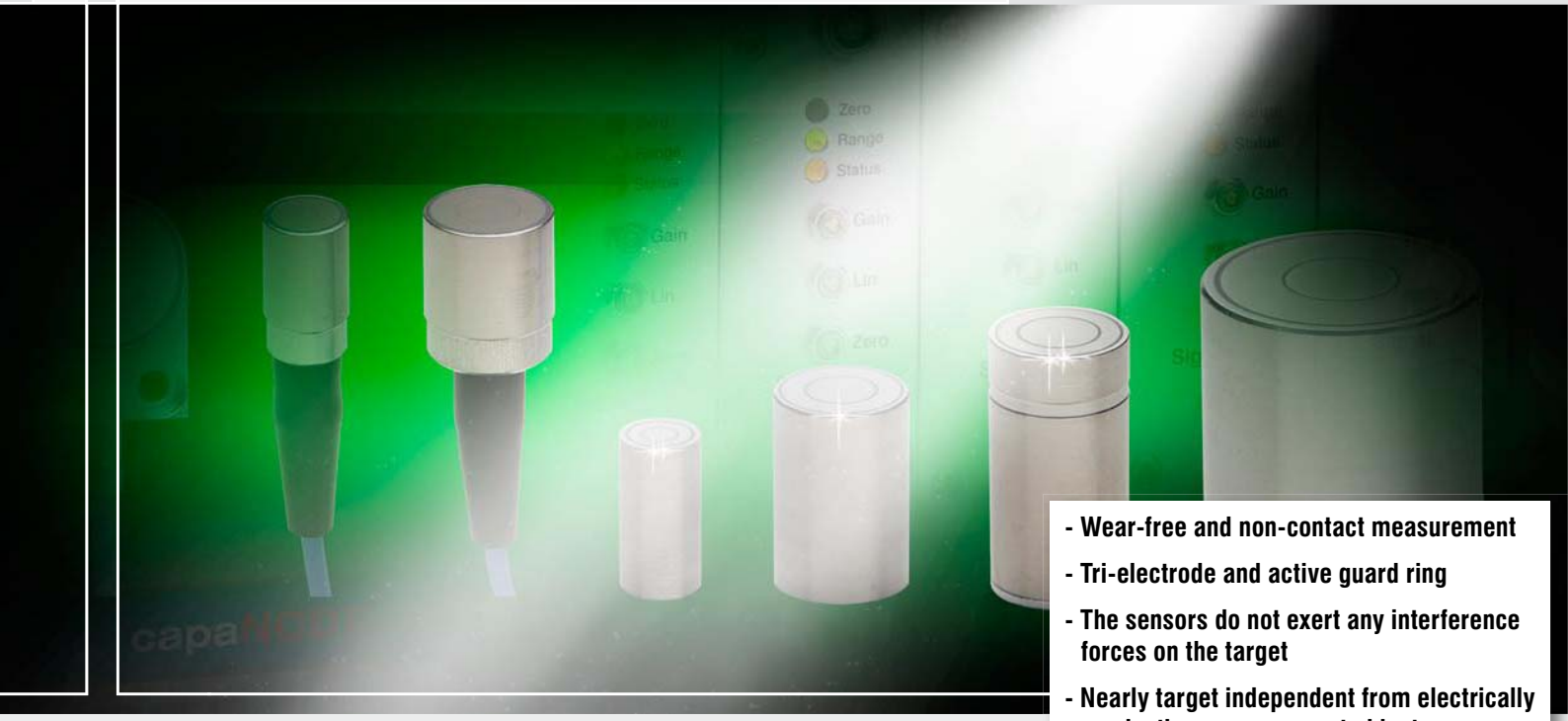
MICRO-EPSILON

More Precision.

capaNCDT

High resolution capacitive displacement sensors and systems

Measuring principle



- **Wear-free and non-contact measurement**
- **Tri-electrode and active guard ring**
- **The sensors do not exert any interference forces on the target**
- **Nearly target independent from electrically conductive measurement objects**

Measuring principle

The principle of capacitive displacement measurement using the capaNCDT (capacitive Non-Contact Displacement Transducer) system is based on how an ideal plate-type capacitor operates. The two plate electrodes are represented by the sensor and opposing measurement object. If a constant alternating current flows through the sensor capacitor, the amplitude of the alternating voltage on the sensor is proportional to the distance between the capacitor electrodes. The alternating current is demodulated and output as, for example, an analogue signal.

