SMC
screw
no details
-65 to +165°C
brass nickel-plated
> 500 mating cycles



- Easy sensor replacement
- Configuration via web browser
- High temperature stability, resolution and linearity
- Bandwidth 25 kHz (-3dB)
- Multi channel applications: synchronisation of up to 10 controller

System design

The eddyNCDT 3100 includes an extremely compact controller and a displacement sensor. The sensors are connected through a 3m or 9m integrated, highly flexible cable and connected to the controller by a user-friendly push-pull plug-in connection.

The controller housing is made from solid cast aluminium and is protected to IP65. Alternative mounting options are slot nuts, mounting holes or a mounting rail. The robust sensors make the eddyNCDT 3100 system ideally suited to measurement tasks in the industrial environment.

Versatile in application

The eddyNCDT 3100 series is the new generation of eddy current displacement measurement systems. The measurement system uses a patented temperature compensation method to provide firstclass stability even with fluctuating temperatures. These sensors are an excellent choice when you need high precision in harsh industrial environments (pressure, dust, temperature).

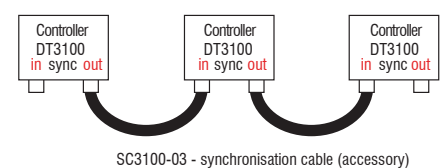
Sensors and cables come with an integrated memory module that stores all the major sensor and cable data. All sensors are factory calibrated to adjust to ferromagnetic and non-ferromagnetic materials.

Multi-channel synchronisation

In the case that more sensors of the series eddyNCDT 3100 are operated next to each other, an influence due to a hardly different oscillator frequency (beat frequency) is possible. This can be avoided by synchronisation. The eddyNCDT 3100-SM is equipped with two additional connectors for the oscillator output („SYNC OUT“) and for the input („SYNC IN“). The electronics is working independently until a connection is built. By means of the connections with the synchronisation cable SC3100-0,3, the electronics switch automatically to synchronisation mode. In this way, two up to ten systems can be synchronised with each other.



All settings are made in the intuitive web interface, eliminating the need for any special software.



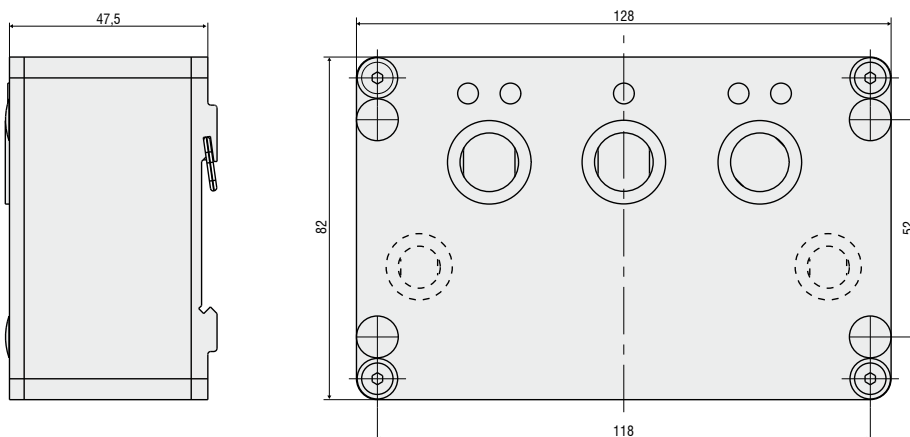
Controller		DT3100
Linearity		$< \pm 0.25 \% \text{ FSO}$
Resolution ¹⁾		$0.005 \% \text{ FSO}$
Bandwidth		voltage output: 25kHz (-3dB)
		digital (Ethernet): 14.4kHz; 7.2kHz; 3.6kHz (each 16 bit)
Temperature compensation range		standard: 10 ... 65 °C
Temperature range	controller	operation: 10 ... 50 °C
Temperature stability	controller (MMR)	$0.05 \% \text{ FSO} / ^\circ\text{C}$
Outputs		0 ... 10 V / - 5 ... + 5 V / 4 ... 20 mA / Ethernet
Power supply		24 VDC (11 ... 30V) / ca. 5W
Synchronisation	only DT3100-SM	via cable SC 3100-0,3 (accessories)
Protection class	controller	IP65 (connected plug-in connections/covers)

FSO = of full scale output

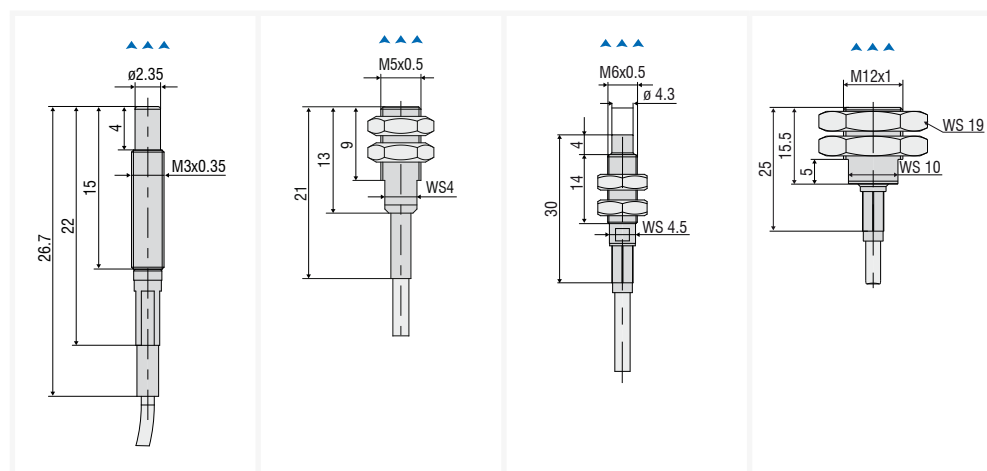
MMR = midrange

¹⁾ Static resolution, relates to centre of measuring range; effective value (RMS)

Controller housing DT3100 / DT3100-SM

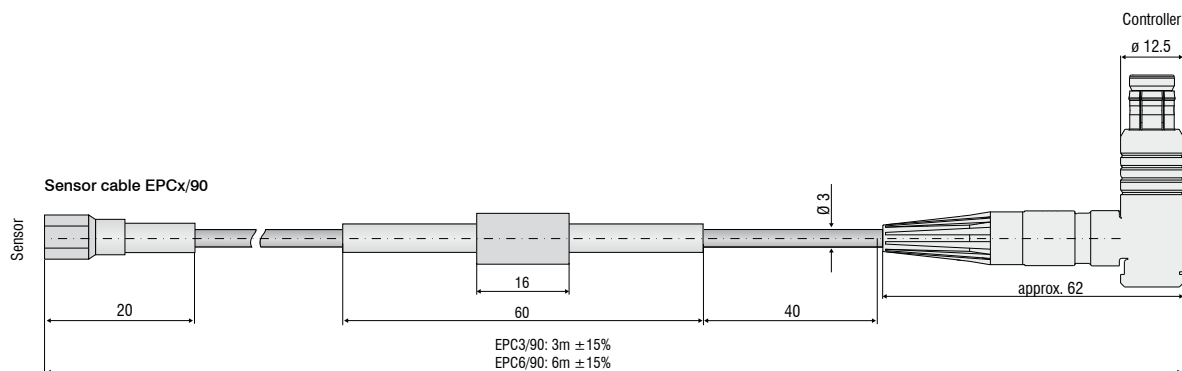
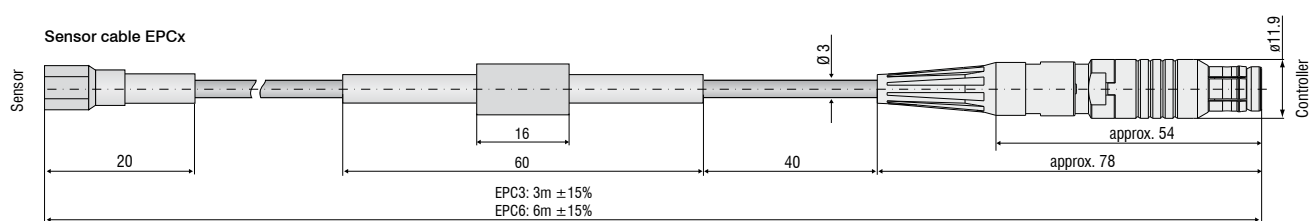


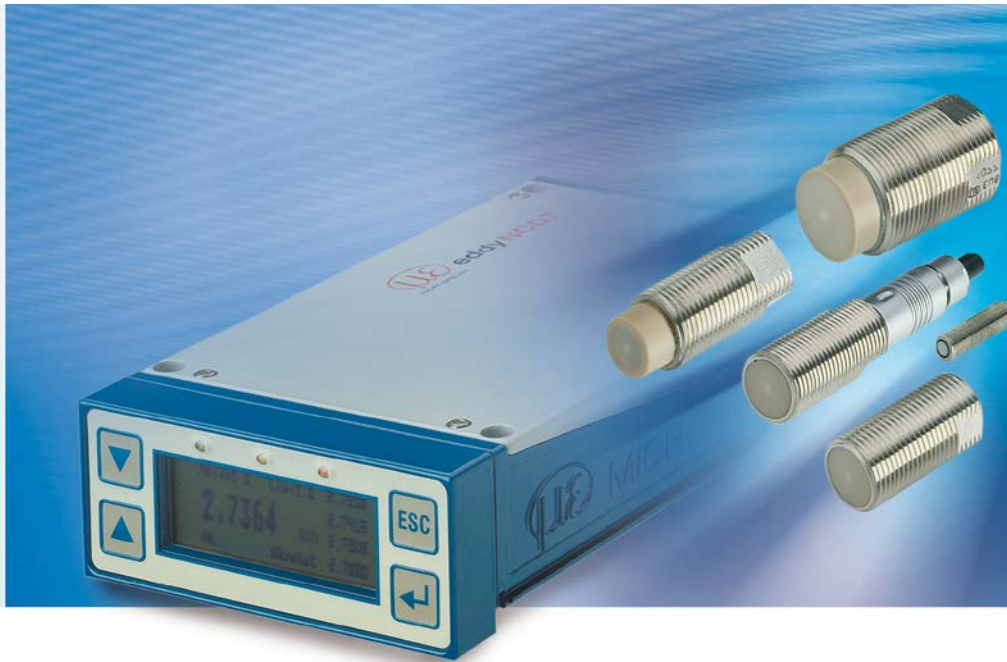
▲▲▲▲
Measurement direction



Sensor type	EPU05	EPS08	EPU1	EPS2
Design	unshielded	shielded	unshielded	shielded
Measuring range	0.5mm	0.8mm	1mm	2mm
Offset distance	0.05mm	0.08mm	0.1mm	0.2mm
Linearity	$\leq \pm 1.25\mu\text{m}$	$\leq \pm 2\mu\text{m}$	$\leq \pm 2.5\mu\text{m}$	$\leq \pm 5\mu\text{m}$
Resolution	$0.025\mu\text{m}$	$0.04\mu\text{m}$	$0.05\mu\text{m}$	$0.1\mu\text{m}$
Temperature stability (MMR)	$\leq \pm 0.25\mu\text{m}/^{\circ}\text{C}$	$\leq \pm 0.4\mu\text{m}/^{\circ}\text{C}$	$\leq \pm 0.5\mu\text{m}/^{\circ}\text{C}$	$\leq \pm 1\mu\text{m}/^{\circ}\text{C}$
Temperature max.	100°C	100°C	100°C	100°C
Protection class (front and rear)	IP67	IP67	IP67	IP67
Integrated cable/ length	3m	3m	3m/9m	3m/9m
Temperature sensor cable	100°C	100°C	100°C	100°C
Housing material	stainless steel and ceramic	stainless steel and plastic	stainless steel and plastic	stainless steel and plastic

