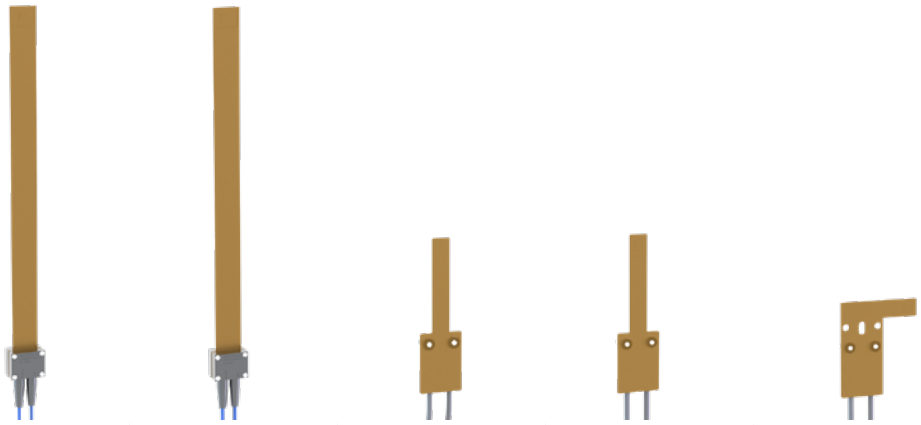
MICRO-EPSILON

More Precision

capaNCDT // Capacitive sensors for displacement, distance & gap

Gap sensors for two-sided measurements
capaNCDT CSG



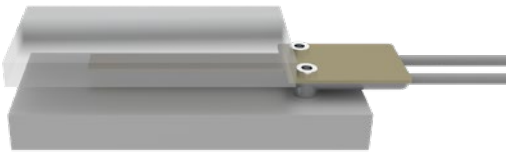
Model		CSG0,50-CAm2,0	CSG1,00-CAm2,0	CSG-0.5/CRg2.0	CSG-1/CRg2.0	CSG-1/90/CRg-2.0
Measuring range	Reduced	0.25 mm	0.5 mm	0.25 mm	0.5 mm	0.5 mm
	Nominal	0.5 mm	1 mm	0.5 mm	1 mm	1 mm
	Extended	1 mm	2 mm	1 mm	2 mm	2 mm
Resolution [1]	Static	0.15 nm	0.3 nm	0.15 nm	0.3 nm	0.3 nm
	Dynamic	10 nm	20 nm	10 nm	20 nm	20 nm
Linearity [2]		< ±0.5 µm	< ±1 µm	< ±1 µm	< ±2 µm	< ±2 µm
Replaceability [3]		< ±1.0 % FSO	< ±1.0 % FSO	< ±1.5 % FSO	< ±1.0 % FSO	< ±1.0 % FSO
Temperature stability		-0.08 µm/K	-0.1 µm/K	-0.2 µm/K	-0.2 µm/K	-0.2 µm/K
Required gap width		≥ 0.9 mm				
Recommended target size (flat) [4]		approx. 9.9 x 15 mm		approx. 10 x 10 mm	approx. 12 x 12 mm	approx. 10 x 10 mm
Active measuring area		4.3 x 3.0 mm	6.2 x 4.2 mm	4.3 x 3.0 mm	4 x 6.5 mm	5.1 x 5.1 mm
Connection		integrated cable with connector (type B); standard length 2.0 m				
Mounting		Surface clamping		Screw mounting via 2x through holes, Ø 3.1 mm, for M3 screws		
Temperature range	Storage	-50 ... 100 °C		-20 ... 100 °C	-20 ... 80 °C	
	Operation	-50 ... 100 °C		-20 ... 100 °C	-20 ... 150 °C (sensor); -20 ... 80 °C (cable)	
Shock (DIN EN 60068-2-27)		30g / 5 ms in XY axis, 1000 shocks each				
Vibration (DIN EN 60068-2-6)		20 g / 58 … 2000 Hz in XY axis, 10 cycles each				
Protection class (DIN EN 60529)		IP40				
Material		Hard tissue (GFRP)				
Weight		approx. 77 g (incl. cable)		approx. 80 g	approx. 90 g	approx. 130 g
Compatibility		Compatible with all capacitive controllers from Micro-Epsilon Sensors can be replaced as required without recalibration (see replacement accuracy)				

[1] RMS noise referred to the end of the measuring range and to the nominal measuring range, using the standard cable CCg (2.0 m); valid for operation with the DT6530: static 2 Hz, dynamic 8.5 kHz
[2] Typical linearity to be added to the controller linearity; valid for standard cable adjustment CCg (2.0 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

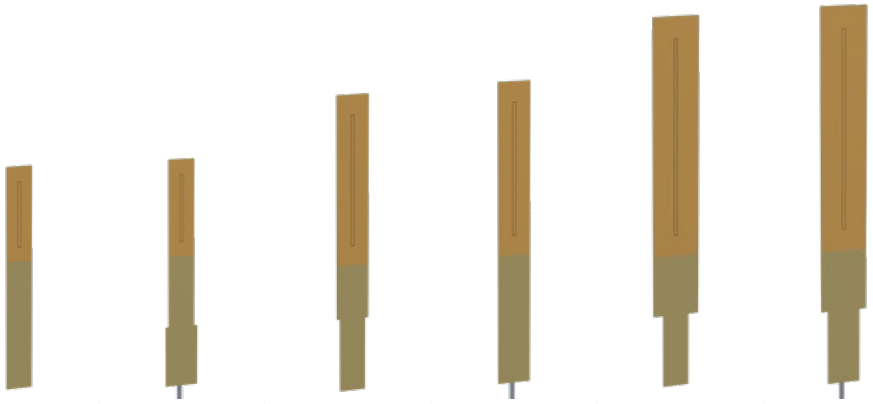
Mounting of CSG gap sensors for two-sided measurements

Gap sensors for two-sided measurements are mounted outside the gap to be measured using screws. The flexible part of the sensor extends freely into the gap. Gap sensors for two-sided measurements can also be used in combination with the MD6-22 mobile controller for mobile gap measurement. For this purpose, the sensor is not mounted but is inserted into the measuring gap by hand.