The capaNCDT system evaluates the reactance of the plate capacitor, which changes in direct proportion to the distance.

$$X_C = \frac{1}{j \cdot \omega \cdot C}$$

$$\text{Capacitance } C = \varepsilon_r \cdot \varepsilon_0 \cdot \frac{\text{area A}}{\text{distance d}}$$

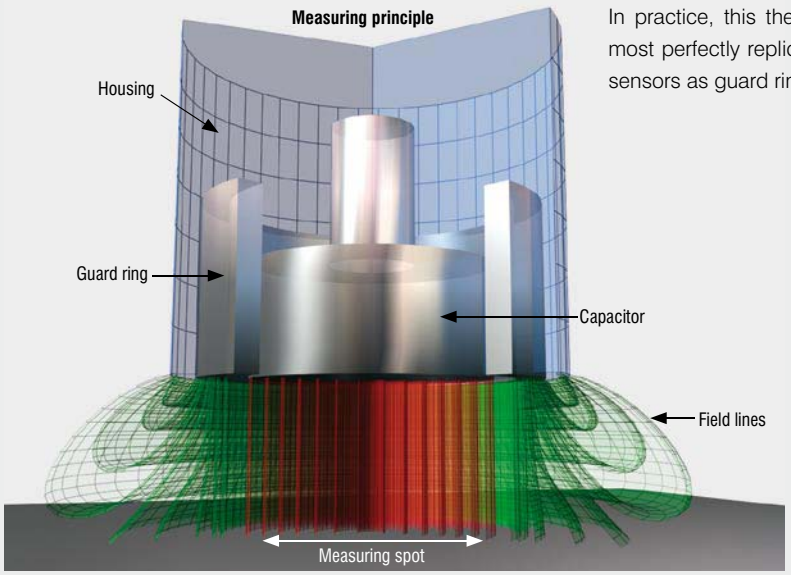
Due to the fact that $j\,\omega\,\varepsilon_r\,\varepsilon_0$ and A do not change during measurements, they are sustituted with a constant:

$$\text{constant } K = \frac{1}{j\omega\varepsilon_r\varepsilon_0 A}$$

According to that, the reactance X_C only depends from the distance:

$$X_C = \text{constant} \cdot \text{distance}$$

In practice, this theoretical relationship is almost perfectly replicated by the design of the sensors as guard ring capacitors.



Use of capacitive sensors

Capacitive sensors are always used if very high accuracy levels are required. The capacitive measuring principle is one of the most precise measurement methods for non-contact displacement measurement.

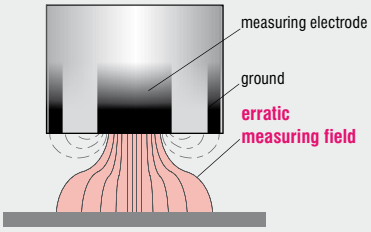
The measurement principle requires a clean environment where a change of the dielectric ε_r affects the measurement result. The sensors measure against all electrically conductive materials.

Use in a vacuum and clean room

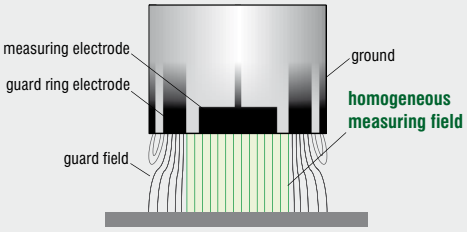
Sensors and sensor cables have proven themselves in clean rooms and under a vacuum. The extremely low gas release is responsible for this. capaNCDT Sensors for ultrahigh vacuum area (UHV) are available on request.

Active guard field for high precision measurement

Common capacitive sensors



MICRO-EPSILON capaNCDT sensors



Triaxial sensor design

The completely triaxial sensor design is unique for capaNCDT sensors, where the guard ring electrode and the grounding are also located on the front edge of the sensor as well as the measurement electrode.