MMR = midrange





- Micrometer accuracy
- Ideal for fast measurements:
Bandwidth up to 100kHz (-3dB)
- Numerous sensor models even for customer-specific applications
- Robust sensor construction for harsh environments
- Synchronised multi-channel measurement

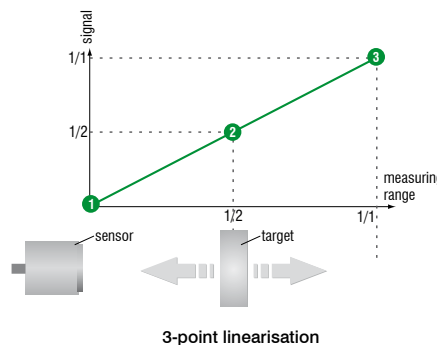
The eddyNCDT 3300 eddy current measuring system is one of the most flexible and highest performing eddy current displacement measurement systems worldwide. Due to a mature technical design, the system offers numerous benefits to customers in multiple application areas such as manufacturing automation, machine monitoring and quality control.

Multifunctional controller

The eddyNCDT 3300 system includes high-performance processors for reliable signal conditioning and further processing. The innovative three-point linearisation technique it uses enables almost completely automatic linearisation which makes possible the optimum accuracies for every metallic measuring object and every installation environment. Operation is supported by an illuminated LC graphical display and on-screen prompts.

Linearisation and calibration

Systems in the eddyNCDT 3300 series can be individually linearised and calibrated by the user. Therefore, optimum measurement accuracies will always be achieved, even in the case of failed measuring object materials or harsh ambient conditions. The adjustment is made using three distance points (①, ②, ③) which are defined by a reference standard.

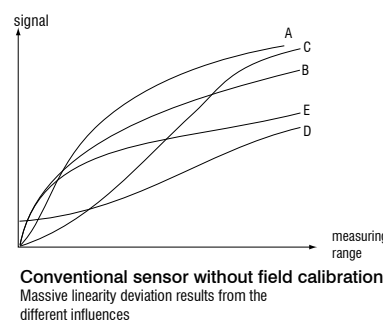


Maximum precision due to field calibration

In order to achieve maximum precision, eddyNCDT 3300 provides the field calibration function for achieving extremely precise measurement results. The following influences are taken into account:

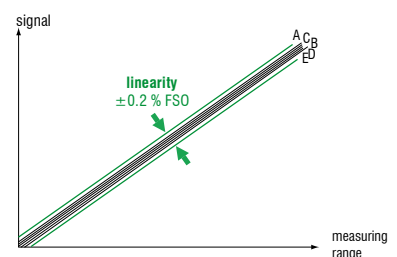
- A: Different target materials**
- B: Different target sizes (measuring spot)**
- C: Target shape**
- D: Side preattenuation**
- E: Target tilt angle**

The measuring range can also be extended using the field calibration.



Synchronisation for multi-channel applications

The MCT304 multi-channel platform is available for thickness and displacement measurements with up to four channels. Up to four controllers can be integrated in a single MCT platform. The platforms can be synchronised with each other, whereby the simultaneous operation of any number of eddyNCDT sensors is possible. In order to compensate for opposing sensor influences, there are synchronisation inputs and outputs.



Controller	DT3300	DT3301
Linearity	$\leq \pm 0.2\%$ FSO	
up to 25Hz	$\leq 0.005\%$ FSO ($\leq 0.01\%$ FSO using ES04, ES05 and EU05)	
Resolution ²⁾	up to 2.5kHz	$\leq 0.01\%$ FSO
up to 25 / 100kHz	$\leq 0.2\%$ FSO	
Bandwidth	selectable 25kHz / 2.5kHz / 25Hz (-3 dB); 100kHz for measuring ranges ≤ 1 mm	
Temperature compensation	10 ... 100°C (option TCS: -40 ... 180°C) ³⁾	
Temperature range	controller	5 ... 50°C
Outputs	selectable 0 ... 5V / 0 ... 10V / ± 2.5 V / ± 5 V / ± 10 V (or inverted) / 4 ... 20mA (load 350 ohm)	
Power supply	± 12 VDC / 100mA, 5.2VDC / 220mA ¹⁾	11 - 32VDC / 700mA
Synchronisation	via cable PSC 30 (accessories)	via cable E SC 30 (accessories)
Electromagnetic compatibility	acc. to EN 50081-2 / EN 61000-6-2	
Controller functions	limit switches, auto-zero, peak-to-peak, minimum, maximum, average, storage of 3 configurations (calibrations)	

FSO = Full Scale Output

Reference material: Aluminum (non-ferromagnetic) and Mild Steel DIN 1.0037 (ferromagnetic)

Reference temperature for reported data is 20°C (70°F); Resolution and temperature stability refer to midrange

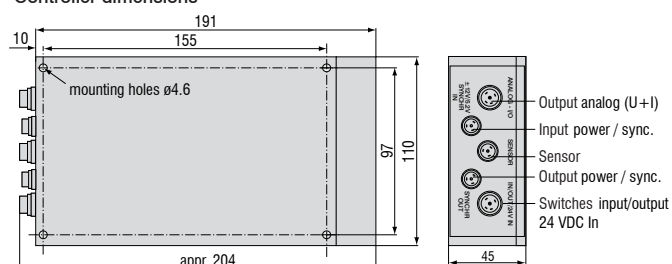
Data may differ with magnetic inhomogeneous material.

¹⁾ additional 24VDC for external reset and limit switch

²⁾ resolution data are based on noise peak-to-peak values

³⁾ temperature stability may differ with option TCS

Controller dimensions



Quadruple limit switch

- Two freely definable minimum and maximum limit values
- Individual switching threshold
- LED display for upper and lower limit warnings

Automatic calibration

- Three-point linearisation for optimum onsite calibration

Four configurations can be stored

- Factory calibration and three individual configurations can be stored
- Simple microprocessor-controlled singlecycle calibration

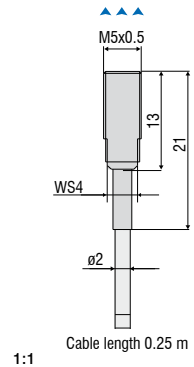
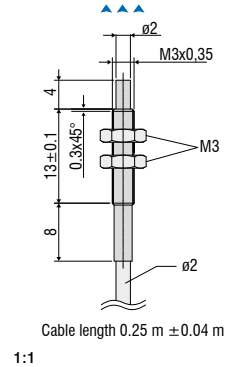
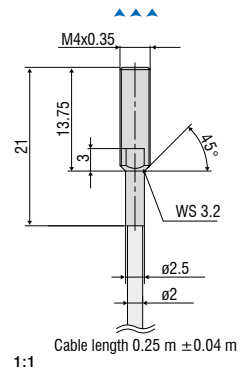


Types of output

- Voltage / current
- Metric / inch and graphical display
- Display of auto-zero, peak-to-peak value, minimum, maximum
- Scalable display for conversion to indirect measured values

▲▲▲▲
Measurement direction

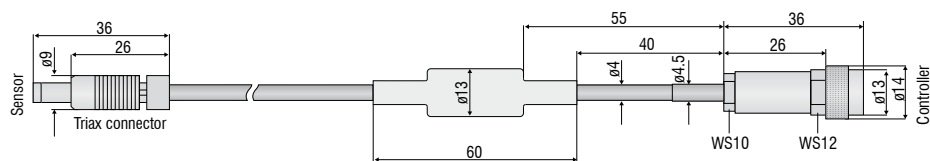
▲
Connector side



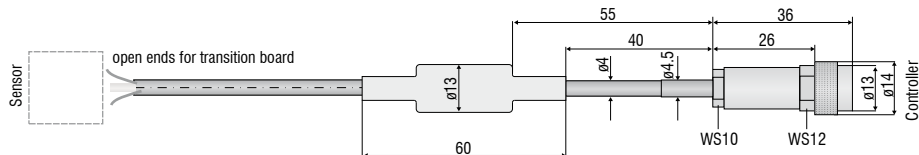
Sensor type	ES04	EU05	ES08
Design	shielded	unshielded	shielded
Measuring range	0.4mm	0.4mm	0.8mm
Offset distance	0.04mm	0.05mm	0.08mm
Linearity	$\leq \pm 0.8 \mu\text{m}$	$\leq \pm 1 \mu\text{m}$	$\leq \pm 1.6 \mu\text{m}$
Resolution	$0.02 \mu\text{m}$	$0.025 \mu\text{m}$	$0.04 \mu\text{m}$
Temperature stability (MMR)	$\leq \pm 0.06 \mu\text{m}/^\circ\text{C}$	$\leq \pm 0.075 \mu\text{m}/^\circ\text{C}$	$\leq \pm 0.12 \mu\text{m}/^\circ\text{C}$
Temperature max.	150°C	150°C	150°C
Pressure resistance sensor front	100bar	-	20bar
Integrated cable/ length	approx. 0.25m	approx. 0.25m	approx. 0.25m
Temperature sensor cable	180°C	180°C	180°C
Housing material	stainless steel	stainless steel and ceramic	stainless steel and plastic