Recommended mounting of CSF sensors



Gap sensors for one-sided measurements
capaNCDT CSF



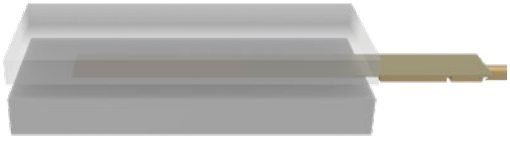
Model		CSF2	CSF2-CRg4.0	CSF4	CSF4-CRg4.0	CSF6	CSF6-CRg4.0
Measuring range	Reduced	1 mm		2 mm		3 mm	
	Nominal	2 mm		4 mm		6 mm	
	Extended	4 mm		8 mm		12 mm	
Resolution [1]	Static	0.6 nm		1.2 nm		1.8 nm	
	Dynamic	40 nm		80 nm		120 nm	
Linearity [2]		< ±4 µm		< ±8 µm		< ±12 µm	
Replaceability [3]		< ±1.5 % FSO		< ±1.0 % FSO		< ±1.0 % FSO	
Temperature stability		-0.2 µm/K		-0.5 µm/K		-0.9 µm/K	
Required gap width		≥ 0.75 mm					
Recommended target size (flat) [4]		approx. 50 x 13 mm		approx. 90 x 16.5 mm		approx. 128 x 25 mm	
Active measuring area		35 x 1.5 mm		70 x 1.5 mm		105 x 1.5 mm	
Connection [5]		triaxial socket (type E)	integrated cable with connector (type B), length 4 m	triaxial socket (type E)	integrated cable with connector (type B), length 4 m	triaxial socket (type E)	integrated cable with connector (type B), length 4 m
Mounting		Bonding to the underside of the sensor (optionally available with magnetic foil on the underside)					
Temperature range	Storage	-40 ... 100 °C					
	Operation	-40 ... 100 °C					
Shock (DIN EN 60068-2-27)		30g / 5 ms in XY axis, 1000 shocks each					
Vibration (DIN EN 60068-2-6)		20 g / 58 … 2000 Hz in XY axis, 10 cycles each					
Protection class (DIN EN 60529)		IP40					
Material		Hard tissue GRP / copper / gold					
Weight		approx. 5 g	approx. 75 g (incl. cable)	approx. 7 g	approx. 77 g (incl. cable)	approx. 10 g	approx. 80 g (incl. cable)
Compatibility		Compatible with all capacitive controllers from Micro-Epsilon Sensors can be replaced as required without recalibration (see replacement accuracy)					

[1] RMS noise referred to the end of the measuring range and to the nominal measuring range, using the standard cable CCg (4.0 m); valid for operation with the DT6530: static 2 Hz, dynamic 8.5 kHz
[2] Typical linearity to be added to the controller linearity; valid for standard cable adjustment CCg (4.0 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] For suitable sensor cables, please refer to Connections

Mounting of CSF gap sensors for one-sided measurements

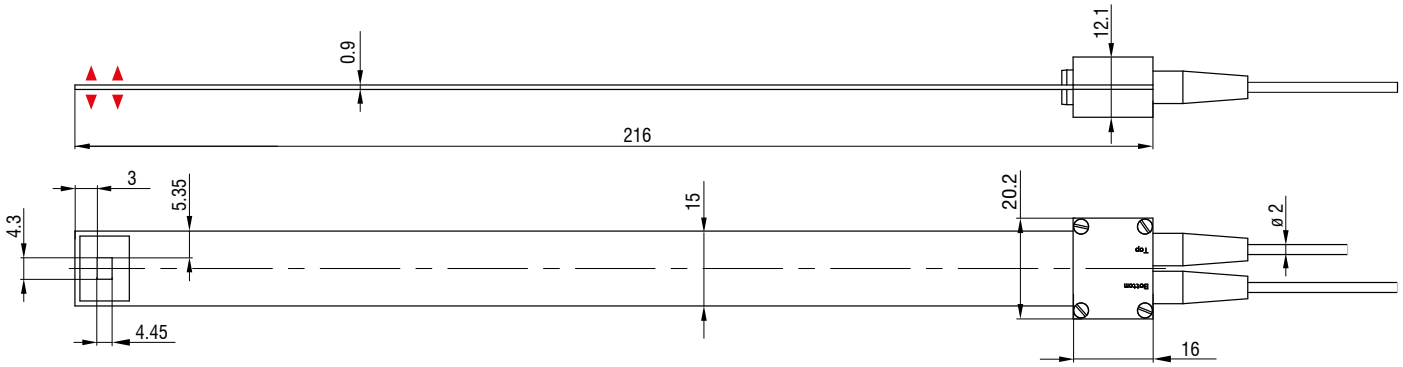
The gap sensors are attached by bonding them directly into the gap to be measured. CSF-type gap sensors are available with a magnetic strip on the back, allowing them to be quickly attached to metal gaps and removed without leaving any residue (recommended only for mobile measurements, not for continuous use).

