

# User Manual

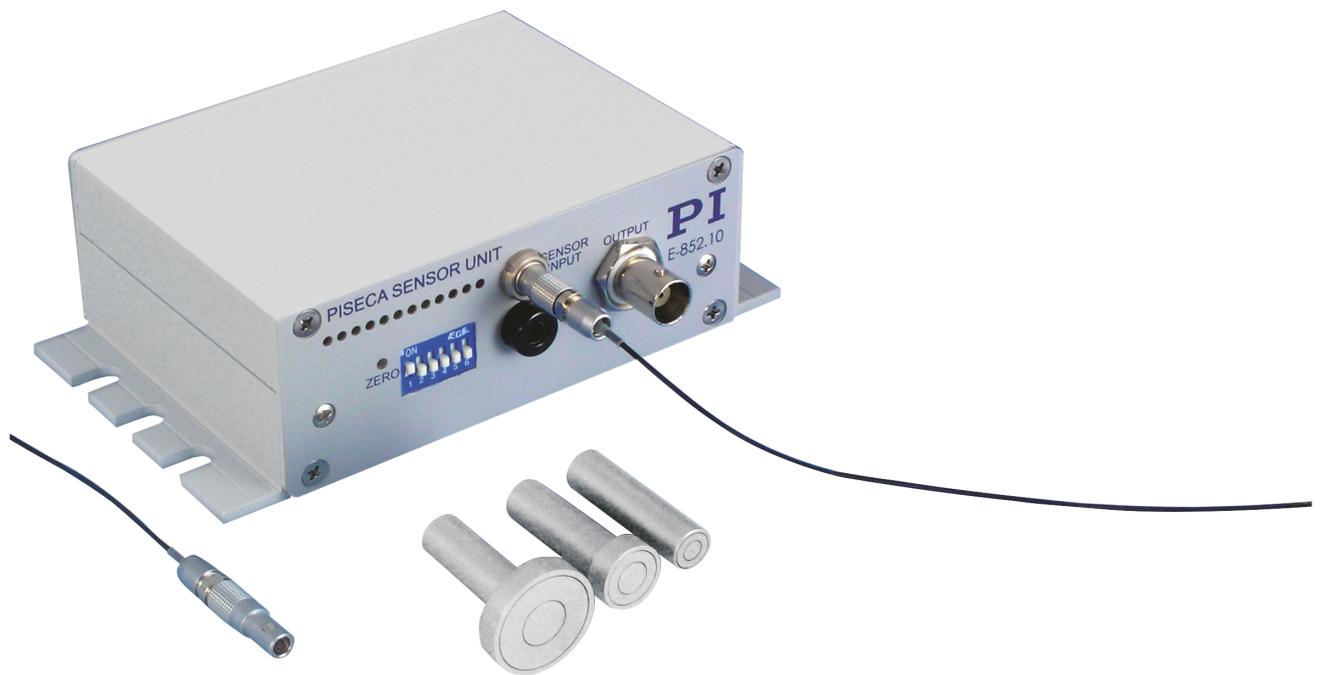
D510T0001, valid for D-510

BSc, BRo, 2/26/2020

# PI

## D-510

PISeCa Single-Electrode Capacitive Sensor Probe



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## Product Description



Figure 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.

## 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:

Product number	Description
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

➤ To order, contact our customer service department (p. 12).

## 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.

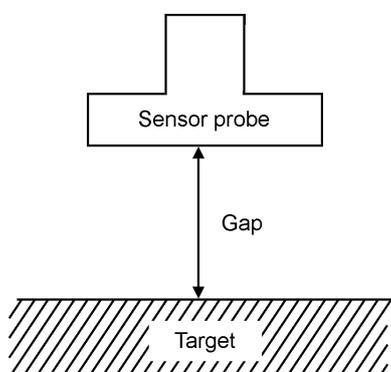


Figure 2: Definitions of "gap" and "target"

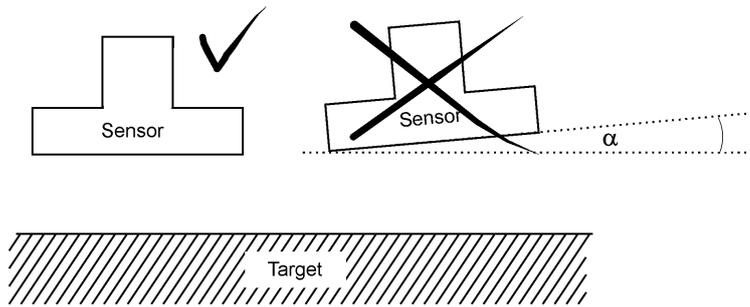


Figure 3: Mounting parallelism: tilt angle  $\alpha$  (see p.7)

## 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:

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

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  $\mu\text{m}$ .