MMR = midrange

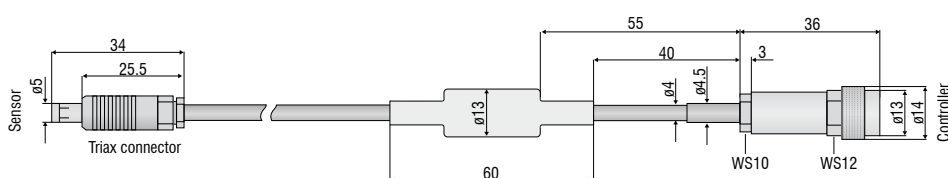
ECx sensor cable, length is selectable up to $x \leq 15\text{m}$



ECx/1 extension cable for solder connection, length is selectable up to $x \leq 15\text{m}$



ECx/2 extension cable for plug connection, length is selectable up to $x \leq 15\text{m}$





MMR = midrange

Cable

Cable design	coaxial with sheath wire
Sheath material	FEP/Flour-Thermoplast
Temperature resistance	-30°C to +200°C
Outer diameter	3.9mm $\pm$ 0.1mm
Bending radius	one-time bending during installation: 2 x cable diameter minimum bending radius for movement: 5 x cable diameter optimum bending radius at continuous movement: 10 x cable diameter
Suitable for use with robots	no

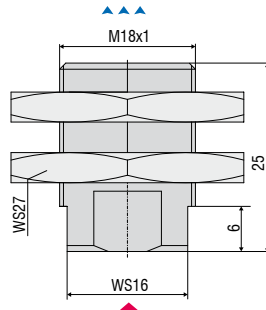
Suitable for use with robots

Plug Model

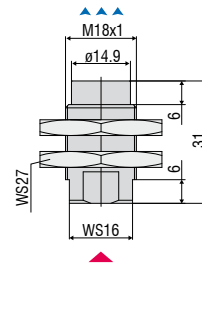
Type	5-pole female connector, cable socket	male connector, triaxial	male connector 5-pol	male connector, triaxial
Locking method	screw	push-pull	screw	push-pull
Protection class	IP67	IP67 (when connected)	IP67 (when connected)	IP68
Temperature resistance	-30 to +85°C	-30 to +150°C	-40 to +85°C	-65 to +135°C
Material housing	Brass nickel-plated	Brass nickel-plated, mat	Brass nickel-plated	Brass nickel-plated, mat
Mechanical service life	> 500 mating cycles	> 500 mating cycles	> 500 mating cycles	> 500 mating cycles

▲▲▲
Measurement direction

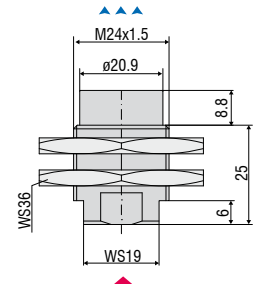
▲
Connector side



1:1



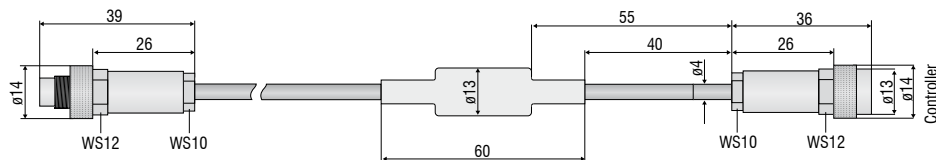
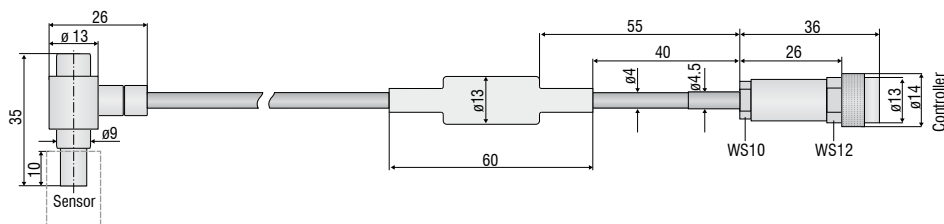
1:2



1:2

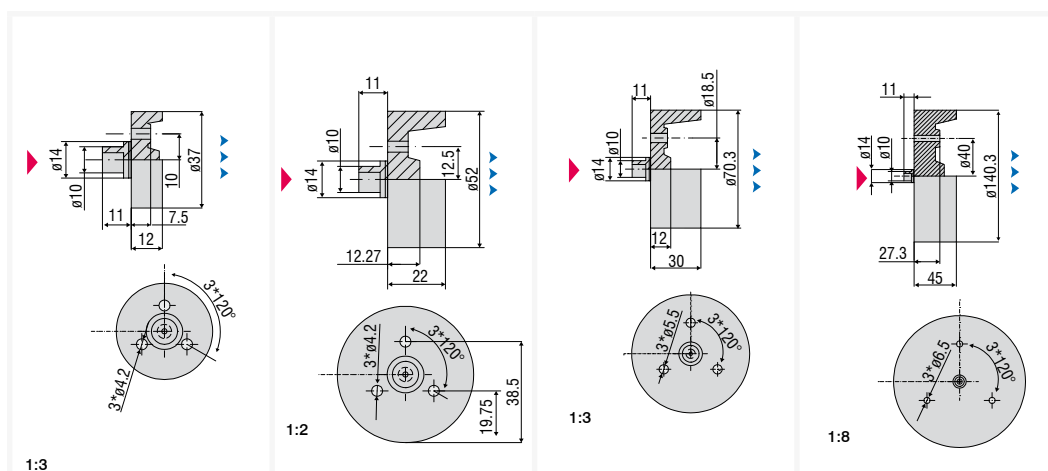
Sensor type	ES4	EU6	EU8
Design	shielded	unshielded	unshielded
Measuring range	4mm	6mm	8mm
Offset distance	0.4mm	0.6mm	0.8mm
Linearity	$\leq \pm 8\mu\text{m}$	$\leq \pm 12\mu\text{m}$	$\leq \pm 16\mu\text{m}$
Resolution	$0.2\mu\text{m}$	$0.3\mu\text{m}$	$0.4\mu\text{m}$
Temperature stability (MMR)	$\leq \pm 0.6\mu\text{m}/^\circ\text{C}$	$\leq \pm 0.9\mu\text{m}/^\circ\text{C}$	$\leq \pm 1.2\mu\text{m}/^\circ\text{C}$
Temperature max.	150°C	150°C	150°C
Pressure resistance sensor front	20bar	20bar	20bar
Integrated cable/ length	-	-	-
Temperature sensor cable	-	-	-
Housing material	stainless steel and plastic	stainless steel and plastic	stainless steel and plastic

MMR = midrange

ECEx sensor cable extension, length is selectable up to $x \leq 15$ mECx/90 sensor cable with 90° connector (sensor-sided), length is selectable up to $x \leq 15$ m

▲▲▲▲
Measurement direction

▲
Connector side



Sensor type	EU15	EU22	EU40	EU80
Design	unshielded	unshielded	unshielded	unshielded
Measuring range	15mm	22mm	40mm	80mm
Offset distance	1.5mm	2.2mm	4mm	8mm
Linearity	$\leq \pm 30\mu\text{m}$	$\leq \pm 44\mu\text{m}$	$\leq \pm 80\mu\text{m}$	$\leq \pm 160\mu\text{m}$
Resolution	$0.75\mu\text{m}$	$1.1\mu\text{m}$	$2\mu\text{m}$	$4\mu\text{m}$
Temperature stability (MMR)	$\leq \pm 2.25\mu\text{m}/^\circ\text{C}$	$\leq \pm 3.3\mu\text{m}/^\circ\text{C}$	$\leq \pm 6\mu\text{m}/^\circ\text{C}$	$\leq \pm 12\mu\text{m}/^\circ\text{C}$
Temperature max.	150°C	150°C	150°C	150°C
Pressure resistance sensor front	-	-	-	-
Integrated cable/ length	-	-	-	-
Temperature sensor cable	-	-	-	-
Housing material	epoxy	epoxy	epoxy	epoxy

MMR = midrange

Cable

Cable design	coaxial with sheath wire
Sheath material	FEP/Flour-Thermoplast
Temperature resistance	-30°C to +200°C
Outer diameter	3.9mm $\pm$ 0.1mm
Bending radius	one-time bending during installation: 2 x cable diameter minimum bending radius for movement: 5 x cable diameter optimum bending radius at continuous movement: 10 x cable diameter
Suitable for use with robots	no

Plug Model

Type	5-pole female connector, cable socket
Locking method	screw
Protection class	IP67
Temperature resistance	-30 to +85°C
Material housing	Brass nickel-plated
Mechanical service life	> 500 mating cycles

Controller side

Type	5-pole male connector
Locking method	screw
Protection class	IP67 (when connected)
Temperature resistance	-30 to +85°C
Material housing	Brass nickel-plated
Mechanical service life	> 500 mating cycles

Sensor side

Type	5-pole male connector
Locking method	screw
Protection class	IP67 (when connected)
Temperature resistance	-30 to +85°C
Material housing	Brass nickel-plated
Mechanical service life	> 500 mating cycles

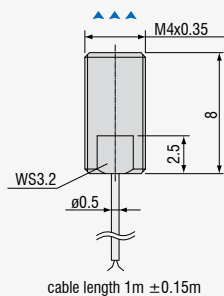
ECx/90

Type	male connector, triaxial, angle
Locking method	push-pull
Protection class	IP67 (when connected)
Temperature resistance	-65 to +135°C
Material housing	Brass nickel-plated, mat
Mechanical service life	> 500 mating cycles



Subminiature sensors for confined installation space

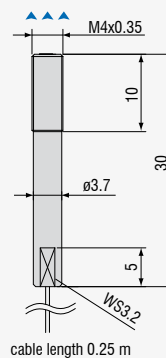
In addition to standard sensors in conventional designs, miniature sensors can also be supplied which achieve high precision measurement results with the smallest possible dimensions. Pressure-resistant versions, screened housings, ceramic types and other special features characterise these sensors, which achieve highly accurate measurement results despite the small dimensions. The miniature sensors are employed in high pressure applications, e.g. in combustion engines.