Recommended mounting of CSF sensors

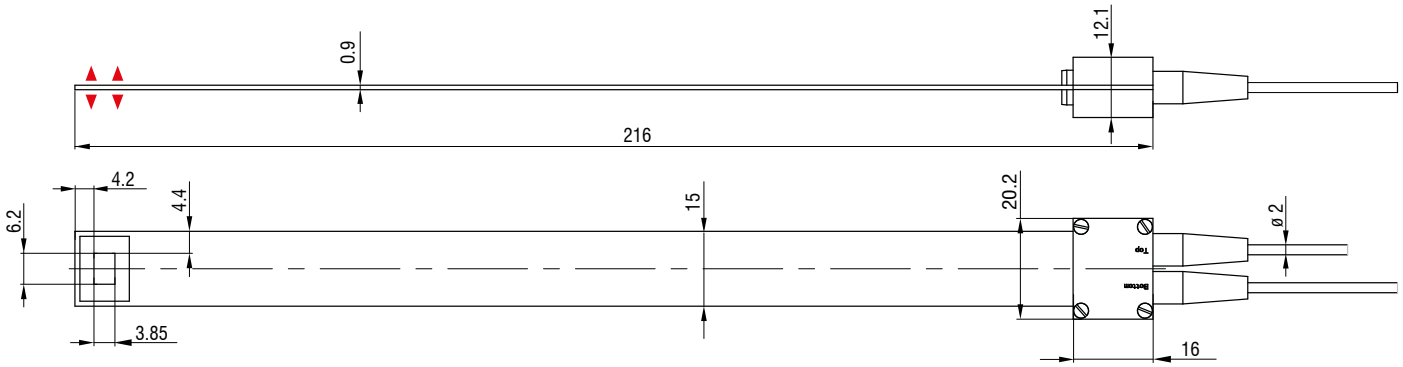


Dimensions
capaNCDT CSG/CSF

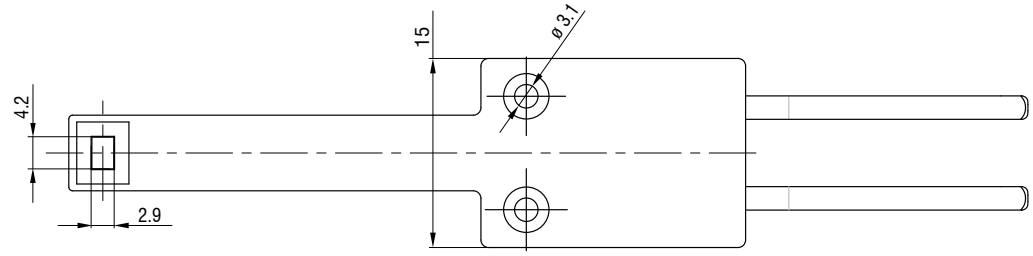
CSG0,50-CAm2,0

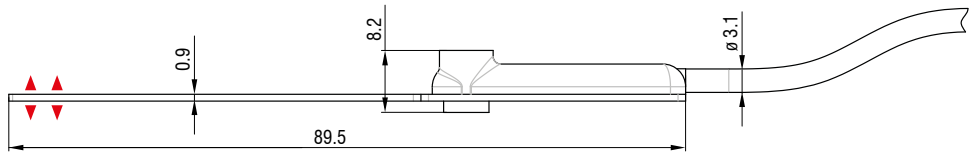


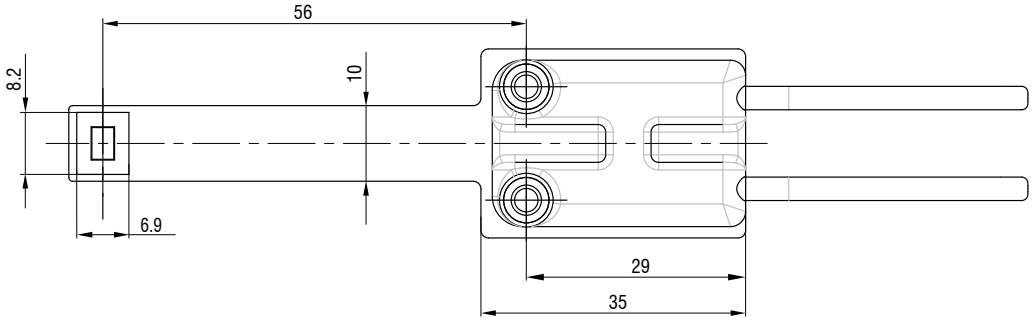
CSG1,00-CAm2,0



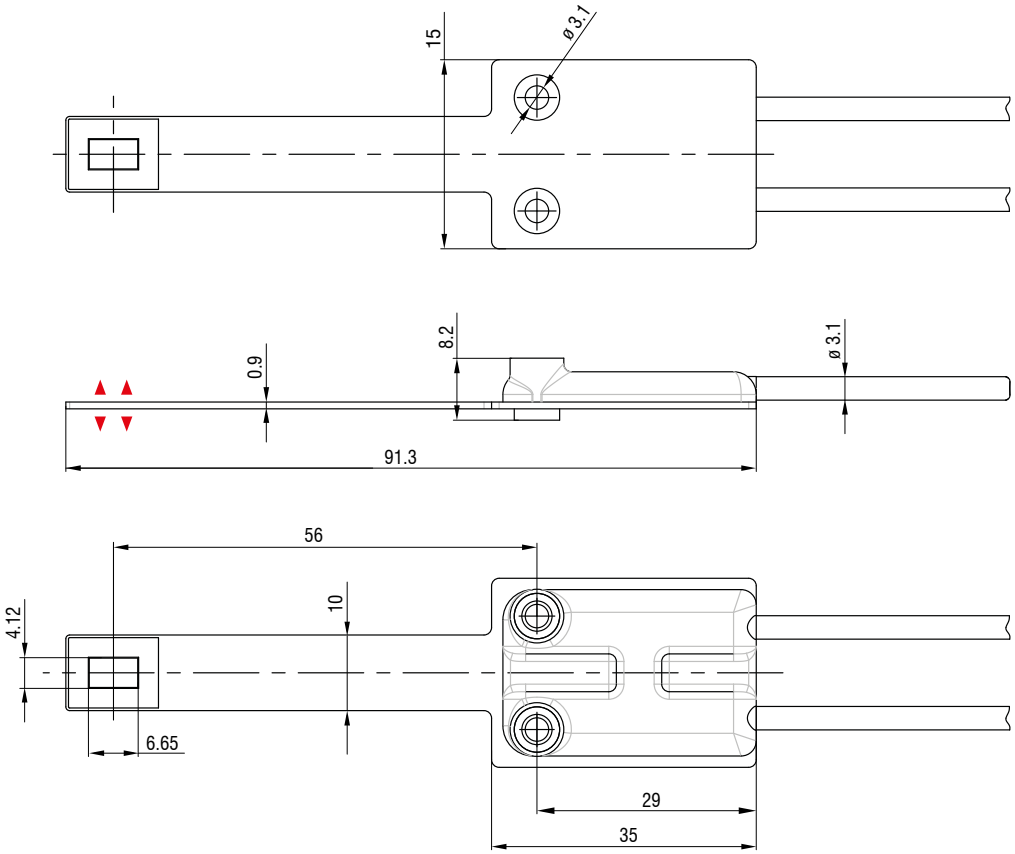