This means capaNCDT sensors can also be installed completely flush in conductive materials. The sensors can also come into contact with each other in the case of multi-channel measurements. Interference of the measuring field is reliably prevented by the triaxial design of the sensor.

Active guard triaxial cable

Capacitive measurement systems from Micro-Epsilon operate with a unique, active, low noise cable in combination with an active guard ring capacitor. A particularly high quality signal is achieved due to the double shielding of the field. The system has an almost perfect impermeable electrical shield, which ensures precise measurements. In addition, the guard ring electrode provides a protected, completely homogeneous measuring field for extremely high stability and interference-free, accurate measurements.

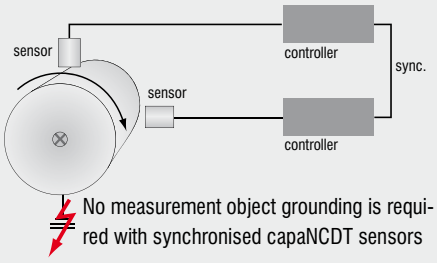
Rapid sensor replacement without calibration

The capacitive measuring principle specially developed by Micro-Epsilon enables the simple change of a sensor in just a few seconds. This simplified replacement of sensors with different measuring ranges and the interchange of different capaNCDT controllers can be easily carried out without any re-calibration. A sensor replacement normally takes around 5 seconds, unlike conventional systems, which have to be subjected to time-consuming calibration and linearisation.

Fast sensor replacement in just 5 seconds!
The interchange of various controllers and sensors in the capaNCDT series is performed rapidly without any time-consuming calibration.

Non-contact target grounding

In many applications, grounding of the target is very difficult or even impossible. Unlike conventional systems, the target for synchronisation of two capaNCDT devices does not necessarily have to be grounded. However, maximum signal quality is only achieved when the measurement object is correctly grounded. All measurement objects must be grounded for applications that use DT6019.

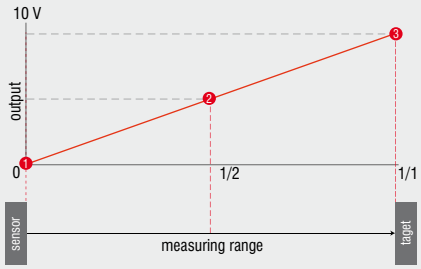


No measurement object grounding is required with synchronised capaNCDT sensors

The schematic diagram shows two synchronised capaNCDT sensors that are measuring against a roller. As the sensors are connected via Micro-Epsilon's unique synchronisation technology, grounding of the target is unnecessary in most cases.

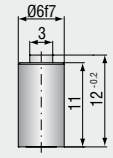
Linearisation and calibration

capaNCDT systems are calibrated at the factory for metallic targets (output 0 – 10V). The nominal output characteristic can be optimised by the user for special target materials or difficult installation conditions using the "Zero Point" potentiometer. Three-point linearisation is necessary for insulators as target. The adjustment is made using three distance points (1 = zero point, 2 = measuring range centre, 3 = measuring range end), which are defined as comparison standard.

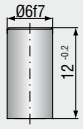


This calibration can be performed for the capaNCDT 6300 and 6500 models.

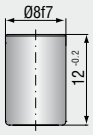
Cylindrical sensors with female connector