ES04/180(25) Shielded Sensor

Measuring range 0.4mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^\circ\text{C}$
 Connection: integrated coaxial cable 1m ($\varnothing 0.5\text{mm}$), short silicon tube at cable exit
 Pressure resistance (static): front 100bar
 Max. operating temperature: 180°C
 Housing material: stainless steel
 Sensor cable: ECx/1 or ECx/2, length $\leq 6\text{m}$

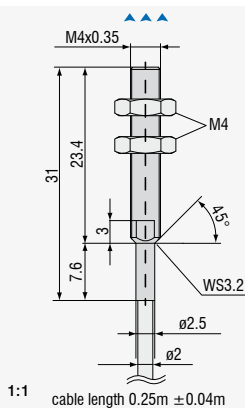
2:1



ES04/180(27) Shielded Sensor

Measuring range 0.4mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^\circ\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 0.5\text{mm}$) with solder connection board
 Pressure resistance (static): front 100bar
 Max. operating temperature: 180°C
 Housing material: stainless steel
 Sensor cable: ECx/1, length $\leq 6\text{m}$

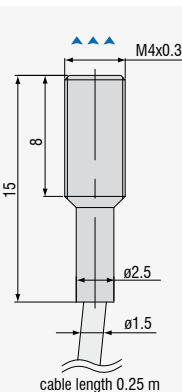
1:1



ES04(34) Shielded Sensor

Measuring range 0.4mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^\circ\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 2\text{mm}$) with sealed triaxial connector
 Pressure resistance (static): front 100bar / rear side splash water
 Max. operating temperature: 150°C
 Housing material: stainless steel and ceramic
 Sensor cable: ECx, length $\leq 6\text{m}$

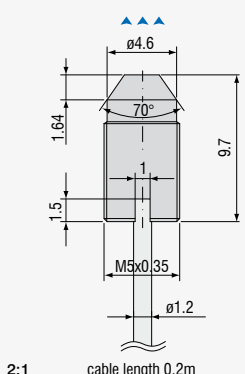
1:1



ES04(35) Shielded Sensor

Measuring range 0.4mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^\circ\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 1.5\text{mm}$) with sealed triaxial connector
 Pressure resistance (static): front 100bar / rear side 5 bar
 Max. operating temperature: 150°C
 Housing material: stainless steel and ceramic
 Sensor cable: ECx/1, length $\leq 6\text{m}$

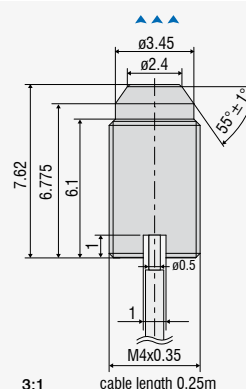
2:1



ES04(44) Shielded Sensor

Measuring range 0.4mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^\circ\text{C}$
 Connection: integrated coaxial cable 0.2m ($\varnothing 1.2\text{mm}$) with sealed triaxial connector
 Pressure resistance (static): front 100bar / rear side splash water
 Max. operating temperature: 150°C
 Housing material: stainless steel and ceramic
 Sensor cable: ECx, length $\leq 6\text{m}$

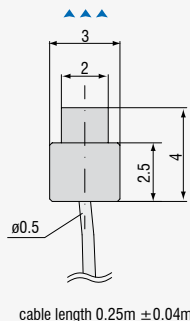
2:1



ES04(70) Shielded Sensor

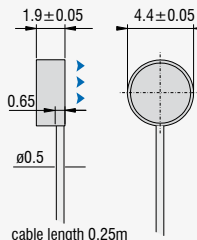
Measuring range 0.4mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^\circ\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 0.5\text{mm}$) with solder connection board
 Pressure resistance (static): front 100bar / rear side splash water
 Max. operating temperature: 150°C
 Housing material: stainless steel and ceramic
 Sensor cable: ECx/1, length $\leq 6\text{m}$

3:1

**EU05(10) Unshielded Sensor**

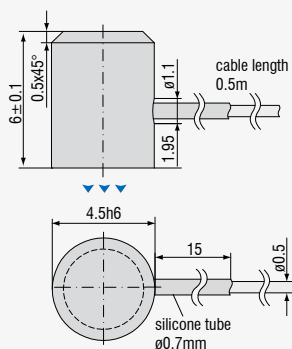
Measuring range 0.5mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^{\circ}\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 0.5\text{mm}$) with solder connection board
 Max. operating temperature: 150°C
 Housing material: stainless steel and ceramic
 Sensor cable: ECx/1, length $\leq 6\text{m}$

3:1

**ES05/180(16) Shielded Sensor**

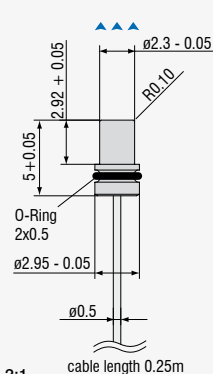
Measuring range 0.5mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^{\circ}\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 0.5\text{mm}$) with solder connection board
 Max. operating temperature: 180°C
 Housing material: stainless steel and epoxy
 Sensor cable: ECx/1, length $\leq 6\text{m}$

3:1

**ES05(36) Shielded Sensor**

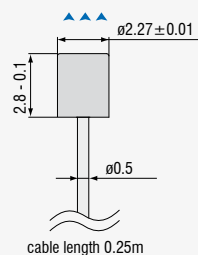
Measuring range 0.5mm
 Connection: integrated coaxial cable 0.5m ($\varnothing 0.5\text{mm}$) with solder connection board
 Max. operating temperature: 150°C
 Housing material: stainless steel and epoxy
 Sensor cable: ECx/1, length $\leq 6\text{m}$

3:1

**EU05(65) Unshielded Sensor**

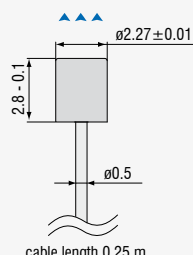
Measuring range 0.5mm
 Connection: integrated coaxial cable 0.25m ($\varnothing 0.5\text{mm}$) with solder connection board
 Pressure resistance (static): front 700bar / rear side splash water
 Max. operating temperature: 150°C
 Housing material: ceramic
 Sensor cable: ECx/1, length $\leq 6\text{m}$

2:1

**EU05(66) Unshielded Sensor**

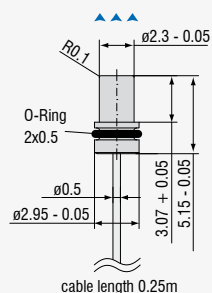
Measuring range 0.5mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^{\circ}\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 0.5\text{mm}$) with solder connection board
 Pressure resistance (static): front 400bar / rear side splash water
 Max. operating temperature: 150°C
 Housing material: ceramic
 Sensor cable: ECx/1, length $\leq 6\text{m}$

3:1

**EU05(72) Unshielded Sensor**

Measuring range 0.4mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^{\circ}\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 0.5\text{mm}$) with solder connection board
 Pressure resistance (static): front 2000bar / rear side splash water
 Max. operating temperature: 150°C
 Housing material: ceramic
 Sensor cable: ECx/1, length $\leq 6\text{m}$

3:1

**EU05(93) Unshielded Sensor**

Measuring range 0.4mm
 Temperature stability $\leq \pm 0.025\% \text{FSO}/^{\circ}\text{C}$
 Connection: integrated coaxial cable 0.25m ($\varnothing 0.5\text{mm}$) with solder connection board
 Pressure resistance (static): front 2000bar / rear side splash water
 Max. operating temperature: 150°C
 Housing material: ceramic
 Sensor cable: ECx/1, length $\leq 6\text{m}$

2:1



- Maximum speed range from 200 to 400,000 RPM
- Miniature sensor design from $\varnothing 3\text{mm}$
- Measurement on aluminium and titanium
- Distance to target up to 2.2mm
- No modification of the compressor wheel
- For test cell and on-vehicle measurements
- Highest EMV immunity and stability
- Operating temperature up to 285°C

Measuring principle

A coil is integrated in a sensor housing and energised by a high-frequency alternating current. The electromagnetic field from the coil generates eddy currents in the turbocharger blade, while every blade generates a pulse. The controller identifies the speed (analogue 0–5V) by considering the number of blades.

Robust miniature controller

As the entire electronics is in a sealed miniature housing and designed for ambient temperatures up to 115°C, the controller is easy to integrate into the engine compartment. turboSPEED DZ140 offers excellent EMV immunity in test cells and road tests.

Reliable speed and temperature measurement

The DZ140 eddy current measuring system is resistant to oil and dirt, which is a key advantage compared to optical speed measuring systems, as this helps to achieve high precision measurements on a continuous basis.

Ease of use

A tri-colour 'status' LED on the controller indicates when the sensor has reached the ideal distance from the turbocharger blades. This simple feature enables greatly reduced installation time. As the sensor is connected with the electronics via a special BNC connector, it is therefore downward compatible with all previous sensor models. An industrial push-pull connector guarantees a reliable connection between the electronics and the power supply as well as the analogue outputs.

Measurement of aluminium and titanium blades

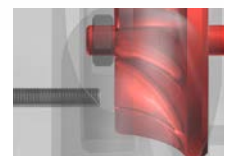
The DZ140 measures both aluminium and titanium blades. The sensors can be mounted at a relatively large distance from the blade. The maximum distance of 2.2mm enables reliable operation.