CSG-0.5/CRg2.0





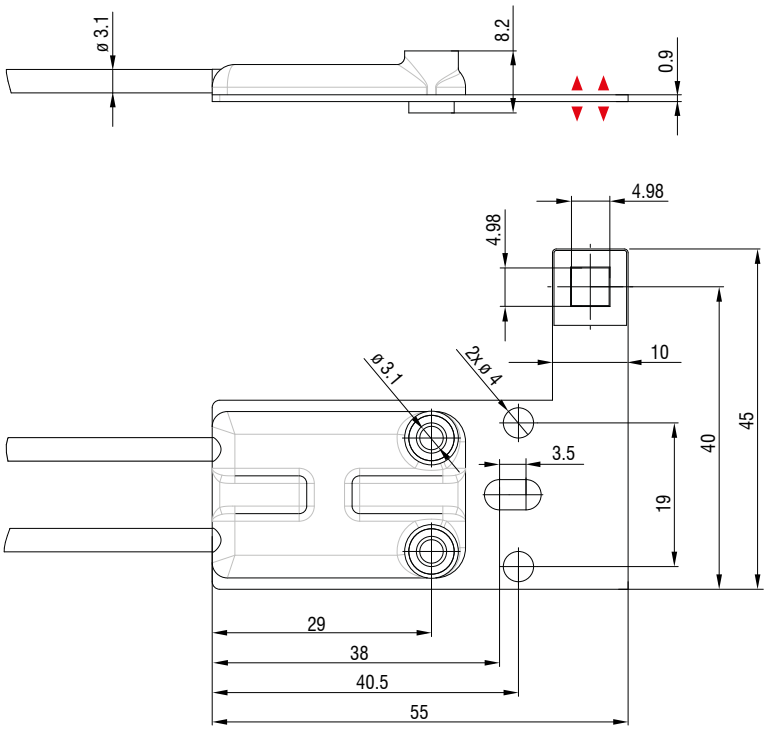


CSG-1/CRg2.0



An optional air-purge collar is available for the CSG-0.5/CRg2.0 and CSG-1/CRg2.0 capacitive gap sensors (see Accessories).

CSG-1/90/CRg2.0



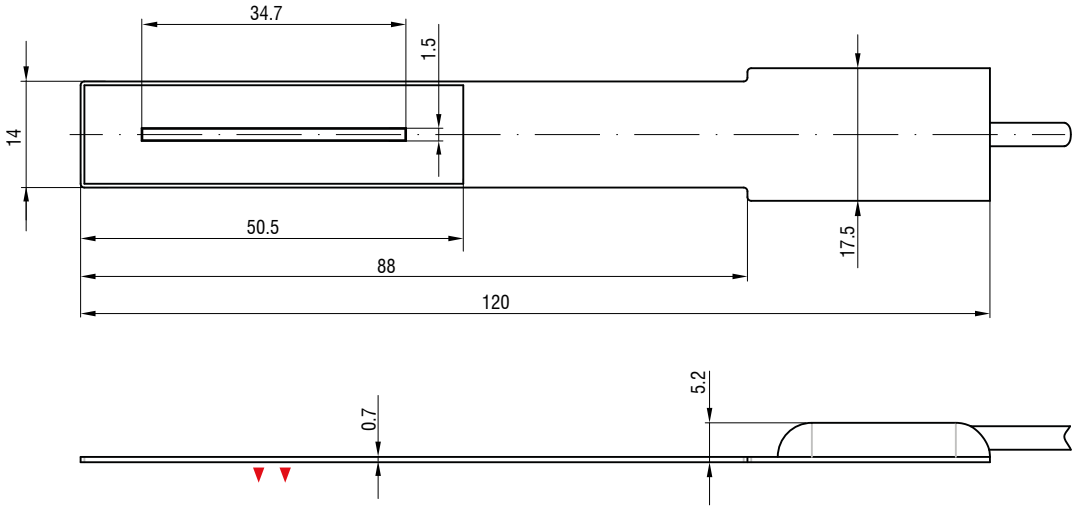
▲ ▲ Measurement direction

(dimensions in mm, not to scale)