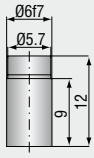
connector side



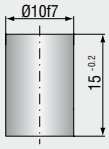
connector side



connector side



connector side



connector side

Sensor Type	CS005	CS02	CS05	CSE05	CS08
Article number	6610083	6610051	6610053	6610102	6610080
Measuring range	0.05mm	0.2mm	0.5mm	0.5mm	0.8mm
Linearity [1]	±0.2 % FSO	±0.2 % FSO	±0.05 FSO	±0.05 FSO	±0.05 FSO
Resolution [1] (static, 2Hz)	0.0375nm	0.15nm	0.375nm	0.375nm	0.6nm
Resolution [1] (dynamic, 8.5kHz)	1nm	4nm	10nm	10nm	16nm
Temperature stability zero [4]	60nm/°C	60nm/°C	60nm/°C	60nm/°C	60nm/°C
Temperature stability sensitivity	-10ppm/°C	-10ppm/°C	-10ppm/°C	-10ppm/°C	-10ppm/°C
Temperature range (operation)	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C
Temperature range (storage)	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C
Air humidity [2]	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.
Sensor dimensions	Ø6 × 12mm	Ø6 × 12mm	Ø8 × 12mm	Ø6 × 12mm	Ø10 × 15mm
Active measuring area	Ø1.3mm	Ø2.3mm	Ø3.9mm	Ø3.9mm	Ø4.9mm
Guard ring width	0.8mm	1mm	1.4mm	0.8mm	1.6mm
Minimum target diameter	Ø3mm	Ø5mm	Ø7mm	Ø6mm	Ø9mm
Weight	2g	2g	4g	2g	7g
Material (housing)	NiFe [3] (magn.)	NiFe (magn.)	NiFe (magn.)	NiFe (magn.)	NiFe (magn.)
Connector type	type C	type C	type C	type C	type C
Mounting	radial clamp	radial clamp	radial clamp	radial clamp	radial clamp

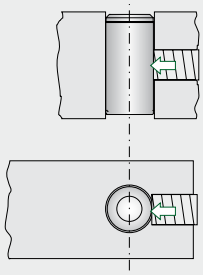
Sensors suitable for controller	6019	-	●	●	●	●
	6100	-	●	●	●	●
	6200	●	●	●	●	●
	6300/6310	●	●	●	●	●
	6350	-	●	●	●	-
	6500	●	●	●	●	●

FSO = Full Scale Output
[1] With controller DT6530
[2] Non condensing
[3] Titanium version available
[4] Sensor mounted in the mid of clamping area

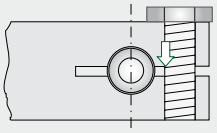
Mounting cylindrical sensors

All sensors can be installed as either freestanding or flush mounted.
Fastening is carried out using a clamp or collet.

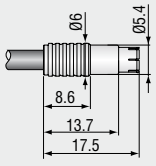
Mounting with grub screw (plastic)



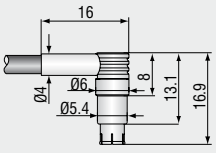
Mounting with collet



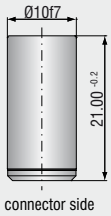
Connector type C

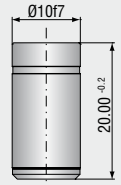


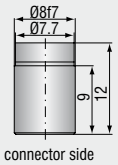
Connector type C/90

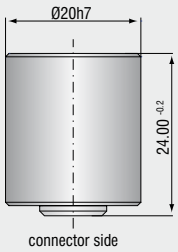


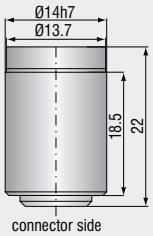
Cylindrical sensors with female connector