Extremely compact design



Large measuring distances both at aluminium and titanium



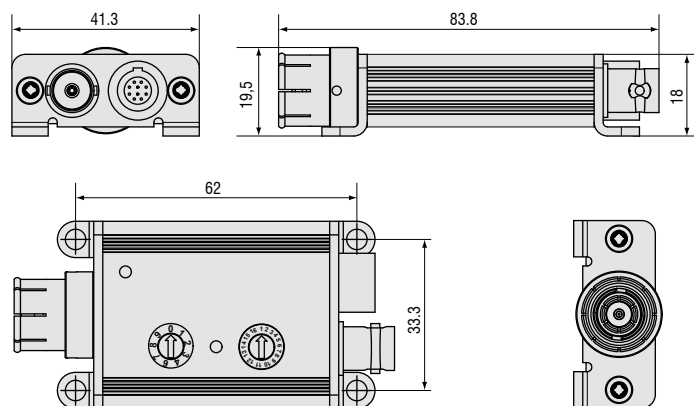
axial installation



radial installation

Model		DZ140 (Controller)							
Sensors		DS 05(03)	DS 05(04)	DS 05(07)	DS 05(14)	DS 05(15)	DS 1	DS 1(04)	DS 1/T
Measuring principle		eddy current principle							
Target (blade material)		aluminium or titanium							
Maximum speed range (measuring range)		200 ... 400,000RPM							
Operating temperature	controller	-20 ... +115°C							
	sensor	-40 ... +235°C (short-term +285°C)							
Distance sensor to blade (wall thickness 0.35mm)	aluminium	radial 0.6mm / axial 1.1mm					radial 1.3mm / axial 1.6mm		
	titan	radial 0.6mm / axial 1.0mm					radial 1.2mm / axial 1.6mm		
		adjustment with three-state LED							
Integral sensor cable		0.5m ±0.15m					0.75m ±0.15m	0.8m ±0.15m	
Number of blades		rotary switch (accessible from the outside) for 1 up to 16 blades							
Output (digital)		1 pulse / blade (TTL-level, variable pulse duration) or 1 pulse / revolution (TTL-level, pulse duration 100µs)							
Output (analogue)		0 ... 5V (200 ... 200,000RPM) 0 ... 5V (200 ... 400,000RPM) adjustable, from the outside accessible via mode rotary switch							
	linearity	±0.2% FSO							
	resolution	0.1% FSO							
		test pulse generation to control the measurement chain; load resistance >5kOhm, load capacitance max. 1nF							
RAW output (via BNC connector)		for easy sensor mounting via oscilloscope							
Power supply		9V ... 30VDC / max. 50mA (short-term up to 36VDC)							
Cable		PC140-3 supply and output cable 3m							
		PC140-6 supply and output cable 6m							
Weight		controller DZ140: appr. 85g							
Protection class		controller DZ140: IP 65							

FSO = Full Scale Output

Controller DZ140

Technical drawing of the DS 05(03) sensor. The sensor cable has a diameter of approximately 3.5mm and a length of 0.5m (±0.15m) with a BNC connector. The housing is curved with a 45°±3° angle. The cable is labeled 'WS4' and 'approx. 10'.

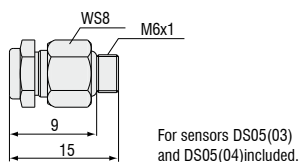
Technical drawing of the DS 05(04) sensor. The sensor cable has a diameter of approximately 3.5mm and a length of 0.5m (±0.15m) with a BNC connector. The housing is straight with a length of 67.8mm and a diameter of Ø3. The cable is labeled 'WS4' and 'approx. 10'.

Technical drawing of the DS 05(07) sensor. The sensor cable has a diameter of approximately 3.5mm and a length of 0.5m (±0.15m) with a BNC connector. The housing is straight with a length of 67.8mm and a diameter of Ø3. The cable is labeled 'WS4' and 'approx. 10'.

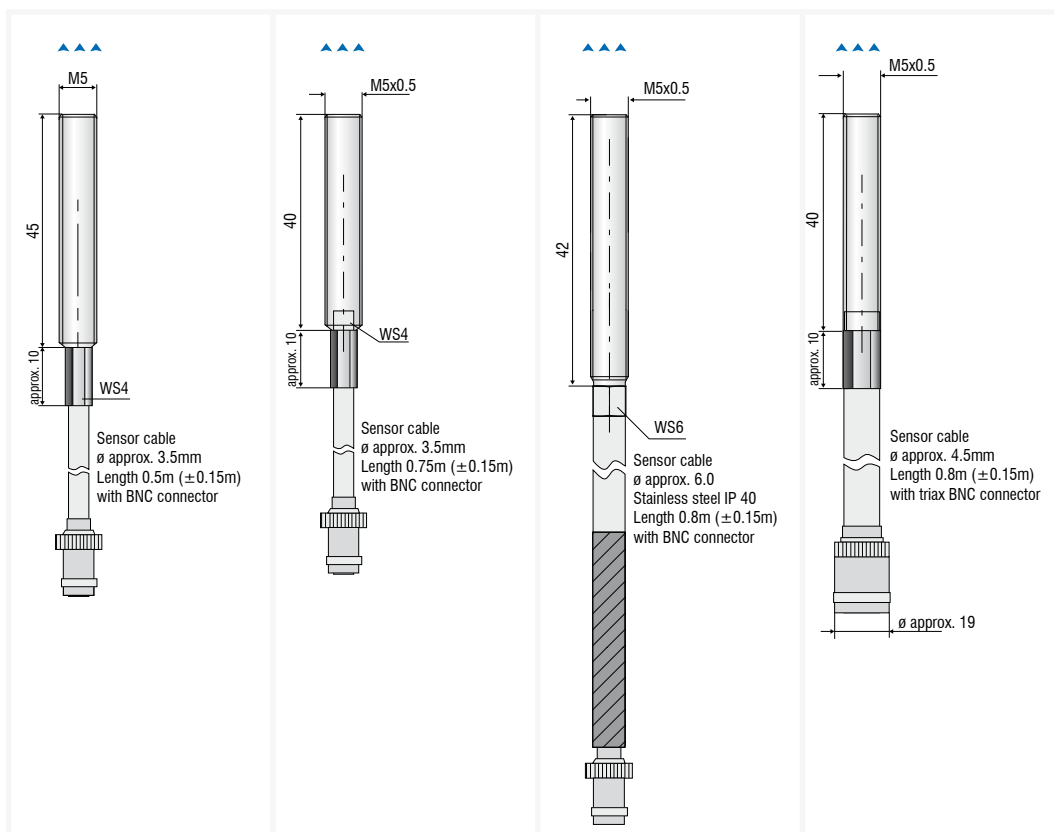
Technical drawing of the DS 05(14) sensor. The sensor cable has a diameter of approximately 3.5mm and a length of 0.5m (±0.15m) with a BNC connector. The housing is straight with a length of 28mm and a diameter of Ø3. The cable is labeled 'WS4' and 'approx. 10'.

Sensor type	DS 05(03)	DS 05(04)	DS 05(07)	DS 05(14)
Measuring range	0.5mm	0.5mm	0.5mm	0.5mm
Thread length	-	-	45mm	28mm
Thread	-	-	M5 x 0.8	M5 x 0.8
Integrated cable/ length	0.5m	0.5m	0.5m	0.5m
Special feature	curved housing	-	-	length of housing 42.5 mm

Mounting adapter MA135



▲▲▲▲
Measurement direction



Sensor type	DS 05(15)	DS 1	DS 1(04)	DS 1/T
Measuring range	0.5 mm	1mm	1 mm	1mm
Thread length	45mm	40mm	40mm	40mm
Thread	M5 x 0.8	M5 x 0.5	M5 x 0.5	M5 x 0.5
Integrated cable/ length	0.5m	0.75m	0.8m	0.8m
Special feature	-	-	stainless steel protection hose	-



- Miniature sensor design
- Sensor technology can be integrated completely into the sensor
- Miniature, compact controller – can be integrated in the spindle or installed on the housing via a flange
- Suitable for ferro- and non-ferromagnetic materials
- Temperature measurement integrated in the sensor
- Cost-effective design

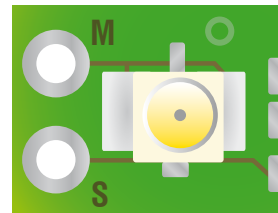
Measuring thermal expansion in spindles

The displacement measurement system SGS 4701 (Spindle Growth System) has been developed specifically for high speed milling machine applications. Due to high machining speeds and the heat generated, the linear thermal expansion of the precision machine tool spindle needs to be compensated for in order to keep the tool in a defined position at all times. The SGS sensor measures the thermal and centrifugal force expansion of the spindle. These measurement values are fed into the CNC machine tool as correction values, compensating for any positioning errors.

The SGS 4701 operates on the eddy current measuring principle. This non-contact measurement is wear-free. Furthermore, the measurement procedure is resistant to disturbances such as heat, dust and oil.

System structure

The SGS 4701 consists of a sensor, a sensor cable and a controller, factory calibrated for ferromagnetic and non-ferromagnetic measurement objects. Two miniature sensors enable it to be installed directly in the spindle, where the measurements take place, typically on the labyrinth-ring of the spindle. As well as measuring linear thermal expansion, the temperature of the sensor is also detected and output. The compact controller can be installed on the spindle housing via a flange or directly in the spindle.

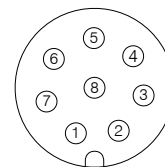


The sensor cable must not be shortened as functionality loss may arise. Removing the connector is only permitted behind the plug-sided crimp when using the solder connections.

S = Signal = inner conductor

M = ground = shield = outer conductor

8-pin. M12 connector



Pin assignment (view on controller)

Pin	Signal
1	Ground
2	+24V
3	Displacement signal
4	Temperature signal
5	not connected
6	do not connect
7	do not connect
8	not connected

Sensor system		SGS4701
Measuring range		500 μ m (option 250 μ m ²⁾)
Offset		100 μ m (option 50 μ m ²⁾)
Linearity		$\pm 2\mu$ m
Resolution ¹⁾		0.5 μ m
Bandwidth		2000Hz
Target		ferromagnetic / non-ferromagnetic
Minimum target diameter		6 mm (option 3.5 mm ²⁾)
Operating temperature	sensor	0 ... +90°C
	controller	10 ... +70°C
Temperature stability	sensor	± 150 ppm FSO/°C (MMR)
	controller	± 500 ppm FSO/°C (MMR)
Temperature compensation range	sensor	+10 ... +80°C
	controller	+10 ... +70°C
Supply voltage		12 ... 32VDC
Analog out	displacement	0.5 - 9.5V $\pm$ 100 - 600 μ m (option 50 - 300 μ m ²⁾)
	temperature	0.5 - 9.5V ($\pm$ 0 ... +90°C)
Protection class	sensor / controller	IP67 ³⁾
Dimensions	EMU04(102)	12x10x4.5mm ⁴⁾
	EMU04(121)	10x4x4mm ⁴⁾
Sensor cable ³⁾	diameter	$\varnothing$ 1.13mm
	length	1000mm (400 - 1500mm on request)
	min. bending radius	12mm
	jacket	FEP

