Technical Note

Piezo · Nano · Positioning

BSc, BRo, 2011-04-05
D510T0001, valid for D-510

D-510 PISeca Single-Electrode Capacitive Sensor Probe

Fig. 1: D-510 Single-Electrode Capacitive Sensor probe with E-852.10 signal conditioner electronics

The D-510 Single-Electrode Capacitive Sensor probes are designed for non-contact measurements of distance, position or motion against any kind of electrically conductive target.

D-510 sensor probes can be used with the following electronics provided by PI:

- E-852 signal conditioner electronics. For details see the E-852 User Manual, PZ180E.
- E-509.E3 position servo-control module and E-509.E03 signal conditioner module. For details see the E-509 User Manual, PZ77E.
- E-711.SE3 module for PISeca capacitive single-electrode sensors, 3 channels, for E-712 modular, digital controller system. For details see the E-712 User Manual, PZ195E.

Contents:

Unpacking

D-510 Sensor probe as ordered

The cable for the connection of the sensor probe with the electronics is not included. Because of calibration, the sensor probe and the cable should be ordered together. The following cables are available:

D-891.01E Sensor cable PISeca, 1 m
D-891.02E Sensor cable PISeca, 2 m
D-891.01A Sensor cable PISeca, right-angle connector, 1 m
D-891.02A Sensor cable PISeca, right-angle connector, 2 m

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General Considerations

The performance of a capacitive sensor depends mainly on flatness of the target, mounting parallelism and centricity.
The sensor probe should be mounted with the utmost care in regard to parallelism and correct mounting distance to achieve highest accuracy.
In regard to best linearity, a surface's roughness of better than N4 is suggested.

Please consider the following:

1. The PISeca system measures changes in capacitance between the sensor probe and a conductive, grounded target surface. The target or structure under test should provide a noise-free, low-impedance return path. To verify that a proper return path is present, connect a ground lead directly from the target to the ground connector on the electronics.
2. To minimize the capacitive influence of the connecting triaxial cable make the target the moving part of the system.
3. Parallelism can influence the linearity and also the gain factor. The target ground plate must be mounted parallel to the sensor surface.
4. The target area size should be considerably larger than the sensor area (by approx. 50%) .
5. Measurement against a semi-conductor target connected to ground is also possible.

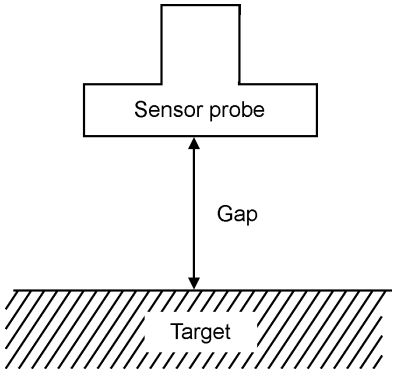

Fig. 2: Definitions of "gap" and "target"

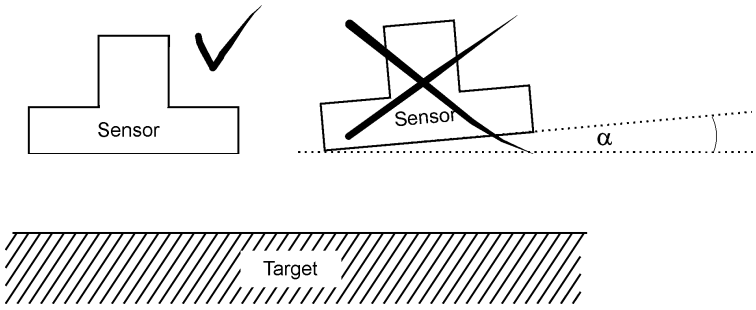

Fig. 3: Mounting parallelism: the tilt angle α (see Influence of Parallelism on Linearity on p.4)

Calibrated System

Do not interchange electronics, connecting cable and/or sensor probe when they have been calibrated together. Respect the assignment of the sensor probe and cable to the individual channel of the electronics, as indicated by the serial numbers on the labels affixed to the devices.

In the calibrated range the minimum probe-to-target gap equals 50% and the maximum gap 150% of the range value (see *Fig. 6*).

