MICRO-EPSILON

More Precision

capaNCDT // Capacitive sensors for displacement, distance & gap



Sensors for challenging environments
capaNCDT CSE/HT

High-temperature sensors for environments up to +800 °C





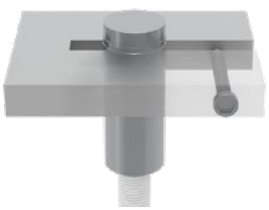

Model		CSE-1/HT/CA-1,0	CSE-2/HT/CA-1,0	CSE-5/HT/CA-1,0	CSE-10/HT/CA-1,0
Measuring range	Reduced	0.5 mm	1 mm	2.5 mm	5 mm
	Nominal	1 mm	2 mm	5 mm	10 mm
	Extended	2 mm	4 mm	10 mm	20 mm
Resolution [1]	Static	10 nm	20 nm	50 nm	100 nm
	Dynamic	80 nm	160 nm	400 nm	800 nm
Linearity [2]		< ±0.5 µm	< ±1.0 µm	< ±3.5 µm	< ±7 µm
Replaceability [3]		< ±5 % FSO	< ±5 % FSO	< ±5 % FSO	< ±5 % FSO
Temperature stability		-0.2 µm / K	-0.4 µm / K	-1.0 µm / K	-2.0 µm / K
Recommended target size (flat) [4]		Ø 8 mm	Ø 14 mm	Ø 30 mm	Ø 50 mm
Active measuring area		Ø 5.7 mm	Ø 8.1 mm	Ø 12.9 mm	Ø 18.2 mm
Connection		integrated cable with socket (type B); standard length 1.0 m			
Mounting		Circumferential clamping			
Temperature range	Storage	-50 ... 200 °C			
	Operation	Sensor with cable -50 … 800 °C / connector -50 … 200 °C			
Shock (DIN EN 60068-2-27)		20 g / 5 ms in XY axis, 1000 shocks each			
Vibration (DIN EN 60068-2-6)		10 g / 10 … 2000 Hz in XY axis, 20 cycles each			
Protection class (DIN EN 60529)		IP40			
Material		Inconel Alloy 625			
Weight		approx. 62 g (incl. cable)	approx. 83 g (incl. cable)	approx. 225 g (incl. cable)	approx. 470 g (incl. cable)
Recommended mounting position [5]		4.75 mm	4.65 mm	9.10 mm	30 mm
Compatibility		Recommended for use with the capaNCDT 6228 controller from Micro-Epsilon			

[1] RMS noise related to the end of the measuring range and to the nominal measuring range, using the standard cable CCm (1.4m) and the integrated HT cable (1 m); valid for operation with the DT6228: static 2 Hz, dynamic 1 kHz
[2] Typical linearity to be added to the controller linearity; valid for standard cable adjustment CCm (1.4 m) and integrated HT cable (1 m)
[3] FSO = Full Scale Output | The value corresponds to the slope error that occurs when a sensor is replaced without recalibration
[4] In relation to the nominal measuring range
[5] From the sensor front face (measuring surface), opposite to the measuring direction

Mounting of cylindrical CSE/HT sensors

CSE/HT cylindrical sensors can be installed either protruding (with the sensor extending beyond the mounting bracket) or flush with the mounting bracket. The sensors are mounted by circumferential clamping using a collet. Please note that the surrounding material may cause heat to build up.

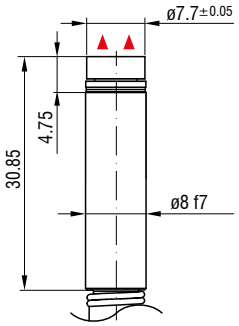
Recommended mounting of CSE/HT sensors



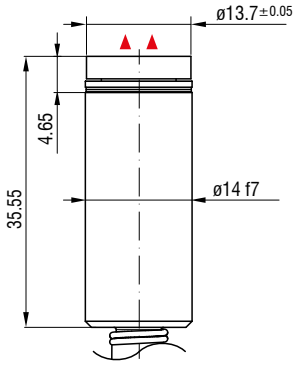
Dimensions
capaNCDT CSE/HT / capaNCDT CSH/SE