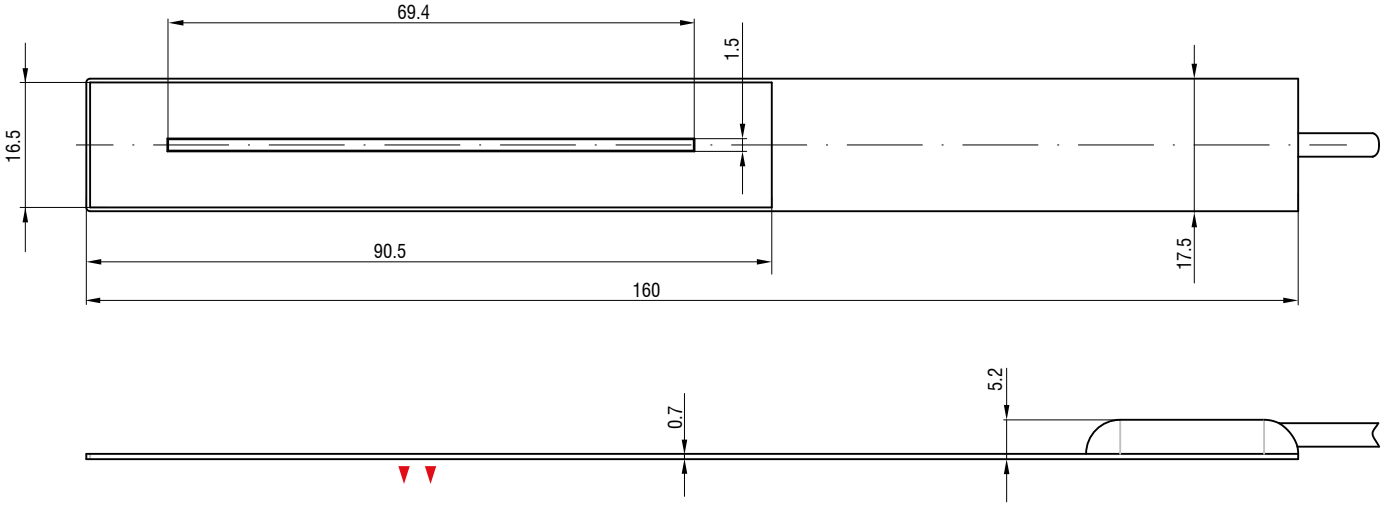
Dimensions
capaNCDT CSF

Flat sensors with integrated sensor cable

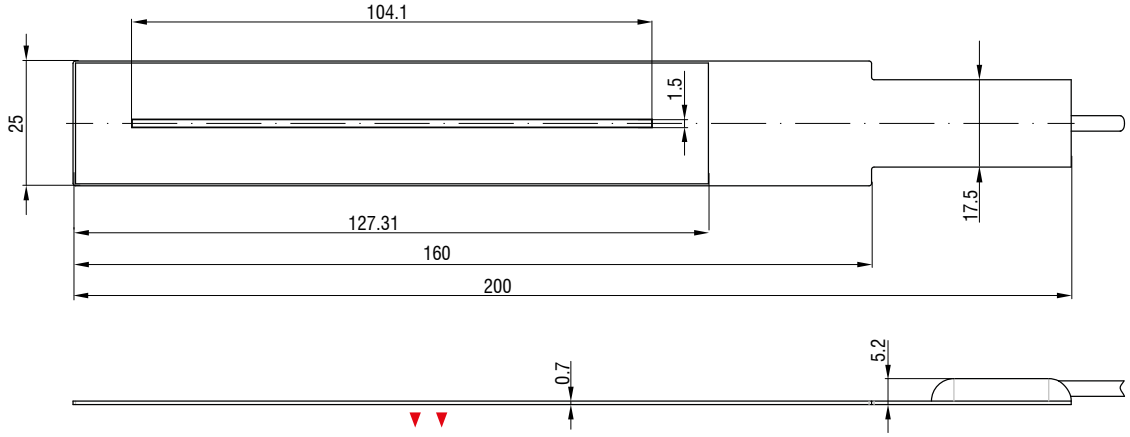
CSF2-CRg4.0



CSF4-CRg4.0

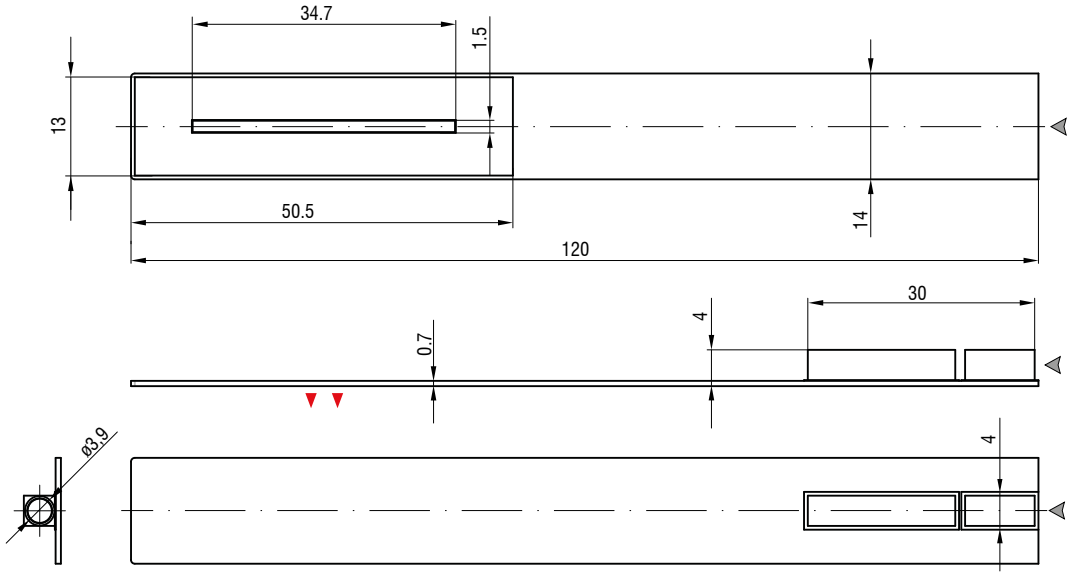


CSF6-CRg4.0

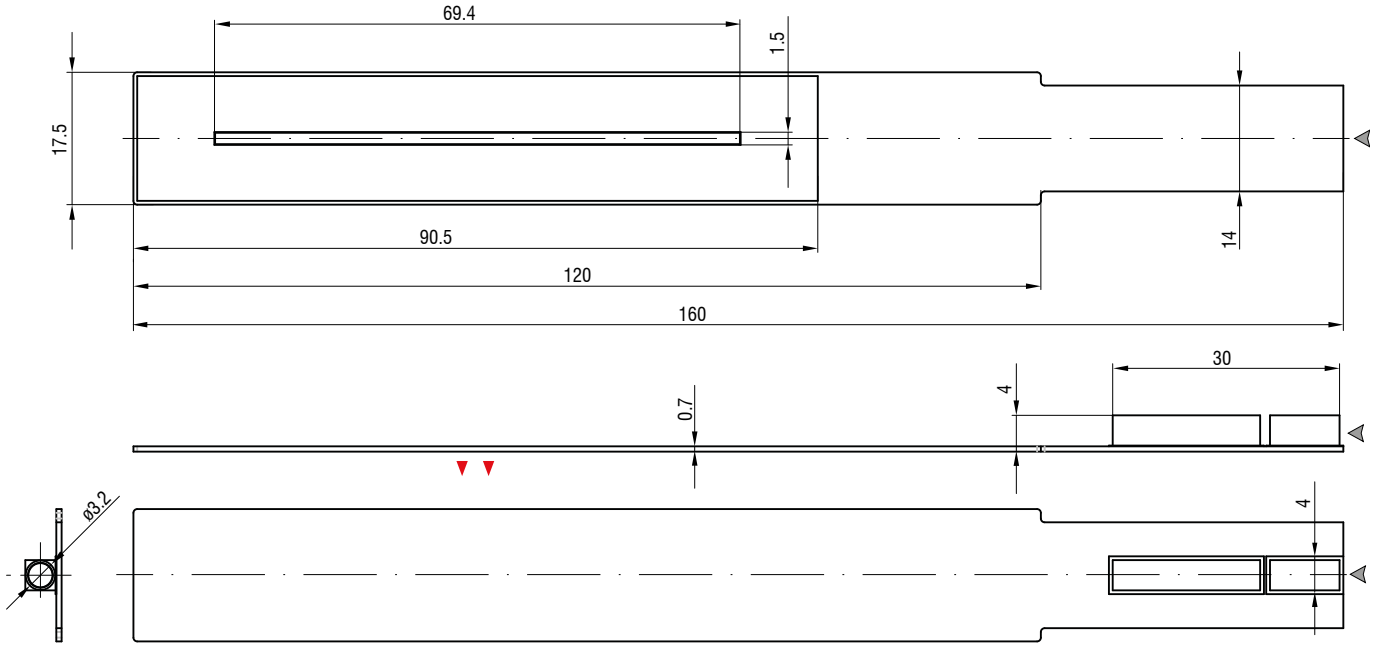


Flat sensors without integrated sensor cable

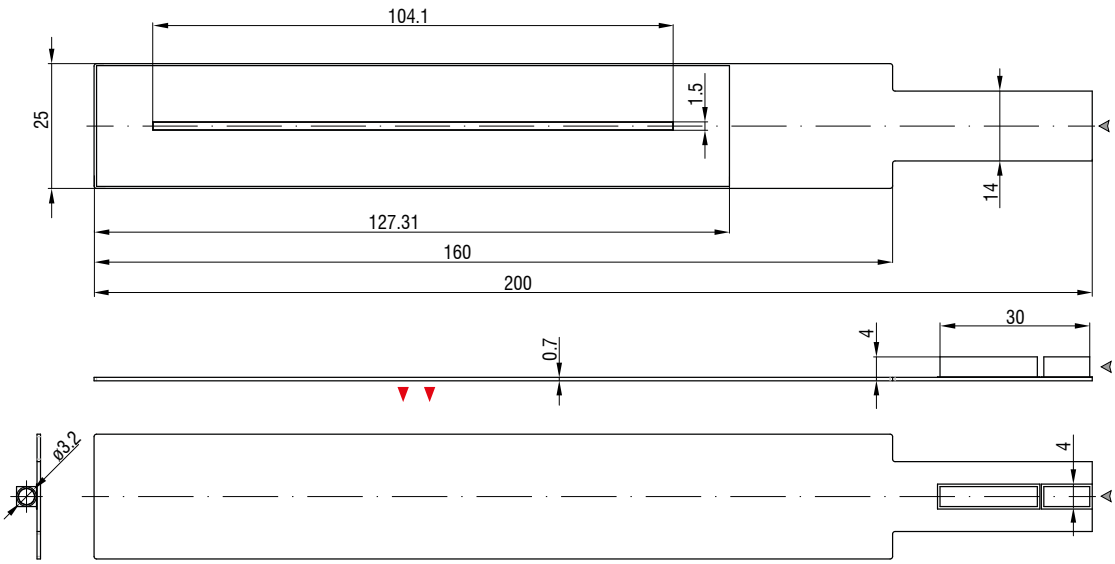
CSF2



CSF4



CSF6



▲ ▲ Measurement direction

△ Connector side

(dimensions in mm,
not to scale)

Dimensions of the connectors
capaNCDT

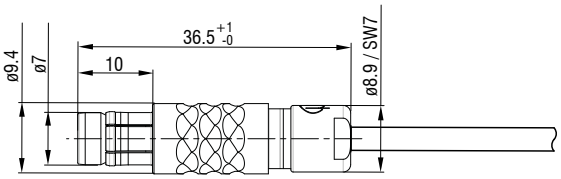
All sensors can be combined with all controllers and sensor cables. To connect the sensors, you simply need to use the correct type of connector. Micro-Epsilon will select the right sensor cable with the appropriate connectors for you during the quotation and ordering process. The following dimensional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

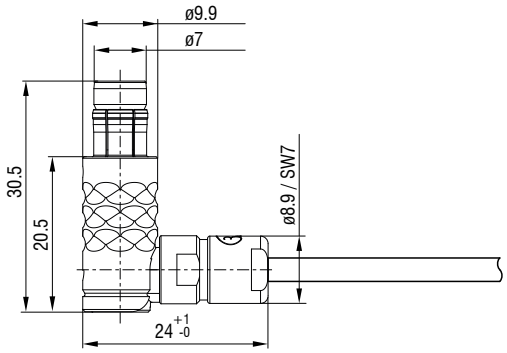
- The sensor connection varies depending on the sensor type. Depending on the model, the cable is either permanently integrated into the sensor or connected via an external sensor