If not ordered otherwise the following is valid for calibration:

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Environmental conditions:..... room temperature 22°C
Parallelism probe surface to target surface:..... tilt under 0.7 mrad

See calibration sheet for details.

NOTES

Read the User Manual of the electronics for details on calibration and measurement ranges.

Differing from the standard calibration routine the D-510.021 sensor probe is calibrated in the 1-fold range for a measurement range from 15 to 30 µm.

Mounting

The sensor can be clamped by the 8 mm shaft.
Mounting examples:

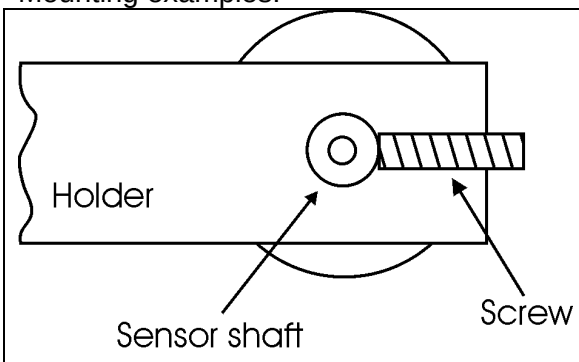

Fig. 4: Clamping: use plastic or nylon screw to avoid damage to the probe

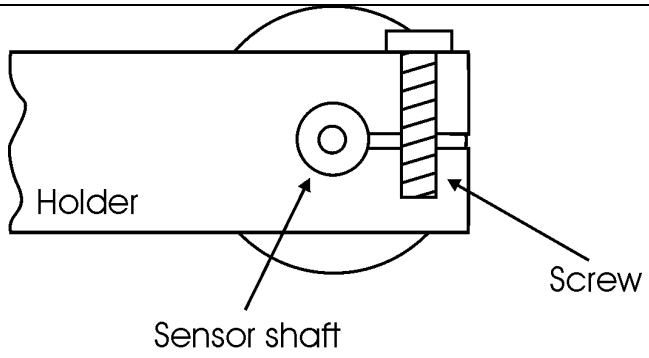

Fig. 5: Fixture with set screw

The probe fixture must have good mechanical stability and alignment, and a good connection to ground is recommended. The fixture must hold the probe securely and keep the probe face parallel to the target surface. Probe tilt causes measurement errors.
Motion of connecting cables has a strong influence on the results and should be avoided. Therefore, if possible, the sensor probe should always be the part of the application that is at rest and the target the moving part.

The probe should be mounted to meet the following important conditions:

1. The minimum probe-to-target gap is 50% of the selected measurement range
2. The minimum allowable probe-to-target gap is 10 µm. At minimum excursion, a probe-to-target gap of 15 µm is recommended.
3. At maximum excursion, the probe-target gap must not exceed 150% of the full probe range

Example: A D-510.100 was calibrated for a 200 µm measurement range. It should be mounted with a minimum probe-to-target gap of 100 µm and a maximum gap of 300 µm.

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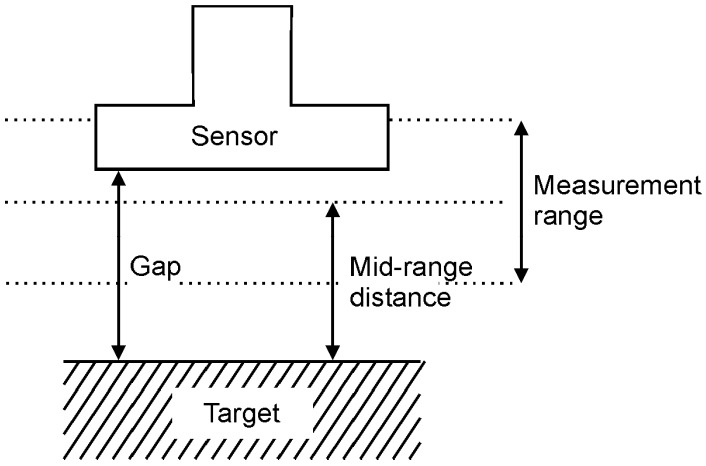

Fig. 6: Relation of measurement range and probe-to-target gap; measurement range and mid-range distance have identical values

Before performing a measurement, ensure that the probe and target under test are clean and free of contamination.