## Mounting

The sensor can be clamped by the 8 mm shaft.

Mounting examples:

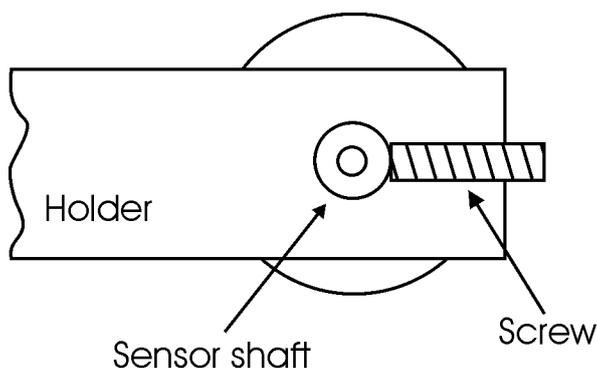


Figure 4: Clamping: use plastic or nylon screw to avoid damage to the probe

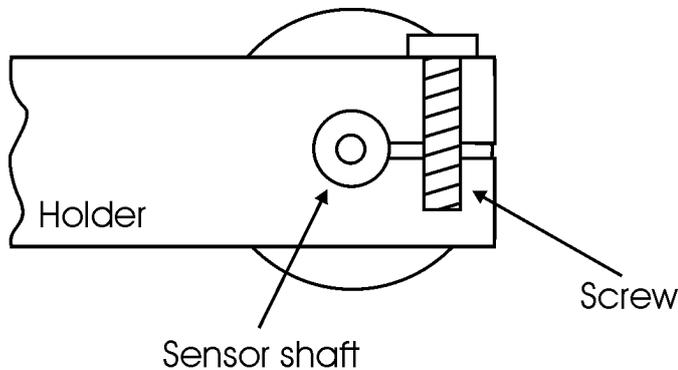


Figure 5: Fixture with set screw

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:

- The minimum probe-to-target gap is 50% of the selected measurement range
- The minimum allowable probe-to-target gap is 10  $\mu\text{m}$ . At minimum excursion, a probe-to-target gap of 15  $\mu\text{m}$  is recommended.
- 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  $\mu\text{m}$  measurement range. It should be mounted with a minimum probe-to-target gap of 100  $\mu\text{m}$  and a maximum gap of 300  $\mu\text{m}$ .

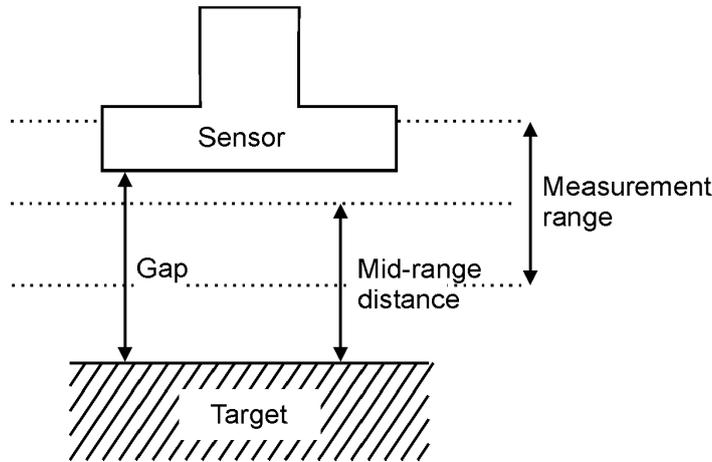


Figure 6: Relation of measurement range and probe-to-target gap; measurement range and mid-range distance have identical values

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

## Influence of Parallelism on Linearity

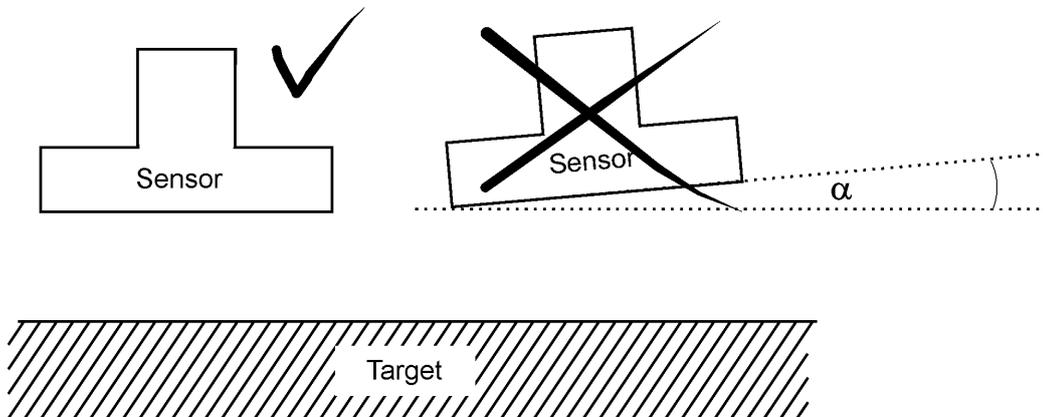


Figure 7: Mounting parallelism: influence of the tilt angle  $\alpha$  on the linearity.  $\alpha$  is given in  $\mu\text{rad}$  in the graphs below