CSE/HT

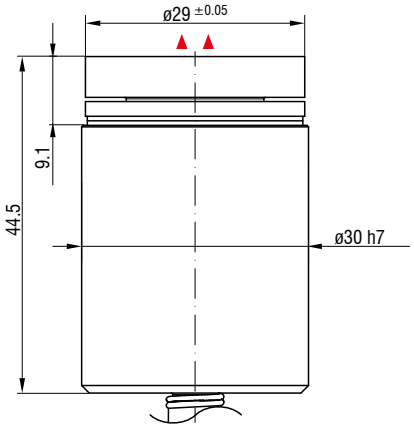
CSE-1/HT/CA-1,0



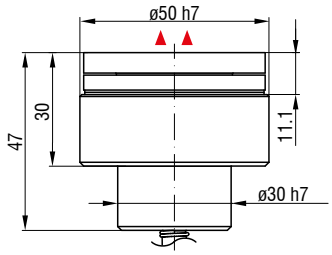
CSE-2/HT/CA-1,0



CSE-5/HT/CA-1.0

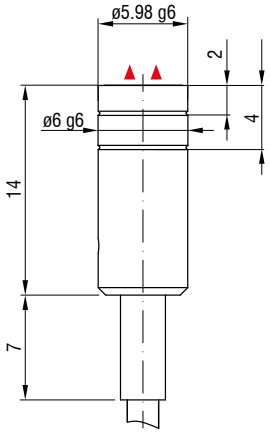


CSE-10/HT/CA-1,0

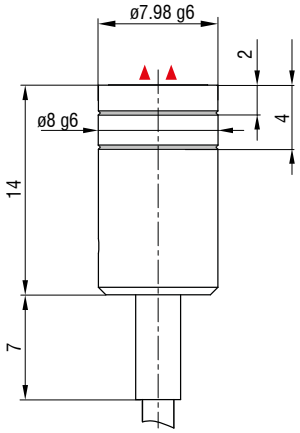


CSH/SE

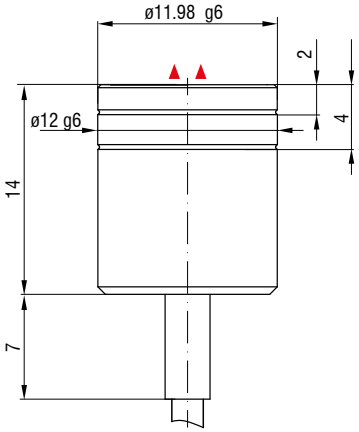
CSH-0,25/SE/ CAm-1,4



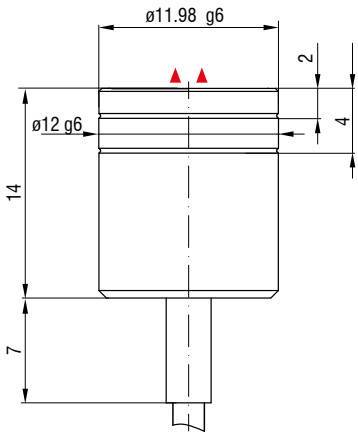
CSH-0,5/SE/CAm-1,4



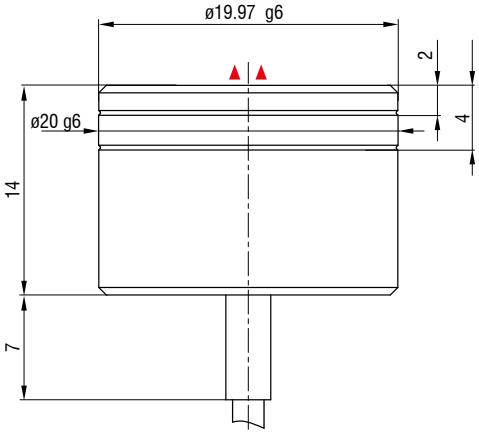
CSH-1/SE/CAm-1,4



CSH-1,2/SE/CAm-1,4



CSH-2/SE/CAm-1,4



Dimensions of the connectors
capaNCDT

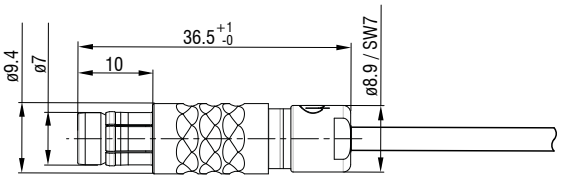
All sensors can be combined with all controllers and sensor cables. To connect the sensors, you simply need to use the correct type of connector. Micro-Epsilon will select the right sensor cable with the appropriate connectors for you during the quotation and ordering process. The following dimensional drawings are intended to help you make an initial selection.