Influence of Parallelism on Linearity

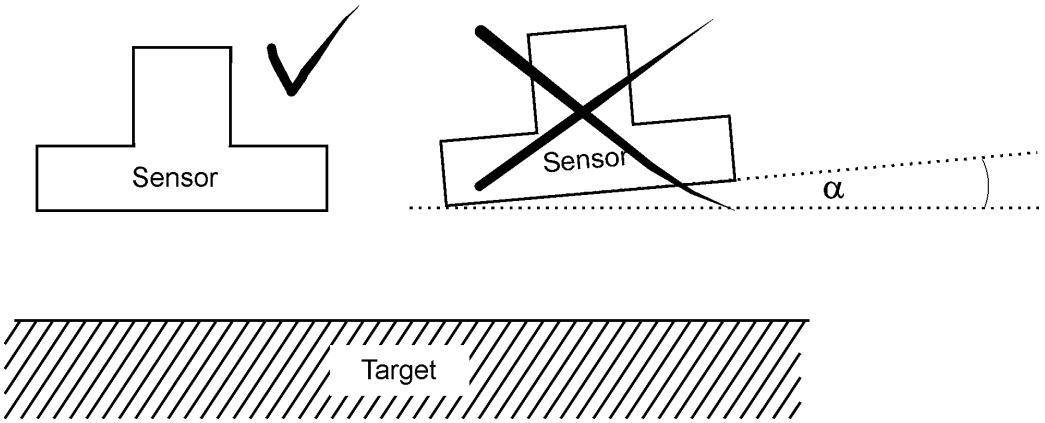

Fig. 7: Mounting parallelism: influence of the tilt angle α on the linearity. α is given in µrad in the graphs below

The following graphs show the influence of angular misalignment of the sensor plate on the linearity of the output signal as a percentage of output voltage over full travel range. “Range 2x / 5x” refers to the measurement extension factors (see User Manual of the electronics for more information).

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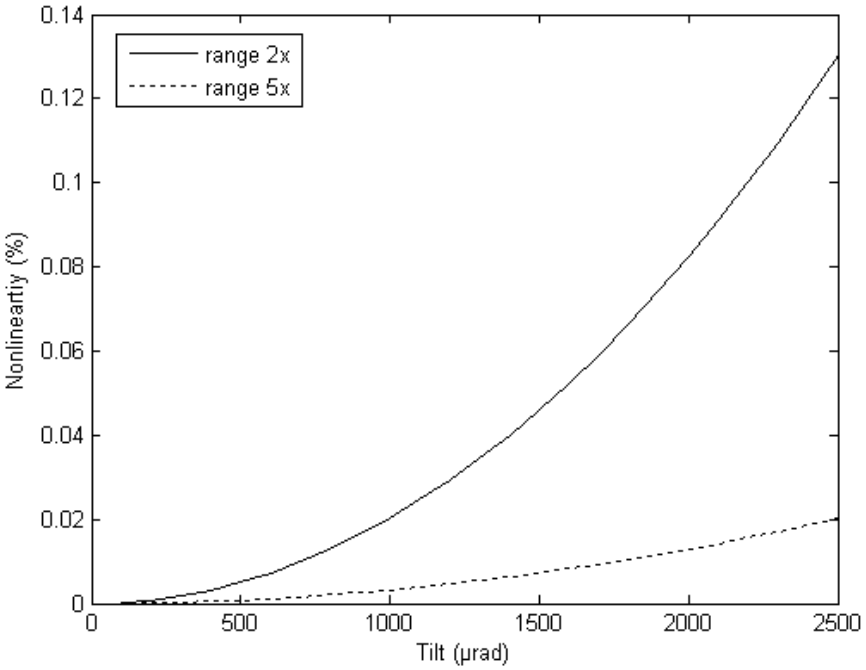