FSO = Full Scale Output; MMR = Midrange

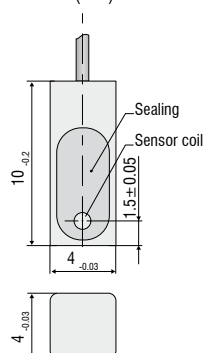
¹⁾ static, MMR

²⁾ For OEM modifications: sensor with measuring range 250 μ m and offset 50 μ m

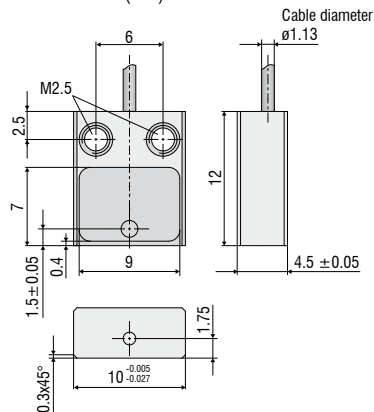
³⁾ In mated condition

⁴⁾ Detailed cable specifications can be found in the operating manual

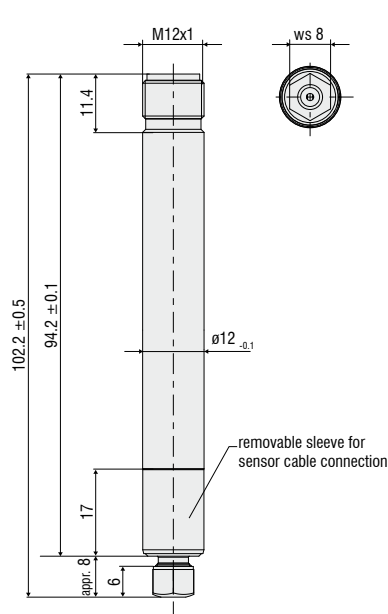
EMU04(121)



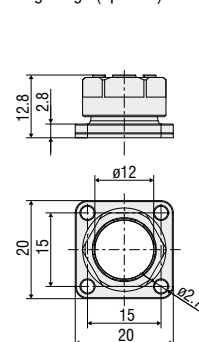
EMU04(102)



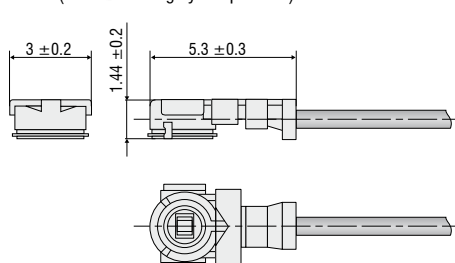
Controller



Mounting flange (optional)

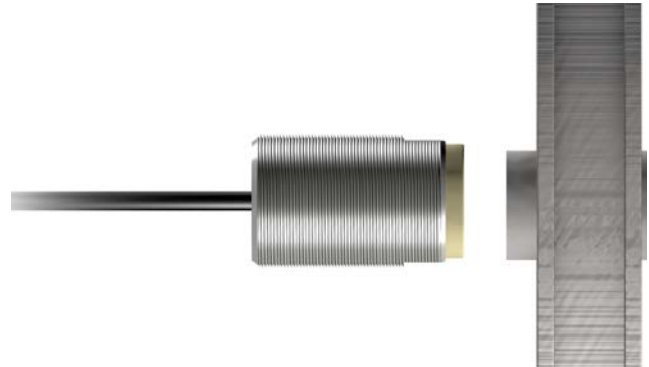


Connector (max. 20 mating cycles possible)

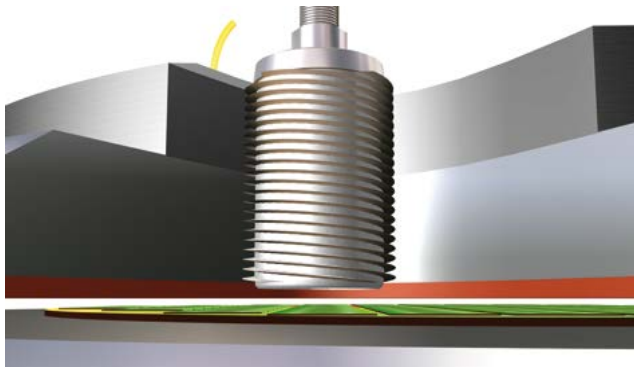


Eddy current sensors from Micro-Epsilon have many possible areas of application. High measurement accuracy and bandwidth together with an extremely robust design enable measurements where conventional sensors are not applicable.

Eddy current sensors from Micro-Epsilon represent high-performance measurement, particularly under extreme operating conditions. Environmental influences such as oil, temperature, pressure and moisture are largely compensated for and have a minimal effect on the signal. For this reason, the sensors are ideal in challenging application areas, such as industrial mechanical engineering and automotive inspection systems.



Measuring the axial shaft oscillation



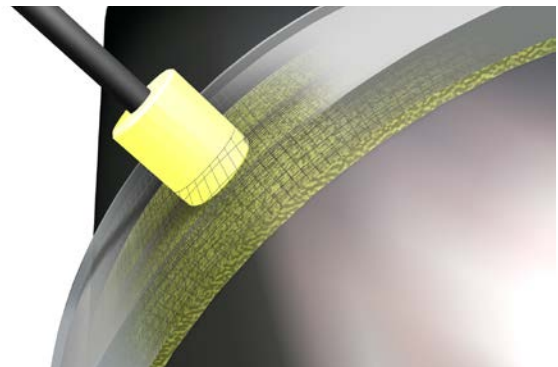
Position measurement for machine monitoring



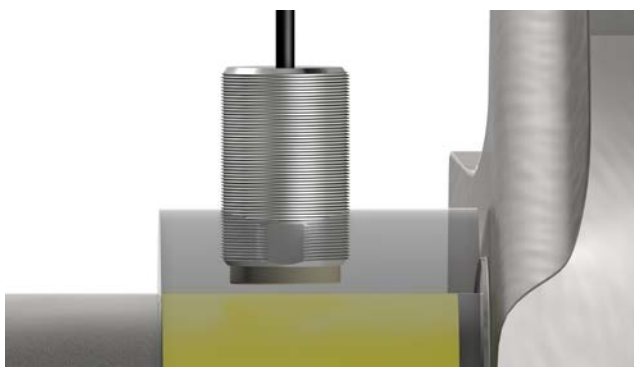
Measuring the thermal expansion



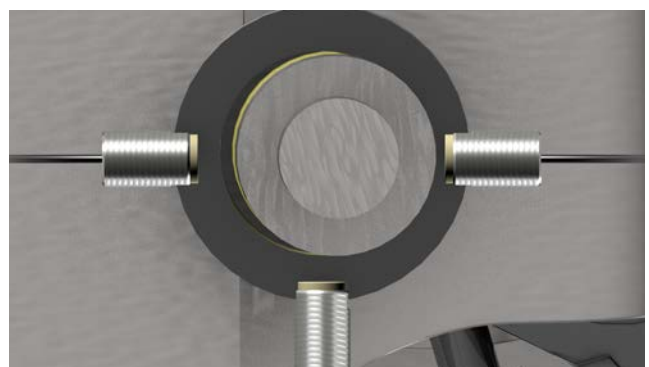
Monitoring the lubricating gap in the combustion engine



Measurement of oil film thickness



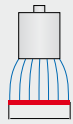
Run-out monitoring of rollers



Measuring the radial shaft expansion

Article	Description	eddyNCDT 3001	eddyNCDT 3005	eddyNCDT 3010	eddyNCDT 3100	eddyNCDT 3300
PC3/8	Power- and output cable, 3m, 8 pin			•		
PC5/5	Power- and signal cable	•	•			
SC30	Synchronisation cable, 30cm			•		
CSP 301	Digital signal processing and display unit up to 2 channels			•		
PC3100-3/6/BNC	Output cable and supply unit, 3m				•	
PS2020	Power Supply 24V / 2.5A; Input 100-240 VAC; Output 24 VDC / 2.5A; DIN rail mounting; 35mm x 7.5mm, DIN 50022				•	•
MC2.5	Micrometer calibration fixture, range 0 to 2.5 mm, division 1 μ m, for sensors EPU05 to EPS2, adjustable offset (zero)			•	•	•
MC25D	Micrometer calibration fixture, range 0 to 25mm, division 1 μ m, for sensors EPU05 to EPU15, adjustable offset (zero)			•	•	•
ECx	Sensor cable, length selectable up to 15m					•
ECx/90	Sensor cable with 90° connector (sensor-sided) length selectable up to 15m					•
ECx/1	Extension cable for solder connection					•
ECx/2	Extension cable for plug connection					•
SCA3/5	Signal cable analogue, 3m					•
SCA3/5/BNC	Signal cable analogue with BNC connector, 3m					•
SCD3/8	Signal cable digital (switch input/output), 3m (also for supply 11 - 32VDC); for DT3301					•
SIC3(07)	Signal cable with BNC connector for direct operation with oscilloscope					•
PSC30	Power / Synchronisation cable, 0.3m, for DT3300					•
ESC30	Synchronisation cable, 0.3m, for DT3301					•
PS300/12/5	Power supply Input 100 - 240VAC; Output $\pm$ 12VDC / 5.2VDC integrated cable 1.5m; for max. 4x DT3300					•
MBC300	Mounting base for controller DT330x, fixing through M4 threaded holes 166x108x60mm					•
MCT304-SM	Tower for max. 4 controller DT 3300; supply 100 - 240VAC					•
MCT304(01)	Tower for max. 4 controller DT 3301; supply 11 - 32VDC					•

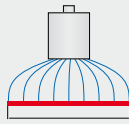
Target size of eddy current sensors



Type ES:
Measuring spot =
1.5x sensor diameter

ES (shielded sensor)

Measuring spot = 1.5x sensor diameter



Type EU:
Measuring spot =
3x sensor diameter

EU (unshielded sensor)

Measuring spot = 3x sensor diameter

The relative size of the measuring object to the sensor affects the linearity deviation for eddy current sensors. Ideally, the measuring object size for shielded sensors should be at least 1.5 times the diameter of the sensor and at least three times the diameter of the sensor for unshielded ones. From this size, almost all lines of the magnetic field run from the sensor to the target. Therefore, almost all magnetic field lines penetrate the target via the face and so contribute to eddy current generation, where only a small linearity deviation occurs.

Factory calibration

As standard, the eddy current sensors are tuned to

- St37 for ferromagnetic calibration.
- Aluminium for non-ferromagnetic calibration

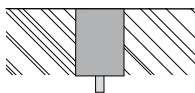
With other materials a factory calibration is recommended.

Choosing the right sensor

Eddy current sensors are grouped into shielded (e.g. ES05) and unshielded (e.g. EU05) sensors. With shielded sensors, the field lines run closer together due to a separate casing. These are less sensitive to radial flanking metals. With unshielded sensors, the field lines emerge at the side of the sensor normally causing an extended measuring range. Correct installation is important for signal quality. The following information applies for mounting in ferromagnetic and non-ferromagnetic materials.