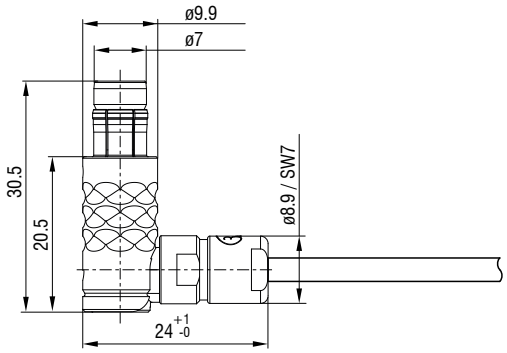
- The sensor connection varies depending on the sensor type. Depending on the model, the cable is either permanently integrated into the sensor or connected via an external sensor cable. Depending on the design and size, different connector types and sizes are used, which must be taken into account when selecting sensor cables. For more information on this, please refer to the technical specifications for the sensors under “Connection”.
- The sensor is always connected to the controller using a type B connector.

You can find an overview of all connection and combination options on pages 52 - 53.

Type B connector

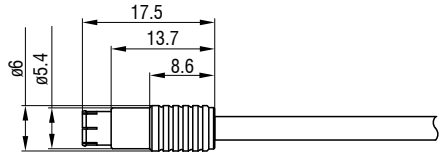
- On each sensor with an integrated cable or on one end of a sensor cable (except CSE/HT)
- For plug-in sensors with measuring ranges of ≥ 1 mm

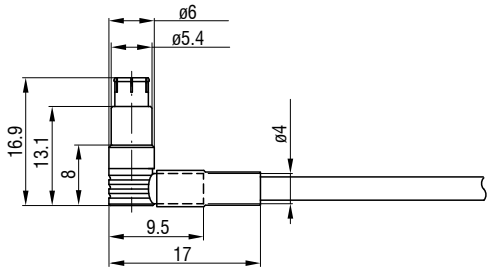




Cable with connector type C

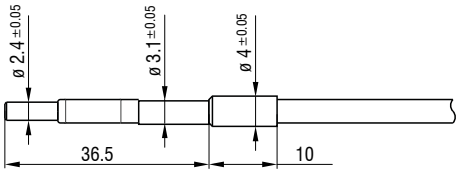
- On one end of a sensor cable
- For all plug-in sensors with measuring ranges of ≤ 1 mm





Cable with connector type E

- On one end of a sensor cable
- For all CSF flat sensors



Capacitive, high-performance measuring system (up to 4 channels)
capaNCDT 6200

- High resolution down to 0.0001 % FSO
- Analog outputs / Ethernet / EtherCAT / PROFINET interface
- Ideal for fast measurements up to 20 kHz
- Digital data rate: 4 x 3.9 kSa/s
- Modular system scalable up to 4 channels
- Supports triggering and synchronization
- Simple configuration via web interface



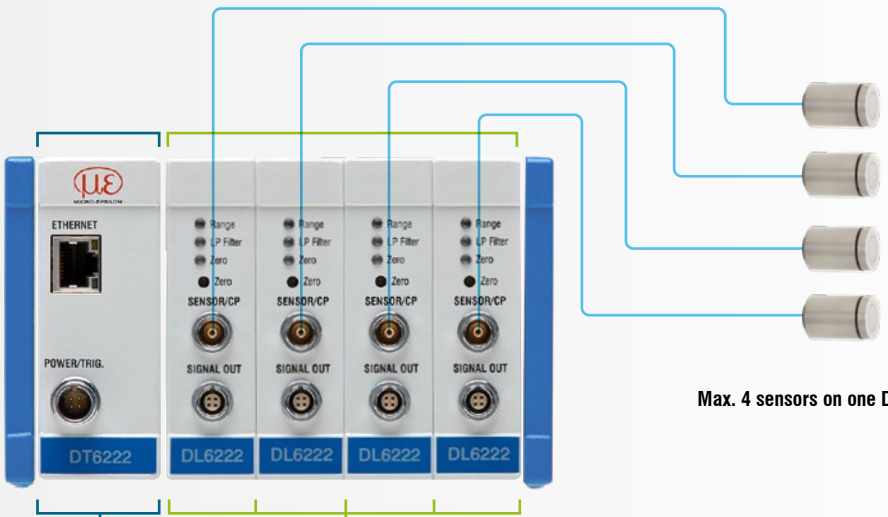
The capaNCDT 6200 is a modular measuring system designed for high-precision measurements. It consists of a controller and the corresponding demodulator for the sensor. The modular design allows up to four measurement channels to be combined and flexibly adapted to different measurement tasks.