Fig. 8: D-510.021: influence of tilt on the output signal

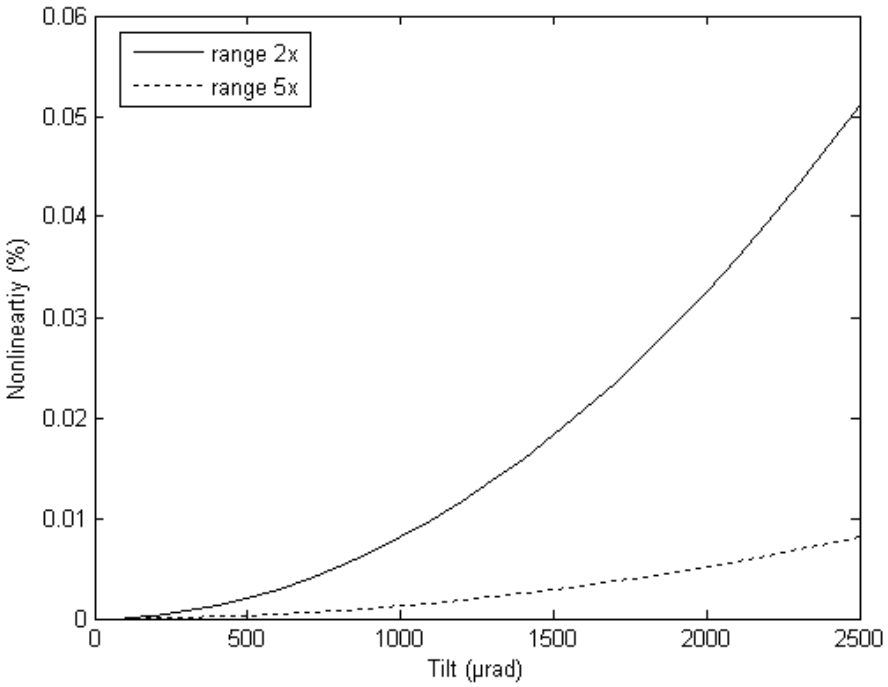

Fig. 9: D-510.051: influence of tilt on the output signal

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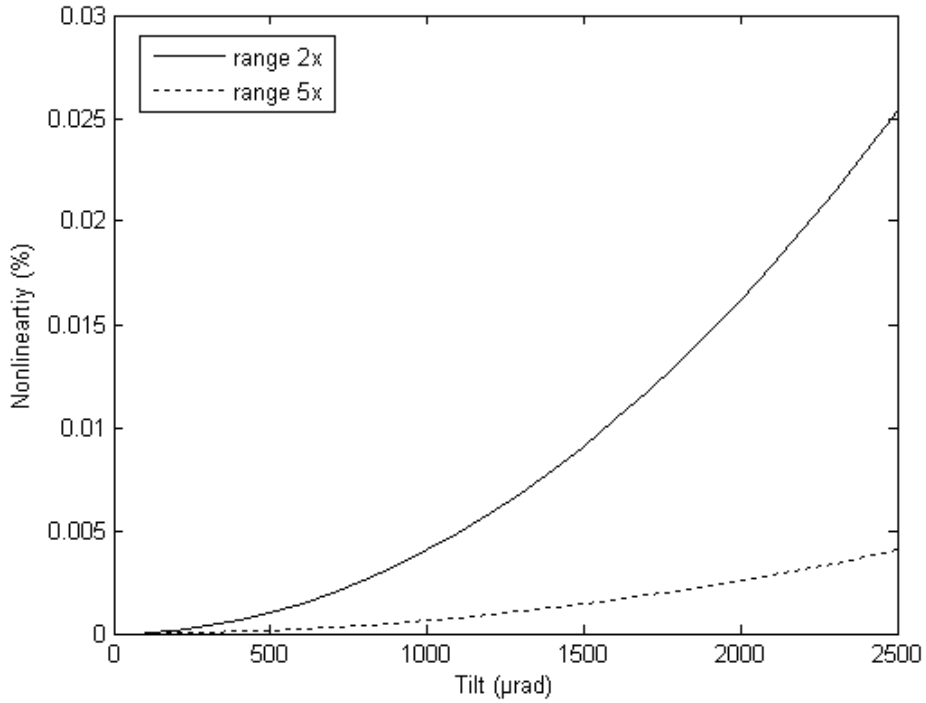

Fig. 10: D-510.101: influence of tilt on the output signal

Influence of Temperature and Humidity

Temperature variations cause changes of sensor probe dimensions. This results in a change of the probe-to-target gap size and thereby also changes the measurement results.
Measurements of the increase in sensor probe thickness give 53 nm/K (D-510.051).