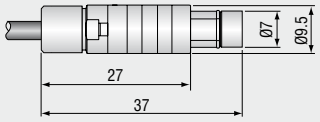




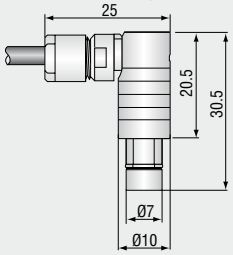
Sensor Type	CS1	CS1HP	CSE1	CS2	CSE2
Article number	6610054	6610074	6610103	6610052	6610104
Measuring range	1mm	1mm	1mm	2mm	2mm
Linearity [1]	±0.05 FSO	±0.05 % FSO	±0.05 % FSO	±0.05 % FSO	±0.05 % FSO
Resolution [1] (static, 2Hz)	0.75nm	0.75nm	0.75nm	1.5nm	1.5nm
Resolution [1] (dynamic, 8.5kHz)	20nm	20nm	20nm	40nm	40nm
Temperature stability zero [4]	170nm/°C	60nm/°C	60nm/°C	170nm/°C	170nm/°C
Temperature stability sensitivity	-32ppm/°C	-10ppm/°C	-10ppm/°C	-32ppm/°C	-32ppm/°C
Temperature range (operation)	-50 … +200°C	-50 … +200°C	-50 … +200 °C	-50 … +200°C	-50 … +200 °C
Temperature range (storage)	-50 … +200°C	-50 … +200°C	-50 … +200 °C	-50 … +200°C	-50 … +200 °C
Air humidity [2]	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.
Sensor dimensions	Ø10 × 21mm	Ø10 × 20mm	Ø8 × 12mm	Ø20 × 24mm	Ø14 × 22mm
Active measuring area	Ø5.7mm	Ø5.7mm	Ø5.7mm	Ø7.9mm	Ø8.0mm
Guard ring width	1.5mm	1.5mm	0.9mm	4.4mm	2.7mm
Minimum target diameter	Ø9mm	Ø9mm	Ø8mm	Ø17mm	Ø14mm
Weight	8g	8g	3.5g	50g	20g
Material (housing)	1.4404 [3] (non-magn.)	NiFe (magn.)	NiFe (magn.)	1.4404 [3] (non-magn.)	1.4404 (non-magn.)
Connector type	type B	type B	type C	type B	type B
Mounting	radial clamp	radial clamp	radial clamp	radial clamp	radial clamp
Sensors suitable for controller 6019	●	●	●	●	●
6100	●	●	●	●	●
6200	●	●	●	●	●
6300/6310	●	●	●	●	●
6350	●	●	●	●	●
6500	●	●	●	●	●

FSO = Full Scale Output
[1] With controller DT6530
[2] Non condensing
[3] Titanium version available
[4] Sensor mounted in the mid of clamping area

Connector type B



Connector type B/90



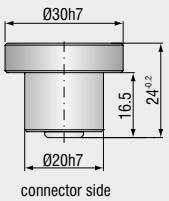
Sensors

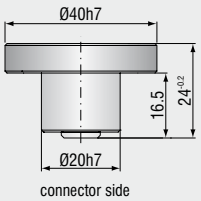
The sensors are designed as guard ring capacitors. They are connected to the signal conditioning electronics with a triaxial cable. The sensor cable is connected to the sensor using a high quality connector. All standard sensors can be used within a maximum deviation of 0.3% without recalibration. Individually matched special sensors are produced on request.

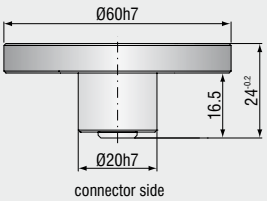
Measuring range expansion / reduction

The capaNCDT controller (except the series DT6019) can optionally be configured so that the standard measuring ranges of the sensors are reduced by half or expanded by the factor of 2. The reduction increases the accuracy while the measuring range expansion reduces the accuracy.