The Ethernet interface integrated in the controller allows for easy configuration via a web browser. In addition, analog outputs and digital interfaces are available.

The compact controller can be used as a benchtop unit or mounted on a DIN rail or wall using adapters.

The DT6200 is available in various models. Depending on the base module (controller) used and the compatible demodulator, different interfaces are available or higher resolutions can be achieved.

Flexible system design for maximum performance in your application



Max. 4 sensors on one DT6200

Basic module (controller)
DT6220: Ethernet
DT6230: Ethernet / EtherCAT
DT6240: PROFINET
DT6222: High speed
DT6228 / DT6238: for HT sensors

Demodulator with integrated preamplifier
Depending on the application
DL6220: Standard
DL6230: Highest resolution
DL6222: High speed
DL6228: For HT sensors

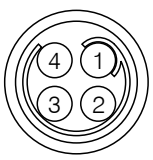
Modular multi-channel system for high-temperature sensors

Model		DT6228	DT6238
Demodulator		**DL6228**	
Resolution [1]	Static	0.0005 % FSO	
	Dynamic	0.01 % FSO	
Frequency response (-3dB)		1 kHz, switchable to 20 Hz	
Measuring rate		max. 3.906 kSa/s	
Linearity [2]		< ±0.05 % FSO	
Temperature stability		< 200 ppm FSO/K	
Replaceability [3]		< ±0.1 % FSO	
Long-term stability		< ±0.02% FSO/month	
Synchronization		yes (only internal)	yes
Supply voltage		12 … 36 VDC	15 … 36 VDC
Power consumption		3.1 W (24 VDC) + 1.8 W / demodulator	3.8 W (24 VDC) + 1.8 W / demodulator
Signal input		Trigger: TTL (5 V)	
Digital interface		Ethernet	Ethernet/EtherCAT
Analog output		0 … 10 V / 4 … 20 mA	
Connection	Sensor	Pluggable cable via triaxial socket	
	Supply/signal	Supply/trigger: 4-pin connector; sync: 5-pin connector; signal: analog via 4-pin connector, digital via RJ45 connector (for suitable connection cables, see accessories)	
Mounting		Table-top device or DIN rail	
Temperature range	Storage	-10 ... 75 °C	
	Operation	10 ... 60 °C	
Shock (DIN EN 60068-2-29)		15 g / 6 ms in 3 axes, two directions each, 1000 shocks each	
Vibration (DIN EN 60068-2-6)		0.75 mm / 10 … 500 Hz in 3 axes, 2 directions and 10 cycles each 2 g / 10 … 500 Hz in 3 axes, 2 directions and 10 cycles each	
Protection class (DIN EN 60529)		IP40	
Weight		approx. 710 g + 185 g / demodulator	approx. 720 g + 185 g / demodulator
Compatibility		Recommended for use with high-temperature sensors (CSE-x/HT models); generally compatible with all capaNCDT sensors	
No. of measurement channels		max. 4	

[1] FSO = Full Scale Output | RMS noise referred to the end of the measuring range; static = 2 Hz, dynamic = maximum frequency response of the controller
[2] Applies to the controller only. The total linearity of the measuring channel is the sum of the controller and sensor values.
[3] FSO = Full Scale Output | The value corresponds to the slope error that results when the controller is replaced without recalibration.