Condensation must be avoided: the measurement values are otherwise no longer reliable.

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Technical Data

	D-510.021	D-510.051	D-510.101	Units	Tolerance
Sensor type	Single-electrode, capacitive	Single-electrode, capacitive	Single-electrode, capacitive		
Measurement accuracy					
Nominal measurement range*	20	50	100	µm	
Min. measurement distance	10	25	50	µm	
Max. measurement distance	150	375	750	µm	
Static resolution**	<0.001	<0.001	<0.001	% of nominal measurement range	typical
Dynamic resolution**	<0.002	<0.002	<0.002	% of nominal measurement range	typical
Linearity***	<0.2	<0.1	<0.1	%	
Mechanical properties					
Sensor active diameter	3.8	6	8.4	mm	
Sensor active area	11.2	27.9	56.1	mm²	
Sensor diameter	8	12	20	mm	
Sensor area	50.3	113.1	314.0	mm²	
Mounting shaft diameter	8	8	8	mm	
Miscellaneous					
Operating temperature range	-20 to +100	-20 to +100	-20 to +100	°C	
Material	Stainless steel	Stainless steel	Stainless steel		
Mass	8	10	16	g	± 5%
Recommended electronics	E-852.10, E-509.E3, E-509.E03, E-711.SE3	E-852.10, E-509.E3, E-509.E03, E-711.SE3	E-852.10, E-509.E3, E-509.E03, E-711.SE3		

*Extended measurement ranges available with electronics provided by PI
**Static resolution: bandwidth 10 Hz, dynamic: bandwidth 10 kHz, with E-852.10 signal conditioner electronics
***Linearity over nominal measurement range

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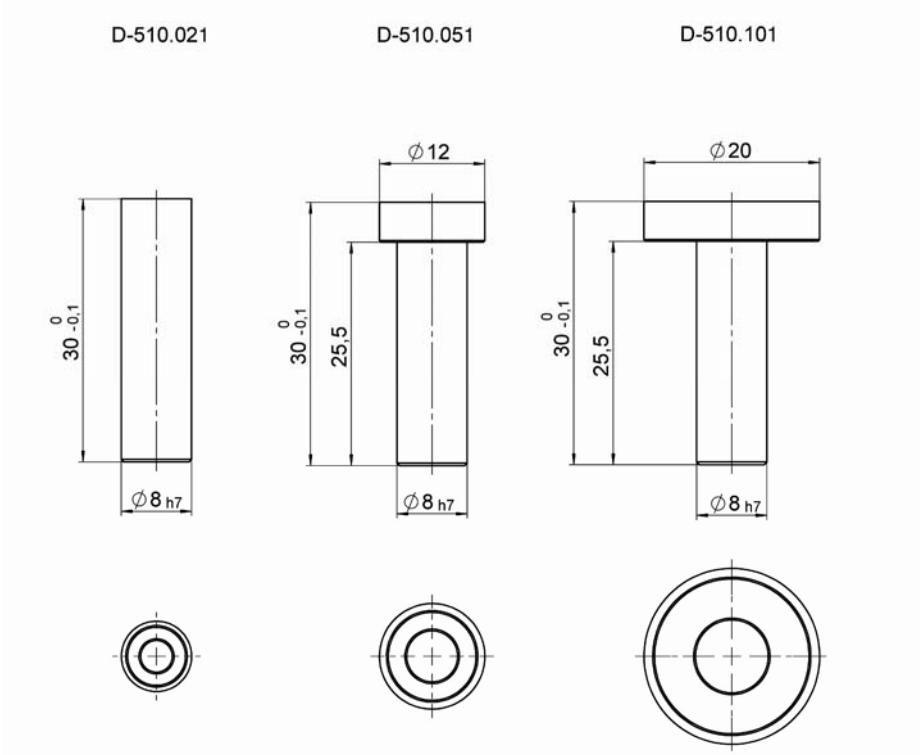

D-510 dimensions in mm, decimal places separated by commas in drawings

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