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 the user manual of the electronics for more information).

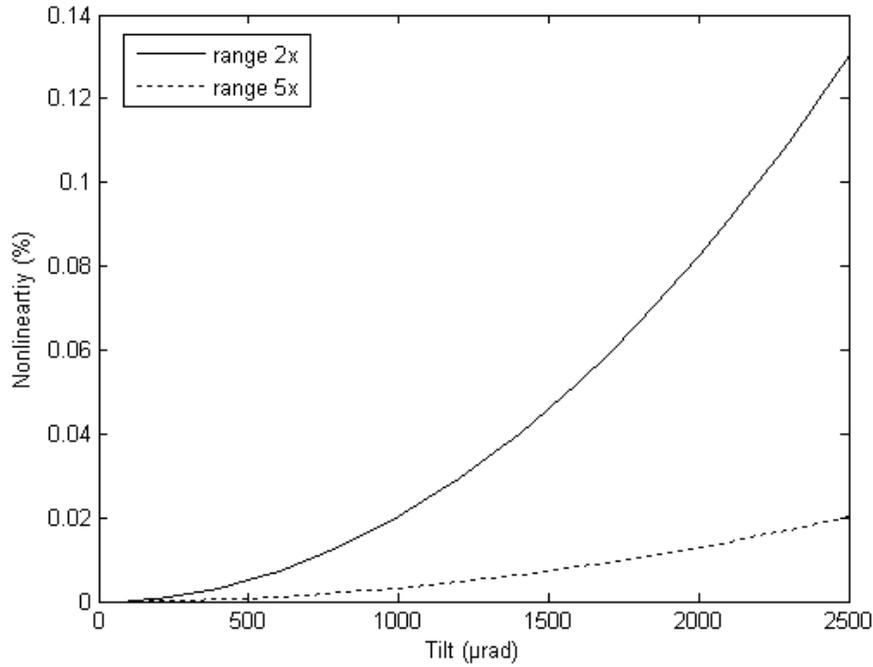


Figure 8: D-510.021: influence of tilt on the output signal

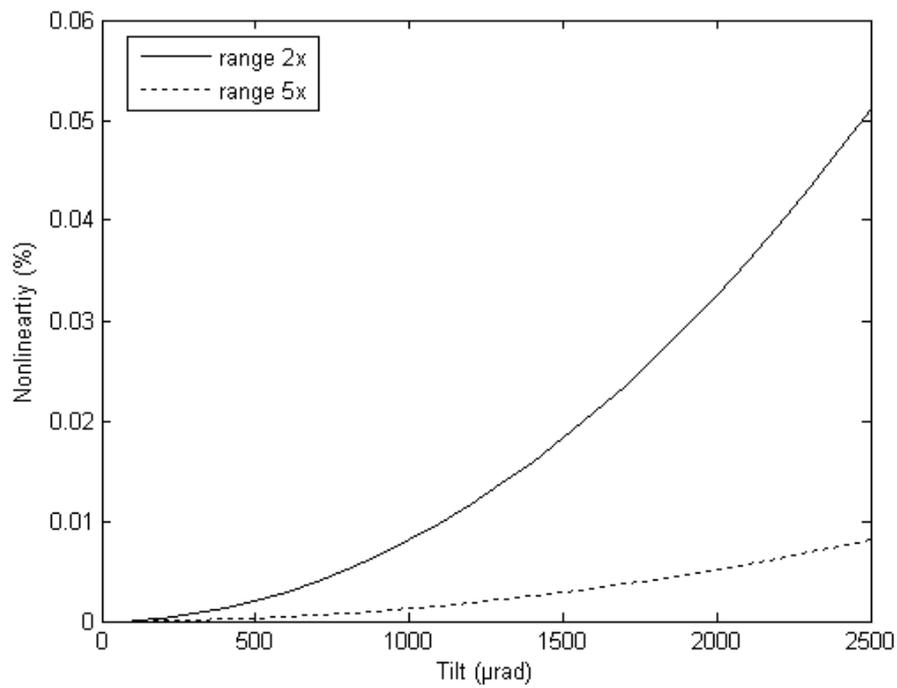


Figure 9: D-510.051: influence of tilt on the output signal

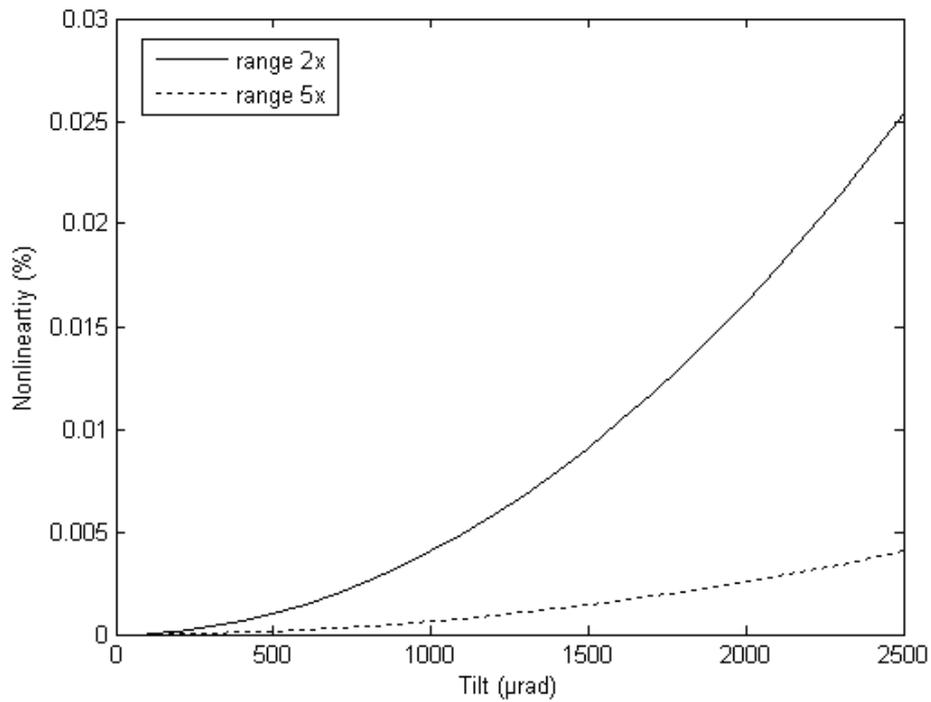


Figure 10: D-510.101: influence of tilt on the output signal

## 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

## Technical Data

### Specifications

	D-510.021	D-510.051	D-510.101
Sensor type	Single electrode, capacitive	Single electrode, capacitive	Single electrode, capacitive

Measurement accuracy	D-510.021	D-510.051	D-510.101
Nominal measuring range*	20 µm	50 µm	100 µm
Smallest measuring gap in the nominal measuring range*	10 µm	25 µm	50 µm
Largest measuring gap in the 5-times extended measuring range*	150 µm	375 µm	750 µm
Static resolution**	<0.001 % of the measuring range (RMS)	<0.001 % of the measuring range (RMS)	<0.001 % of the measuring range (RMS)