DT6228 / DT6238
Pin assignment for power supply and trigger

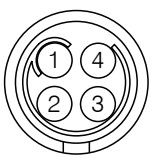
Pin	Assignment	Color (cable PC6200-3/4)
1	Supply +24 V	Brown
2	GND supply	White
3	Trigger IN+, TTL level	Yellow
4	Trigger IN-	Green



Solder side view,
4-pin socket

DT6228 / DT6238
Pin assignment for analog output

Pin	Assignment	Color (color SCACx/4)
1	U_{OUT} (load min. 10 kOhm)	Brown
2	I_{OUT} (burden max. 500 ohm)	Yellow
3	Analog ground	Gray
4	Analog ground	White



Solder side view,
4-pin cable
connector

Connections and combinations
capaNCDT

Controller



DT6100



DT6200



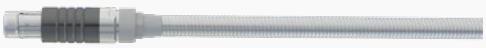
DT6500

Sensor cable



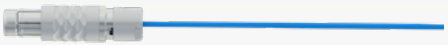
Type: CCg

Robust triaxial cable for industrial applications
Cable diameter: 3.1 mm (±0.1 mm)
Minimum bending radius: static approx. 10 mm / dynamic approx. 30 mm
Temperature resistance: -20 ... +85 °C (permanent) / -20 ... +100 °C (limited to 10,000 h)
Standard length: 2 m (optional lengths see p. 41)



Type CCg/PT

Crush-resistant triaxial cable with protective metal tubing
Cable diameter: 6 mm (± 0.15 mm)
Minimum bending radius: static approx. 20 mm / dynamic approx. 30 mm
Temperature resistance: -20 °C ... +85 °C (permanent) / -20 ... +100 °C (limited to 10,000 h)
Standard length: 2 m (optional lengths see p. 41)



Type CCm

Low-outgassing triaxial cable for UHV and cleanroom
Cable diameter: 2.1 mm (±0.1 mm)
Minimum bending radius: static approx. 7 mm / dynamic approx. 25 mm
Temperature resistance: up to -100 ... 200 °C
Standard length: 1.4 m (optional lengths see p. 41)



Type CCo

Low-outgassing triaxial cable for high temperatures
Cable diameter: 3.1 mm (±0.1 mm)
Minimum bending radius: static approx. 10 mm / dynamic approx. 30 mm
Temperature resistance: -20 ... +200 °C
Standard length: 2 m (optional lengths see p. 41)

Sensors with integrated cable use the cable types CCM and CCg

Type CCm

Low-outgassing triaxial cable for UHV and cleanroom
Cable diameter: 2.1 mm (±0.1 mm)
Minimum bending radius: static approx. 15 mm / dynamic approx. 30 mm
Temperature resistance: up to 200 °C
Standard length: 1.4 m (optional lengths see p. 41)

Type: CCg

Robust triaxial cable for industrial applications
Cable diameter: 3.1 mm (±0.1 mm)
Minimum bending radius: static approx. 10 mm / dynamic approx. 30 mm
Temperature resistance: -20 °C ... +85 °C (permanent) / -20 ... +100 °C (limited to 10,000 h)
Standard length: 2 m (optional lengths see p. 41)