Cylindrical sensors with female connector





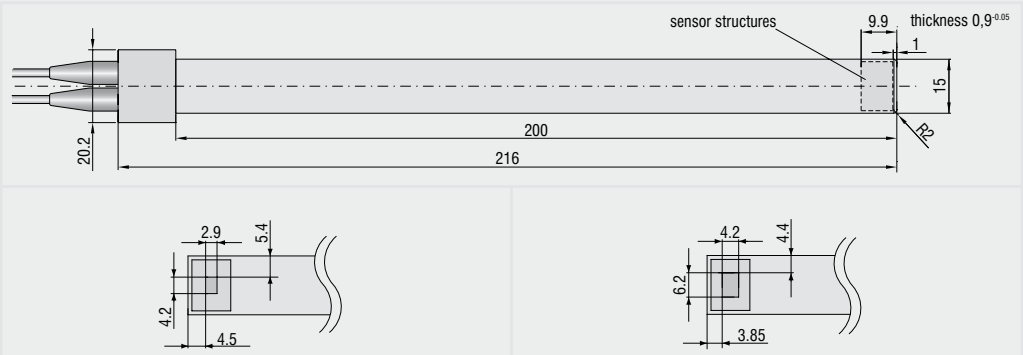


Sensor Type	**CS3**	**CS5**	**CS10**
Article number	6610055	6610056	6610057
Measuring range	3mm	5mm	10mm
Linearity [1]	±0.05 % FSO	±0.05 % FSO	±0.05 % FSO
Resolution [1] (static, 2Hz)	2.25nm	3.75nm	7.5nm
Resolution [1] (dynamic, 8.5kHz)	60nm	100nm	200nm
Temperature stability zero [4]	170nm/°C	170nm/°C	170nm/°C
Temperature stability sensitivity	-32ppm/°C	-32ppm/°C	-32ppm/°C
Temperature range (operation)	-50 … +200°C	-50 … +200°C	-50 … +200°C
Temperature range (storage)	-50 … +200°C	-50 … +200°C	-50 … +200°C
Air humidity [2]	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.
Sensor dimensions	Ø30 × 24mm	Ø40 × 24mm	Ø60 × 24mm
Active measuring area	Ø9.8mm	Ø12.6mm	Ø17.8mm
Guard ring width	8mm	11.6mm	19mm
Minimum target diameter	Ø27mm	Ø37mm	Ø57mm
Weight	70g	95g	180g
Material (housing)	1.4404 (non-magn.)	1.4404 [3] (non-magn.)	1.4404 [3] (non-magn.)
Connector type	type B	type B	type B
Mounting	radial clamp	radial clamp	radial clamp

Sensors suitable for controller	6019	●	●	●
	6100	●	●	●
	6200	●	●	●
	6300/6310	●	●	●
	6350	●	●	●
	6500	●	●	●

FSO = Full Scale Output
[1] With controller DT6530
[2] Non condensing
[3] Titanium version available
[4] Sensor mounted in the mid of clamping area

Flat sensors with connector

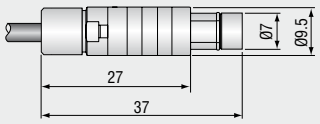


Sensor Type	CSG0,50-CAm2,0	CSG1,00-CAm2,0
Article number	6610112	6610111
Measuring range	0.5mm	1mm
Gap width [1]	0.9 - 1.9mm	0.9 - 2.9mm
Linearity [1]	±0.1% FSO	±0.1% FSO
Resolution [1] (static, 2Hz)	4nm	8nm
Resolution [1] (dynamic, 8.5kHz)	90nm	180nm
Temperature stability zero	50nm/°C	50nm/°C
Temperature stability sensitivity	-40ppm/°C	-40ppm/°C
Temperature range (operation)	-50…+100°C	-50 …+100°C
Temperature range (storage)	-50…+100°C	-50…+100°C
Air humidity [2]	0…95%	0…95%
Sensor dimensions	200 x 15 x 0.9mm	200 x 15 x 0.9mm
Active measuring area	3 x 4.3mm	4.2 x 5.1mm
Guard ring width	2.7mm	2.2mm
Minimum target diameter	approx. 7 x 8mm	approx. 8 x 9mm
Weight	77g	77g
Material (housing)	1.4301	1.4301
Material (sensor)	FR4	FR4
Integrated cable	2m	2m

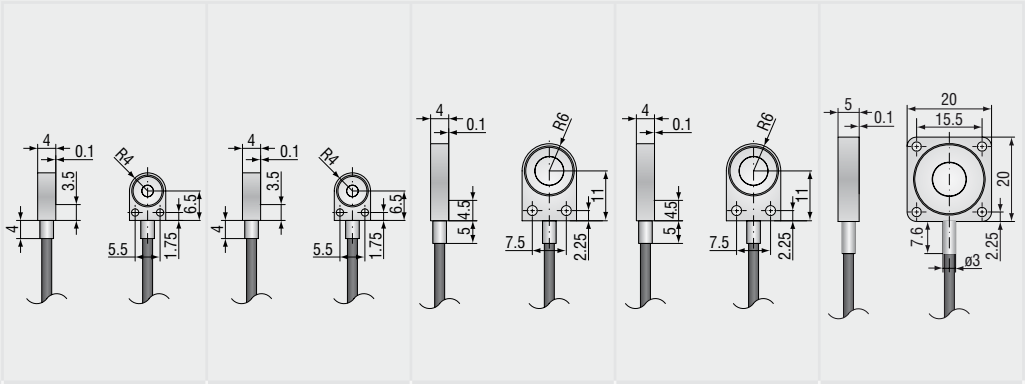
Sensors suitable for controller	6019	-	-
	6100	●	●
	6200	●	●
	6300/6310	●	●
	6350	●	●
	6500	●	●