cable. Depending on the design and size, different connector types and sizes are used, which must be taken into account when 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

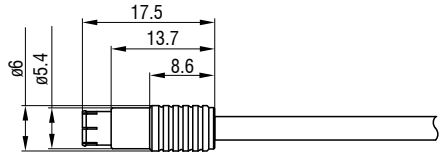
- On each sensor with an integrated cable or on one end of a sensor cable (except CSE/HT)
- For plug-in sensors with measuring ranges of ≥ 1 mm

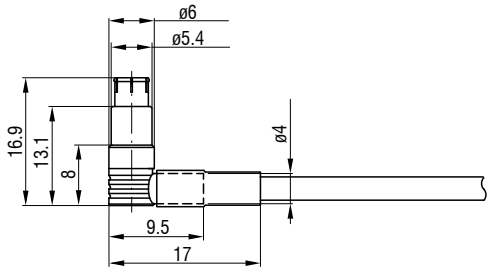




Cable with connector type C

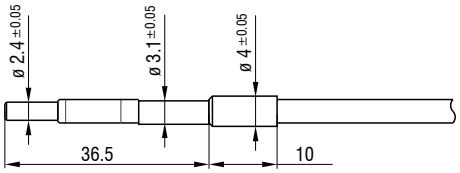
- On one end of a sensor cable
- For all plug-in sensors with measuring ranges of ≤ 1 mm





Cable with connector type E

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



Connections and combinations
capaNCDT

Controller

DT6100

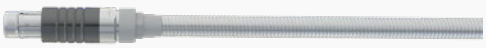
DT6200

DT6500

Sensor cable

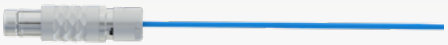
Type: CCg

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

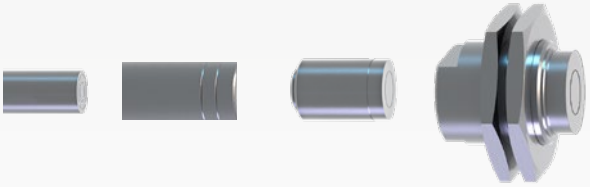
Type C connector

Type C / 90 connector

Type E connector

Sensors with socket

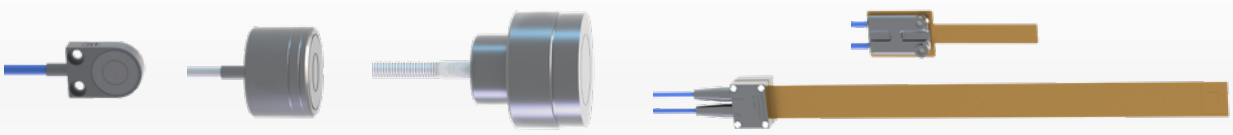
CS-x, CSE and CSE/Mx models
with a measuring range from 1 mm