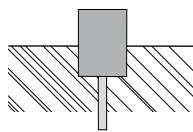
Assembly references for shielded sensors (ES) in metal

✓ Correct



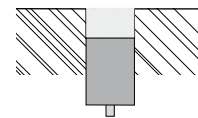
Flush mounting

✓ Correct



Protruding mounting

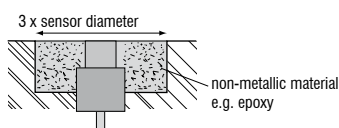
✗ False



Surrounding material attenuates the sensor;
Measurement not possible.

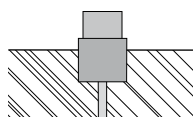
Assembly references for unshielded sensors (EU) in metal

✓ Correct



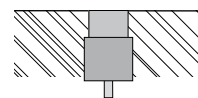
Sensor must be set up free-standing.
Minimum distance to the sensor: approx.
three times the diameter of the sensor

✓ Correct



Protruding sensor mounting
Projecting length: 2-3 times the measuring range

✗ False

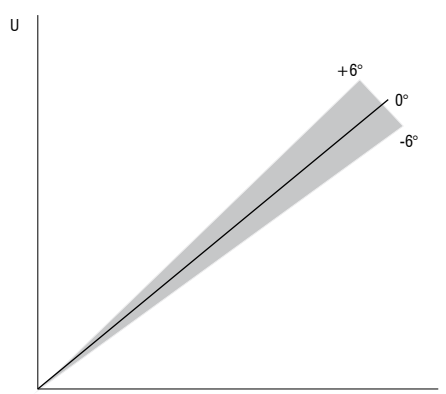
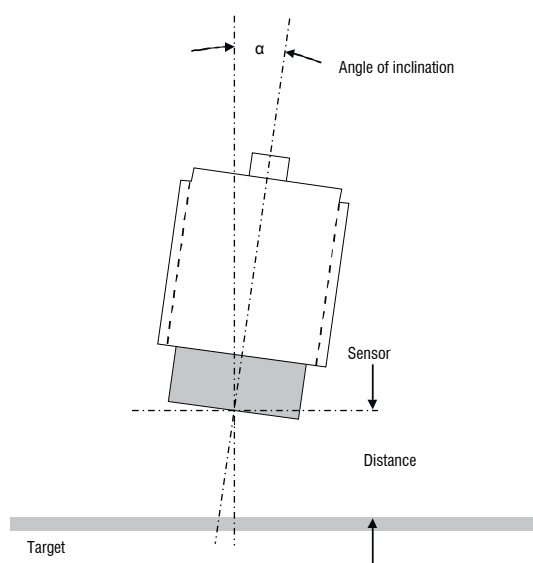


Surrounding material attenuates sensor in the
standard version; Measurement not possible.

Tilt angle and measuring signal

The non-contacting displacement measuring system eddyNCDT is often used because of its excellent linearity and high resolution. This high resolution is achieved with right angle position, only. Sometimes an exact right angle mounting of the sensor to the target is difficult or

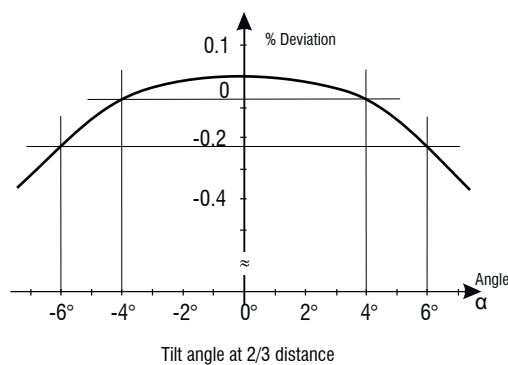
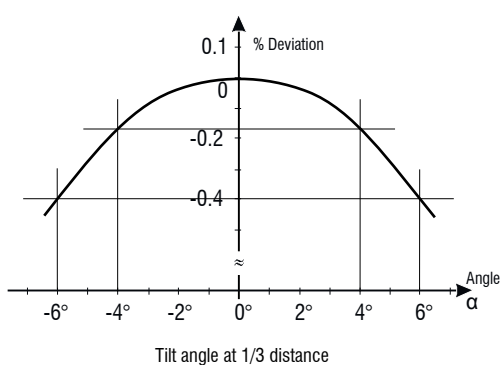
impossible. In this case, the measured values deviate marginal from values, measured in right angle position. Hence it is important to know the influence to the measuring signal if the sensor is tilted. The following graphs show the influence to the measuring signal of a tilted sensor.



Example: Tilt a sensor 6° with 3 mm measuring range, means a deviation of 5 μm at 2/3 measuring distance.

A permanent tilt angle can already be lodged at the controller with the 3-point linearisation. This avoids an influence of this tilt angle to the signal.

Tilt angles, the controller not linearised for, cause deviations of the measured values in comparison to right angled measurements.



The extent of deviation is different from sensor to sensor. These diagrams were taken with a U6 sensor and aluminium target. The diagrams show, that an inclination of ± 4 degrees can be accepted and neglected in most applications.

A tilt angle of more than 6 degree is rather possible with unshielded sensors than with shielded, but should be avoided. In principle, only a special linearised sensor provides a precise signal.

Resolution of displacement measurement systems

Definition of terms

The resolution is a measure of the fineness with which a change of displacement is reliably detected by a measurement system and the clear distinctive feature of two measurement values that are close to each other. Such displacements can only be measured with high complexity, because temperature effects, vibrations and other mechanical influences might disturb within measurement arrangement. Consequently, the signal-to-noise ratio is used in determining the resolution of the respective measurement system. The signal-to-noise ratio describes the level difference between the useful and interfering components of a signal.

Interfering component of a signal - thermal noise

The main constituents of the interfering component in a signal are the sum of the thermal noise of the measurement system including sensor cable, external interference effects and the residual ripple of the supply voltage. The principal component is caused by noise in the electronics. Due to the thermal movement of electrons in an electrical resistance, a noise process is produced which is described by.

The noise power density: $\frac{dP_r}{df} = 4k_B T$

k_B = Boltzmann constant (1.3806504 · 10⁻²³ J/K)

T = absolute temperature

Measurement technology, effective noise voltage and RMS

For the random signals, electrical measurement technology makes use of descriptive quantities which can be derived from the electrical measurement quantities of voltage or power. This is based on the assumption that the mean of the observed signals is zero, i.e. they have no constant component as they vary about the value „0“. Then the quadratic mean is equal to the variance. If the root of the variance is then taken, the dispersion is obtained which in turn describes the effective noise voltage. The dispersion or effective noise voltage is measured with an instrument which measures the effective value. Instruments from the English-speaking regions also use the term RMS (Root Mean Square, i.e. root of the squared mean) for the effective noise voltage.

The power developed across a resistance is termed as the noise power P_n and is described by

$$\text{the equation } P_n = \frac{V_{n,rms}^2}{R}$$

If the thermal noise on a resistance or system is measured with an RMS instrument, it must be taken into account that the instruments are restricted in their bandwidth (upper bandwidth - lower bandwidth).

Consequently, instead of acquiring the infinite variance, only an extract of it is obtained. The RMS noise voltage can therefore be quoted as follows:

$$V_{n,rms} = \sqrt{4 \cdot k_B \cdot T \cdot R \cdot \Delta f}$$

The noise voltage is then dependent on the absolute temperature and the bandwidth considered.

Resolution and signal amplification

The theoretical infinite resolution is in practice limited by temperature effects and the bandwidth. Amongst the temperature effects there is also the response time of the electronics during which the measurement device reaches the operating temperature by self-heating. That process is necessary in order to obtain reproducible measurement results. However, the noise voltage is inevitably increasing with the temperature.

As a rule, minor movements are associated with high speed. A corresponding high bandwidth is necessary in order to detect the high speed. For measurement devices, a high frequency leads to increased noise voltage and reduced resolution.

Systems with non-linear characteristics, such as for example the eddyNCDT are linearised through circuitry. The larger gain required here for an increasing measurement distance also increases the noise voltage. Capacitive displacement measurement systems which exhibit an inherently linear characteristic have better prerequisites with regard to resolution.

Static or dynamic measurement

The resolution is given separately as static and dynamic values in the technical data on displacement measurement systems. One speaks of a static resolution when it can be assumed that the measurement object or the sensor is at a standstill. In the technical data tables this is occasionally quoted with the footnote $f \leq 1\text{Hz}$ or $f \leq 10\text{Hz}$. The dynamic or effective resolution is related to the application and is always subject to a footnote regarding the bandwidth. If there is no differentiation between statistic and dynamic, it is to be assumed that the statistic value is given which appears to be the better one.

Micro-Epsilon's measurement methods for determining the resolution.

The signal-to-noise ratio is determined using the following methods at three different distances (SMR, CMR and EMR) in the enclosed EMC cabin to avoid ambient effects, such as transmitter systems

1. RMS measurement

The bandwidth of the digital multimeter (DMM) is 150kHz. The output voltage of the respective measurement system is amplified by a factor of 100 with an AC amplifier. This voltage is passed through an RC low-pass filter, the output of which is connected to DMM. The filter frequencies of the RC low-pass filters of the 1st order are 16Hz, 150Hz, 1.4kHz, 14.92kHz and 148.7kHz. An AC measurement without amplifier and low-pass filter is then made to determine possible residual carriers, etc.

2. Measurement of the noise peak value (V_{pp}) with the oscilloscope.

The measurements are carried out with a digital storage oscilloscope. The measurement setup corresponds to the method for the RMS measurement. Then, also here an AC measurement without amplifier and low-pass filter is carried directly on the output.

The assignment of LP filter frequency and time-base on the oscilloscope:

16Hz/200ms	150Hz/20ms
1.4kHz/2ms	14.92kHz/200 μ s
148.7kHz/20 μ s	without LP/20 μ s

3. Measurement of the noise peak value (V_{pp}) with the oscilloscope in the envelope-curve mode.

With this measurement, 128 measurement runs are recorded and displayed simultaneously. Isolated peaks and freak values also contribute fully to the measurement. This measurement also enables low-frequency noise to be acquired which otherwise would not be detected.

4. Measurement using LF spectrum analyser.

This measurement is also carried out. The spectrum in the range of the respective signal bandwidth is recorded here as well as the spectrum with multiples of the respective carrier frequency. It is decisive for the quality of the measurement that it occurs with adaptation of the power, i.e. the output resistance of the controller is equal to the input resistance of the spectrum analyser.