[1] Sensor width + measuring range on both sides
[2] With controller DT6530
[3] Non condensing

Connector type B



Flat sensors with integrated cable



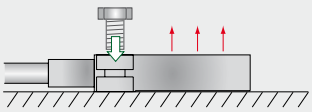
Sensor Type	CSH02FL-CRm1,4	CSH05FL-CRm1,4	CSH1FL-CRm1,4	CSH1,2FL-CRm1,4	CSH2FL-CRm1,4
Article number	6610075	6610085	6610072	6610077	6610094
Measuring range	0.2mm	0.5mm	1mm	1.2mm	2mm
Linearity [1]	±0.05 % FSO	±0.05 % FSO	±0.05 % FSO	±0.05 % FSO	±0.05 % FSO
Resolution [1] (static, 2Hz)	0.15nm	0.38nm	0.75nm	0.9nm	1.5nm
Resolution [1] (dynamic. 8.5kHz)	4nm	10nm	20nm	24nm	40nm
Temperature stability zero [4]	-37.6 / 2.4nm/°C	-37.6 / 2.4nm/°C	-37.6 / 2.4nm/°C	-37.6 / 2.4nm/°C	-47 / 4nm/°C
Temperature stability sensitivity	-12 ppm/°C	-12 ppm/°C	-12 ppm/°C	-12 ppm/°C	-12 ppm/°C
Temperature range (operation)	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C
Temperature range (storage)	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C
Air humidity [2]	0 … 95% r.H.	0 … 95% r.H	0 … 95% r.H	0 … 95% r.H	0 … 95% r.H
Sensor dimensions	10.5 × 8 × 4mm	10.5 × 8 × 4mm	17 × 12 × 4mm	17 × 12 × 4mm	20 × 20 × 5mm
Active measuring area	Ø2.6mm	Ø4.1mm	Ø5.7mm	Ø6.3mm	Ø8.1mm
Guard ring width	Ø1.9mm	Ø1.2mm	Ø2.4mm	Ø2.1mm	Ø4.4mm
Minimum target diameter	Ø7mm	Ø7mm	Ø11mm	Ø11mm	Ø17mm
Weight (incl. cable and connector)	28g	28g	30g	30g	36g
Material (housing)	1.4104 (magn.)	1.4104 (magn.)	1.4104 (magn.)	1.4104 (magn.)	1.4104 (magn.)
Integrated cable	Ø2.1mm×1.4m radial	Ø2.1mm×1.4m radial	Ø2.1mm×1.4m radial	Ø2.1mm×1.4m radial	Ø2.1mm×1,4m radial
Mounting	2x thread M2	2x thread M2	2x screw M2 DIN 84A	2x screw M2 DIN 84A	4x screw M2 DIN 84A
Sensors suitable for controller [5] 6019	-	-	-	-	-
6100	●	●	●	●	●
6200	●	●	●	●	●
6300/6310	●	●	●	●	●
6350	●	●	●	●	●
6500	●	●	●	●	●

FSO = Full Scale Output
[1] With controller DT6530
[2] Non condensing
[3] Without cable, bend protection and crimp
[4] In the case of a sensor mounting on the top and underside
[5] CSH Sensors are matched to controller with standard cable length 1m

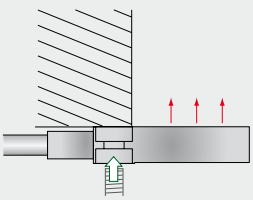
Mounting flat sensors

The flat sensors are attached using a threaded bore for M2 (for the sensors CSH02FL and CSH05FL) or using a through-hole for M2 bolts. The sensors can be bolted from above or below.