Plug connector



Type B connector



Type B / 90 connector



Type B / IP connector



Type C connector



Type C / 90 connector

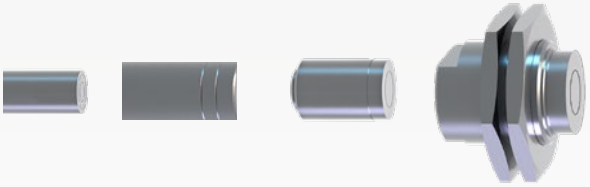


Type E connector

Sensors with socket



CS-x, CSE and CSE/Mx models
with a measuring range from 1 mm

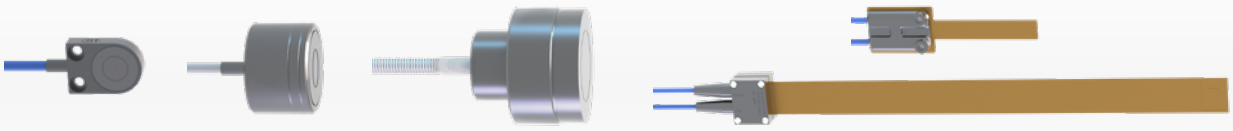


CS, CS-x, CSE and CSE/Mx models
with measuring range up to 1 mm



CSF flat sensors with socket

Sensors with integrated cable



Accessories
capaNCDT

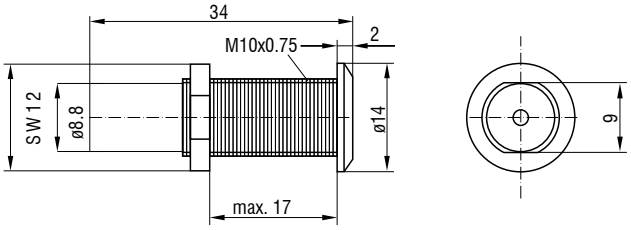
Vacuum feedthroughs

Micro-Epsilon offers a variety of vacuum feedthroughs for the quick and easy integration of capacitive sensors in high-vacuum and ultra-high-vacuum environments. The feedthroughs are available as screw-in or weld-in versions, or with a large flange. All models are designed for sensors with a type B connector. Feedthroughs for sensors with connector types C and E are available upon request.

Vacuum feedthrough screwable

Art. no. 0323050



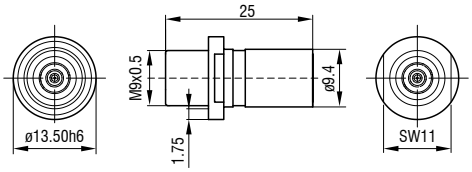


Maximum leak rate: 1 × 10^{-7} mbar·l·s^{-1}, compatible with type B connectors

Vacuum feedthrough weldable

Art. no. 0323346



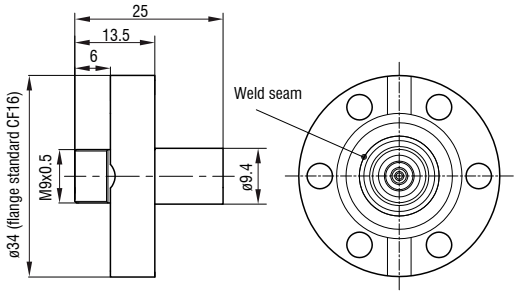


Maximum leak rate: 1 × 10^{-9} mbar·l·s^{-1}, compatible with type B connectors

Vacuum feedthrough with flange (CF16)

Art. no. 0323349



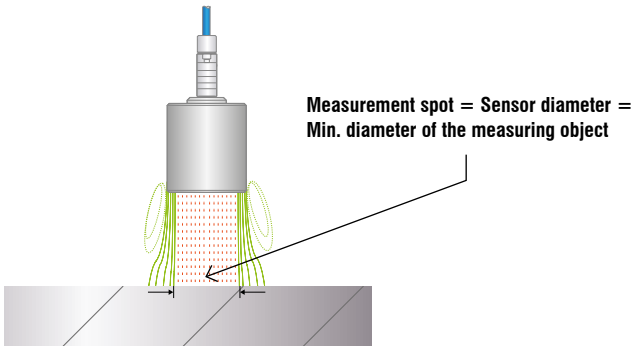


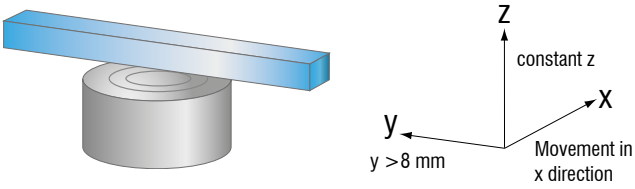
Maximum leak rate: 1 × 10^{-9} mbar·l·s^{-1}, compatible with type B connectors

Technical details
capaNCDT

Minimum diameter of the measuring object

The relative size of the target has effects on the linearity deviation. Ideally, the object being measured should be at least as large as the “Recommended target size” specified in the technical data, or at least as large as the sensor’s diameter. In this case, the sensor’s full measuring range can be used without the need for additional calibration. Measuring objects smaller than the sensor diameter require a special calibration. The smaller the size (ratio measurement electrode and measuring object), the lower the accuracy.