Calculation of the resolution of the noise voltage

As briefly illustrated at the start, the resolution is given separately as static and dynamic values in the technical data on displacement measurement systems. The resolution can be calculated from the noise voltage using the following formula:

$$\text{Resolution}_{\text{rms}} [\text{mm}] = \frac{V_{n,\text{rms}} [\text{V}]}{V_{\text{Output, MR}} [\text{V}]} \cdot \text{MR} [\text{mm}]$$

$V_{n,\text{eff}}$	= effective noise voltage
$V_{\text{Output, MR}}$	= output voltage of the measuring range
MR	= measuring range of the sensor

RMS value or peak-peak value

With a standard deviation of 1 σ (sigma) the RMS value is obtained in the Gaussian normal distribution. For signal components with a higher amplitude the probability that they are present in the signal decreases. For practical considerations a limit of $\pm 3 \sigma$ is assumed. According to this, the signal is located in this region with a confidence level of 99.7%. In order that resolutions, RMS or peak-peak, can be compared against one another, the following rule of thumb can be used:

$$\text{Peak-peak value } V_{pp} = 6 \cdot \text{RMS value } [\pm 3 \sigma].$$

The figure for the noise voltage or resolution as the RMS or peak-peak value depends on the objectives followed and has no influence on the actual resolution of a displacement measurement system. RMS values convey better values at first glance and are therefore the reason for frequent use in the technical data.

Conclusion

The resolution of displacement measurement systems is measured using two different methods. The background to both measurements is the measurement of the noise voltage. The most common method is the effective measurement which is usually quoted as RMS (Root Mean Square) in technical documentation. Quoting the resolution as a peak-peak value is rare, because the values obtained appear subjectively less favorable than for the RMS measurement.

Whether a manufacturer quotes the resolution as the RMS or peak-peak value depends on his objectives. It does not have any influence on the actual resolution of a displacement measurement system. Micro-Epsilon normally uses the RMS value for figures in the data sheet and identifies this with the note @RMS.

When considering technical data, it is decisive that RMS values and peak-peak values are only compared like with like. For the conversion the rule of thumb can be used the following formula:

$$\text{Peak-peak value} = 6 \cdot \text{RMS value (at } \pm 3 \sigma \text{)}.$$

Required target thickness

The principle of eddy current displacement measurement requires a minimum thickness for stable results. This minimum thickness depends on the target material used and the sensor frequency. The sensor generates an alternating electromagnetic field which penetrates the target. Eddy currents being formed in the target cause a secondary magnetic field which attenuates the primary field.

Skin or penetration depth

Electromagnetic fields are attenuated on entering an electrically or magnetically conducting material. The reduction in the field strength and therefore the current density is accompanied by losses which occur in the vicinity of the material surface. The characteristic length at which the current density reduces to the value 1/e or to 37% is known as the skin depth (see Fig. 2).

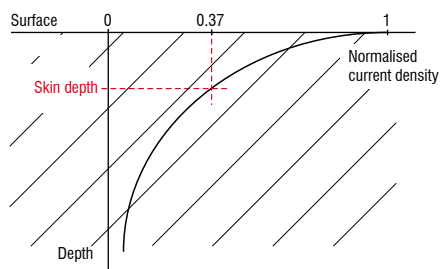


Fig. 2: Current density distribution in the target

Calculating the skin depth

The skin depth can be calculated with the following formula (it applies to the ideal case of a plane boundary layer and an infinitely extended object).

You can determine the permeability for some materials from Fig. 3. Or you can read off the skin depth directly from Table 1.

$$\delta = \frac{1}{\sqrt{\sigma \cdot f \cdot \mu \cdot \pi}}$$

δ = Skin depth
 σ = electrical conductivity
 f = Sensor frequency
 $\mu = \mu_0 \cdot \mu_r$ = Permeability
 $\mu_0 = 12,566 \cdot 10^{-7} \frac{Vs}{Am}$

Target material	Skin depth in μm at	
	250kHz	1MHz
Aluminium	168	84
Lead	459	230
Gold	149	74
Graphite	2700	1350
Copper	134	67
Magnesium	209	104
Brass	249	124
Nickel	27	14
Permalloy	4	2
Phosphor Bronze	302	151
Silver	130	65
Steel DIN 1.1141	23	12
Steel DIN 1.4005	55	27
Steel DIN 1.4301	848	424

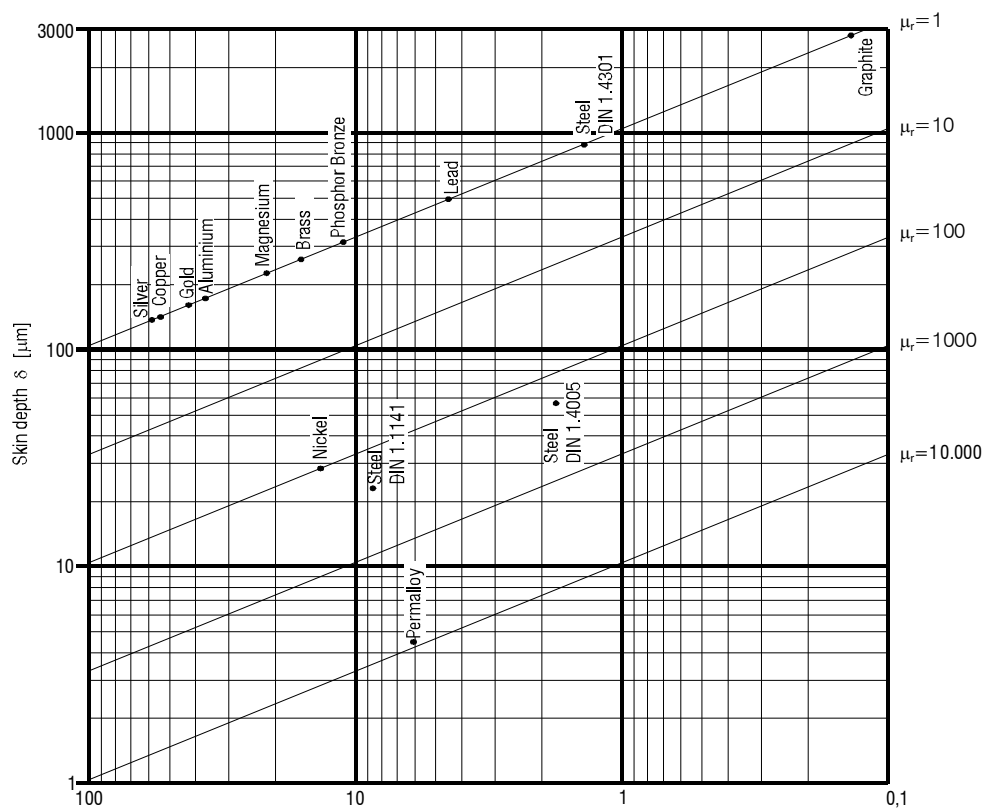
Tab. 1: Various skin depths

Calculating the minimum thickness

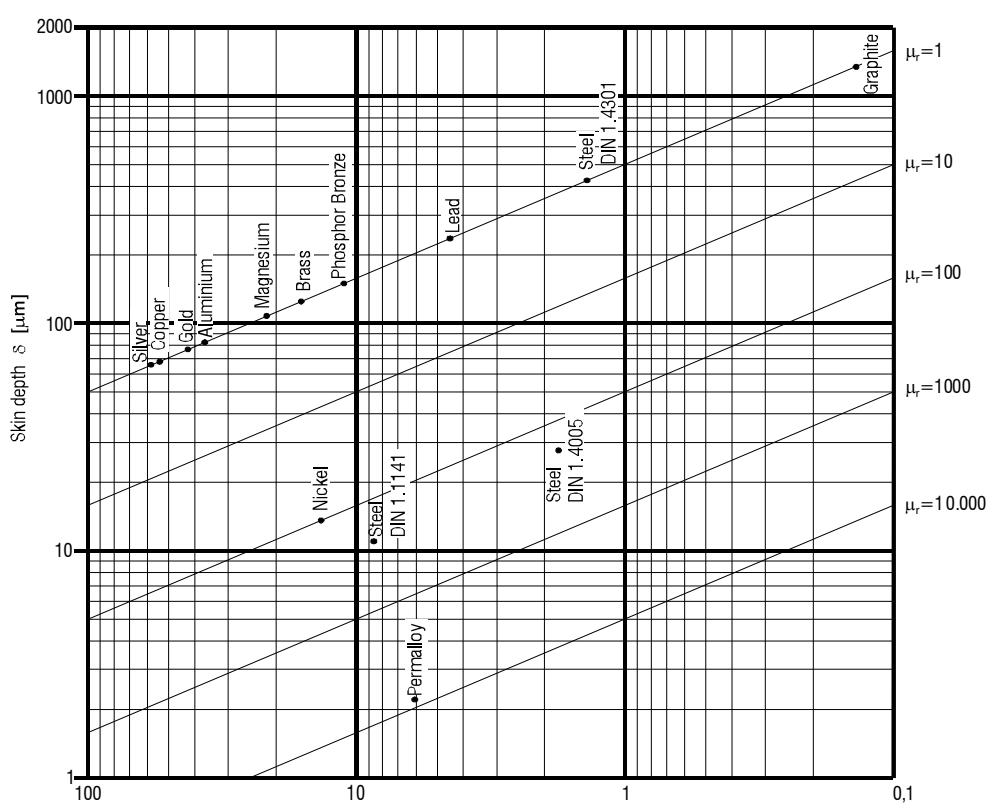
To calculate the minimum thickness of a material, take the appropriate skin depth from Table 1 or read off the skin depth from Fig. 3. Then you find the minimum thickness with the approximation value from Table 2. This calculation only applies when using a sensor with a frequency of 250kHz or 1MHz.

Measurement application	Minimum target thickness
Object detection (without displacement measurement)	"Skin depth" x 0.25
Displacement measurement at approx. constant (room)temperature	"Skin depth" x 1.00
Displacement measurement with changing temperature	"Skin depth" x 3.00
Thickness measurement with two opposing sensors	"Skin depth" x 6.00

Tab. 2: Approximation values for simple determination of the minimum thickness



Tab. 3a: Skin depth at 250 kHz



Tab. 3b: Skin depth at 1 MHz

High performance sensors made by Micro-Epsilon



Sensors and systems for displacement and position



Sensors and measurement devices for non-contact temperature measurement



2D/3D profile sensors (laser scanner)



Optical micrometers, fibre optic sensors and fibre optics



Colour recognition sensors, LED analyzers and colour online spectrometer



Measurement and inspection systems