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

CSF flat sensors with socket

Sensors with integrated cable



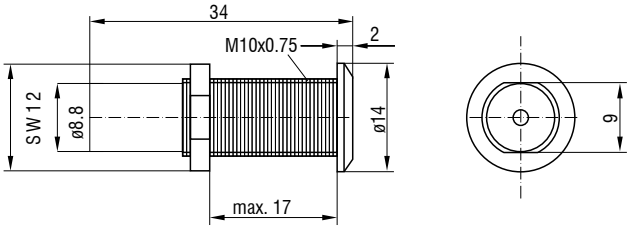
Accessories
capaNCDT

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

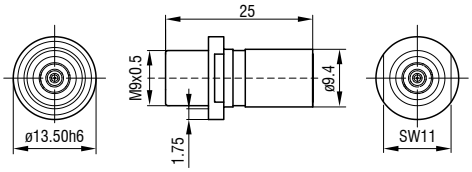
Art. no. 0323050



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

Vacuum feedthrough weldable

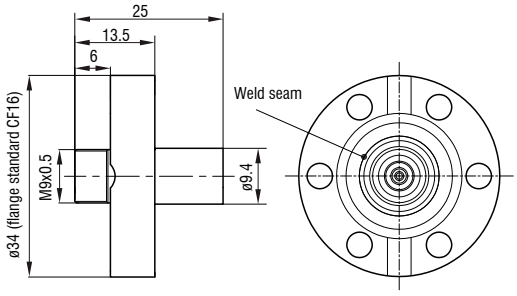
Art. no. 0323346



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

Vacuum feedthrough with flange (CF16)

Art. no. 0323349

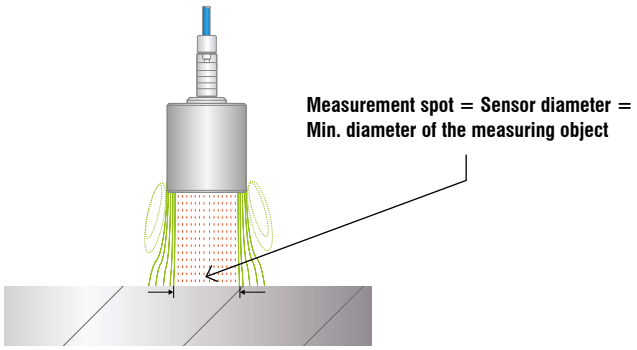


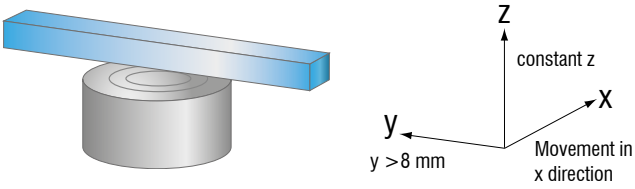
Maximum leak rate: 1 × 10^{-9} mbar·l·s^{-1}, compatible with type B connectors

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.



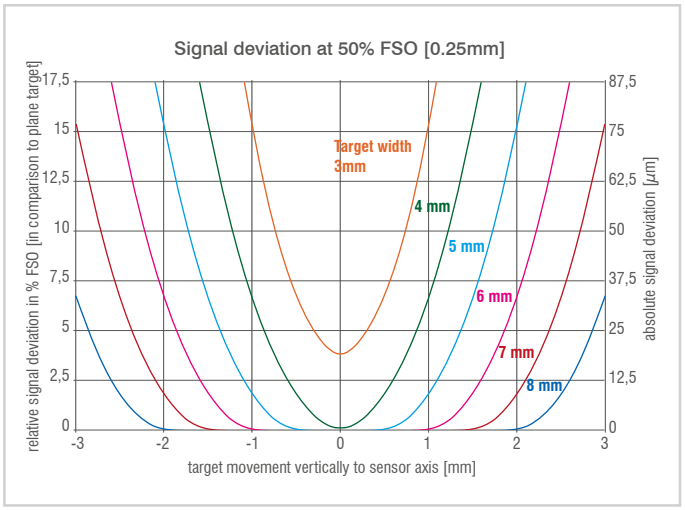


Measurement on narrow targets

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.

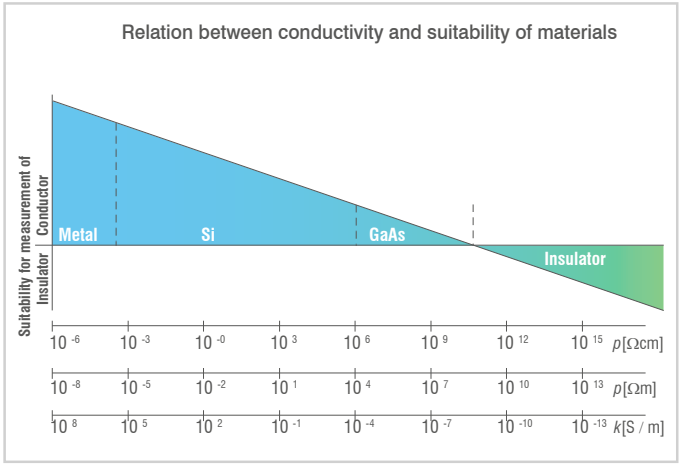
The results show that the electric field does not extend beyond the entire diameter of the sensor. This makes it possible to take precise measurements even on narrow objects.



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.