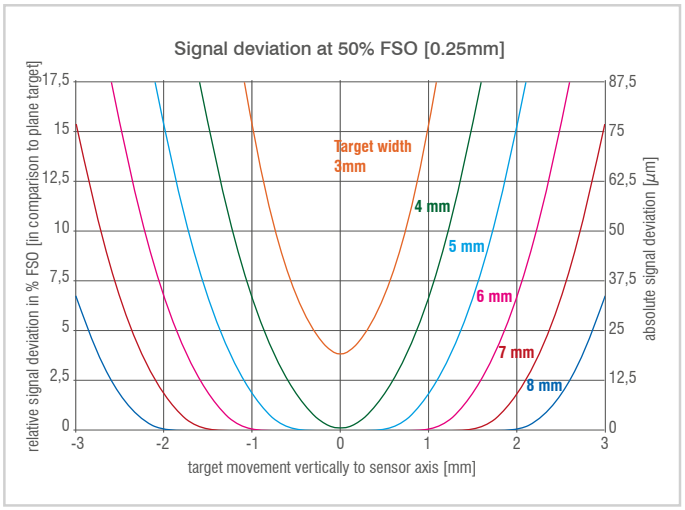


Measurement on narrow targets

The width of the object being measured affects the capacitive measurement signal. Simulations using a CS05 sensor (8 mm diameter) as an example show that even narrow objects can be measured reliably, provided they are sufficiently large and correctly positioned.

At a distance of 0.25 mm (mid of measuring range), even a centrally positioned object 5 mm wide produces a stable measurement signal. The larger the distance between the sensor and the measuring object, the larger the required minimum width.

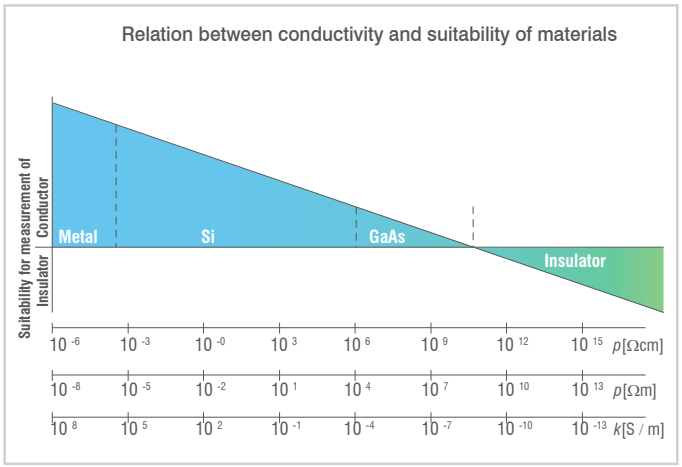
The results show that the electric field does not extend beyond the entire diameter of the sensor. This makes it possible to take precise measurements even on narrow objects.



Conductivity of the measuring object

In order to achieve a linear output signal across the complete measuring range, certain requirements for the target or the counter electrode must be complied with. The impedance in the ideal plate capacitor can be shown in the equivalent circuit diagram by a capacitor and a resistor connected in parallel. For measurement against metals, the ohm part can be disregarded; the impedance is only determined by the capacitive part. Conversely, only the ohm part is considered for measurements against insulators.

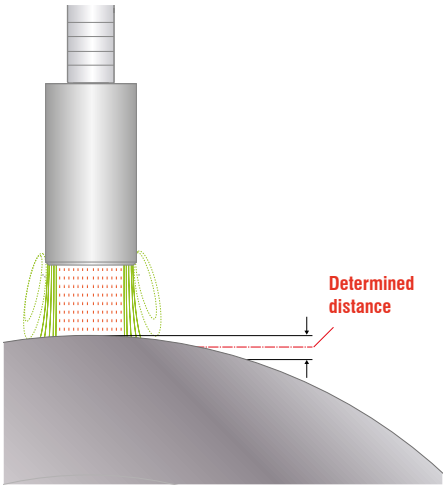
In between, there is the large range of semiconductors. Most semiconductors can be measured very well as electrical conductors. The requirement is that the capacitive part of the total impedance is still significantly larger (>10x) than the ohmic part. This is almost always the case for silicon wafers irrespective of the endowment. Nevertheless, semiconductors with poor conductivity (e.g. GaAs) can also be measured as conductors under certain circumstances.



However, various adjustments are required for this, e.g. reduction of the operating frequency or a temporary, partial increase of the conductivity.

Minimum diameter of round measuring objects:

When measuring distances on curved surfaces such as when measuring wave patterns on rollers, measurement errors may occur. This is caused by the altered field line distribution and an enlarged effective measurement spot, which changes the measured capacitance. In practice, this results in a virtual zero point for the sensor, meaning that the measurement value of 0 µm is no longer achieved. Since capacitive sensors integrate over their entire measuring surface, the virtual mean measurement plane lies behind the actual generatrix of the cylindrical target object. As this effect is predictable, corresponding correction curves can be stored in the controller.