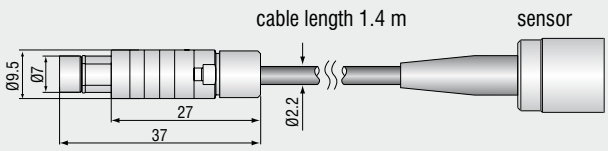
Screw connection from above on the underside



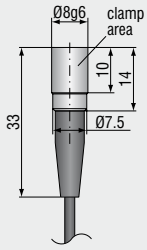
Screw connection from below on the sensor top side

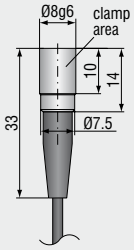


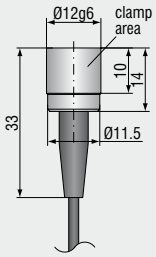
Connector for integrated cables

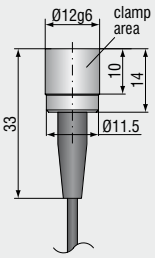


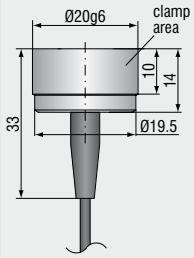
Cylindrical sensors with integrated cable











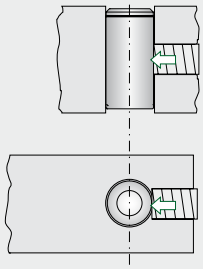
Sensor Type		CSH02-CAm1,4	CSH05-CAm1,4	CSH1-CAm1,4	CSH1,2-CAm1,4	CSH2-CAm1,4
Article number		6610086	6610087	6610088	6610089	6610107
Measuring range		0.2mm	0.5mm	1mm	1.2mm	2mm
Linearity [1]		±0.05 % FSO	±0.05 % FSO	±0.05 % FSO	±0.05 % FSO	±0.05 % FSO
Resolution [1] (static, 2Hz)		0.15nm	0.38nm	0.75nm	0.9nm	1.5nm
Resolution [1] (dynamic. 8.5kHz)		4nm	10nm	20nm	24nm	40nm
Temperature stability zero [4]		-19nm/°C	-19nm/°C	-19nm/°C	-19nm/°C	-19nm/°C
Temperature stability sensitivity		-12ppm/°C	-12ppm/°C	-12ppm/°C	-12ppm/°C	-12ppm/°C
Temperature range (operation)		-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C
Temperature range (storage)		-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C	-50 … +200°C
Air humidity [2]		0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.	0 … 95% r.H.
Sensor dimensions		Ø8 × 14mm	Ø8 × 14mm	Ø12 × 14mm	Ø12 × 14mm	Ø20 × 14mm
Active measuring area		Ø2.6mm	Ø4.1mm	Ø5.7mm	Ø6.3mm	Ø8.1mm
Guard ring width		1.9mm	1.2mm	2.4mm	2.1mm	4.4mm
Minimum target diameter		Ø7mm	Ø7mm	Ø11mm	Ø11mm	Ø17mm
Weight (incl. cable and connector)		30g	30g	33g	33g	38g
Material (housing)		1.4104 (magn.)	1.4104 (magn.)	1.4104 (magn.)	1.4104 (magn.)	1.4104 (magn.)
Integrated cable		Ø2.1mm×1.4m axial	Ø2.1mm×1.4m axial	Ø2.1mm×1.4m axial	Ø2.1mm×1.4m axial	Ø2.1mm×1.4m axial
Mounting		radial clamp	radial clamp	radial clamp	radial clamp	radial clamp
Sensors suitable for controller [5]	6019	-	-	-	-	-
	6100	●	●	●	●	●
	6200	●	●	●	●	●
	6300/6310	●	●	●	●	●
	6350	●	●	●	●	●
	6500	●	●	●	●	●

FSO = Full Scale Output
[1] With controller DT6530
[2] Non condensing
[3] Without cable, bend protection and crimp
[4] Sensor mounted 2mm behind front surface
[5] CSH Sensors are matched to controller with standard cable length 1m

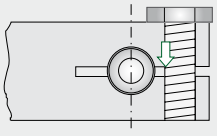
Mounting cylindrical sensors

All sensors can be installed as both freestanding and flush units.
Fastening is carried out by using a clamp or collet.

Mounting with grub screw (plastic)



Mounting with collet



Important!
All Micro-Epsilon sensors are short circuit proof. Unlike other systems the pre-amplifier will not get damaged, if the front face of the sensor gets shorted by touching the conductive target