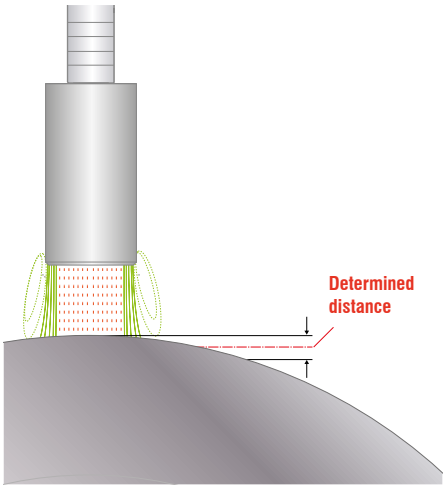
In between, there is the large range of semiconductors. Most semiconductors can be measured very well as electrical conductors. The requirement is that the capacitive part of the total impedance is still significantly larger (>10x) than the ohmic part. This is almost always the case for silicon wafers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



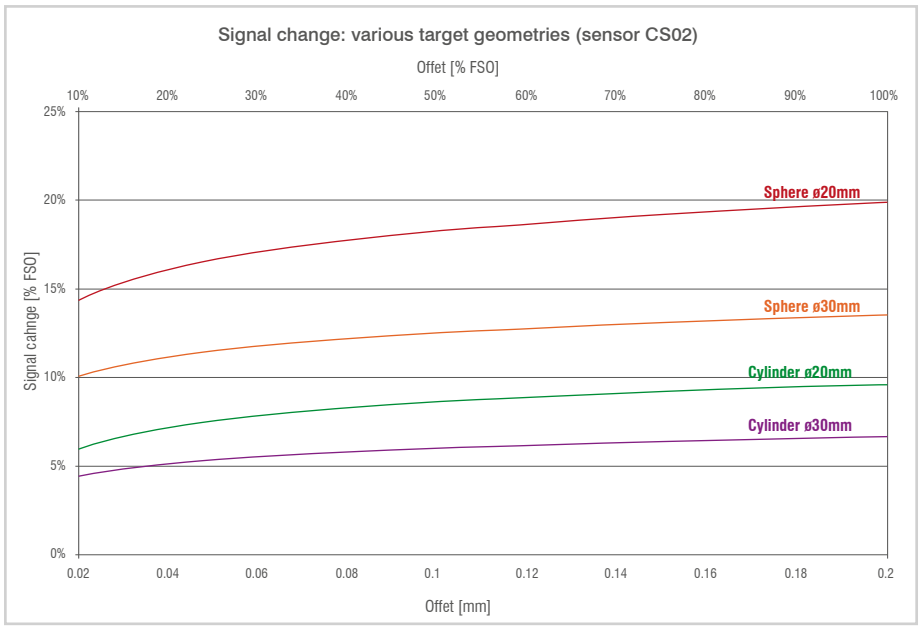
However, various adjustments are required for this, e.g. reduction of the operating frequency or a temporary, partial increase of the conductivity.

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.

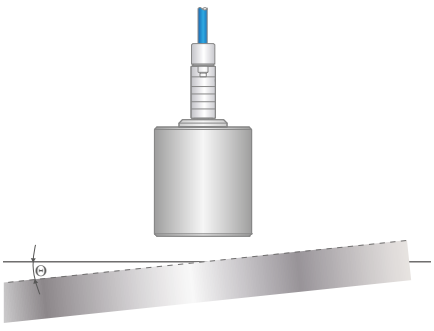


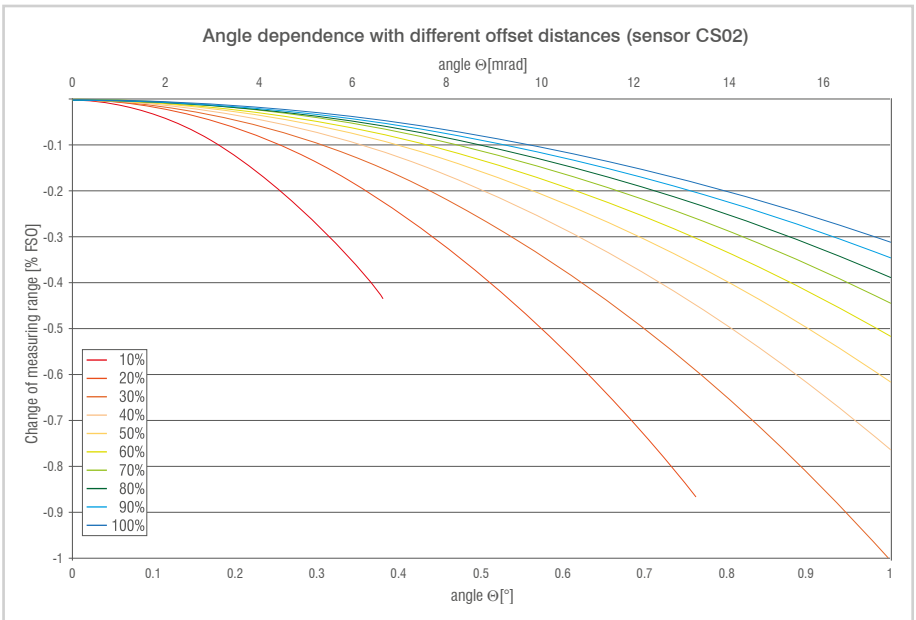
Example: For a sensor with a 200 µm measuring range and a roller with an outer diameter of 30 mm, an actual gap of 20 µm results in a measured value that is approximately 5 % higher. This corresponds to approx.10 µm of the measuring range.



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.

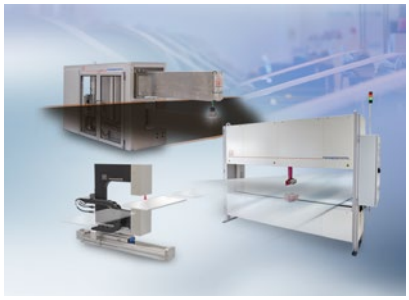




Sensors and Systems from Micro-Epsilon

Sensors and systems for displacement, distance and position

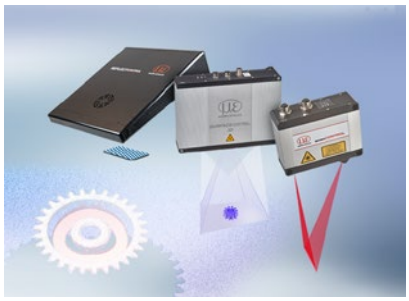
Sensors and measurement devices for non-contact temperature measurement



Measuring and inspection systems for metal strips, plastics and rubber

Optical micrometers and fiber optics, measuring and test amplifiers

Color recognition sensors, LED analyzers and inline color spectrometers



3D measurement technology for dimensional testing and surface inspection

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