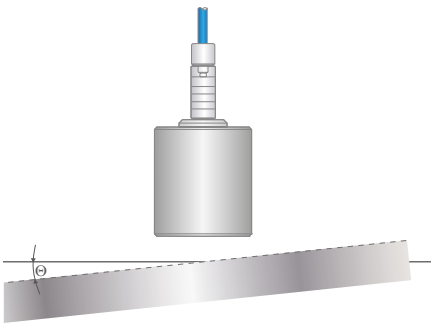


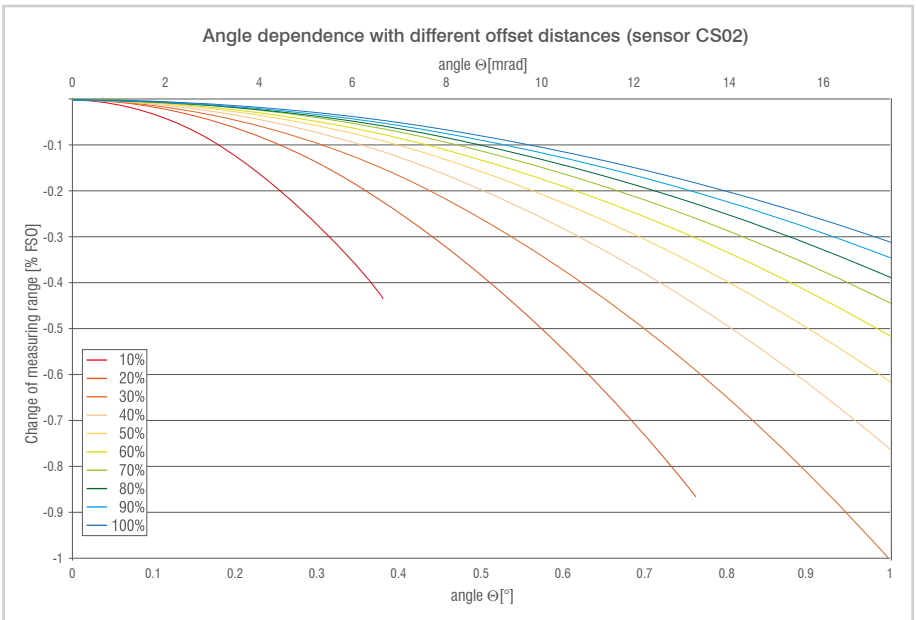
Example: For a sensor with a 200 µm measuring range and a roller with an outer diameter of 30 mm, an actual gap of 20 µm results in a measured value that is approximately 5 % higher. This corresponds to approx.10 µm of the measuring range.



Inclination:

If the capacitive sensor or the measuring object is tilted, an error is likely to occur, as the geometric conditions of the field relative to the object being measured change. In fact, the average distance of the sensor remains constant; however, the edge areas move closer or further away from the target. The following figure illustrates this effect using the CS02 sensor as an example, with a maximum tilt angle of 1° at various sensor distances. At a 10 % offset along the sensor axis, contact between the sensor housing and the measuring object occurs at 0.38°; at a 20 % offset, contact occurs at 0.76°. The simulation can be performed for all sensors and installation conditions; tilt angles around a decentralized tilt point can also be calculated.





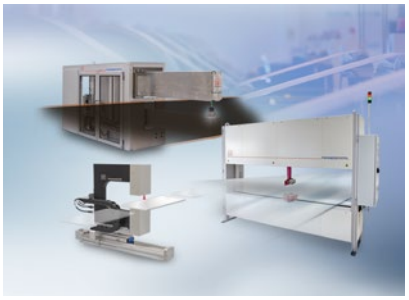
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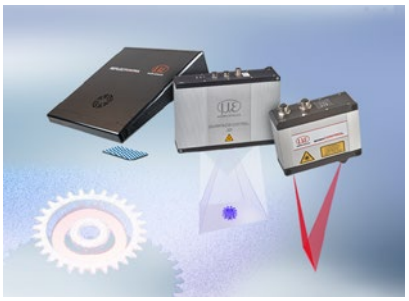
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