Dynamic resolution**	<0.002 % of the measuring range (RMS)	<0.002 % of the measuring range (RMS)	<0.002 % of the measuring range (RMS)
Linearity error***	<0.2 %	<0.1 %	<0.1 %

Mechanical properties	D-510.021	D-510.051	D-510.101
Sensor active diameter	3.8 mm	6 mm	8.4 mm
Sensor active area	11.2 mm <sup>2</sup>	27.9 mm <sup>2</sup>	56.1 mm <sup>2</sup>
Sensor diameter	8 mm	12 mm	20 mm
Sensor area	50.3 mm <sup>2</sup>	113.1 mm <sup>2</sup>	314.0 mm <sup>2</sup>
Mounting shaft diameter	8 mm	8 mm	8 mm

Miscellaneous	D-510.021	D-510.051	D-510.101
Operating temperature range	-20 to 100 °C	-20 to 100 °C	-20 to 100 °C
Material	Stainless steel	Stainless steel	Stainless steel
Mass	8 g (±5 %)	10 g (±5 %)	16 g (±5 %)
Suitable connecting cable	D-891.01x, D-891.02x	D-891.01x, D-891.02x	D-891.01x, D-891.02x
Recommended electronics	E-852.10, E-852.10A1, E-711.SE3, E-509.E03, E-509.E3	E-852.10, E-852.10A1, E-711.SE3, E-509.E03, E-509.E3	E-852.10, E-852.10A1, E-711.SE3, E-509.E03, E-509.E3

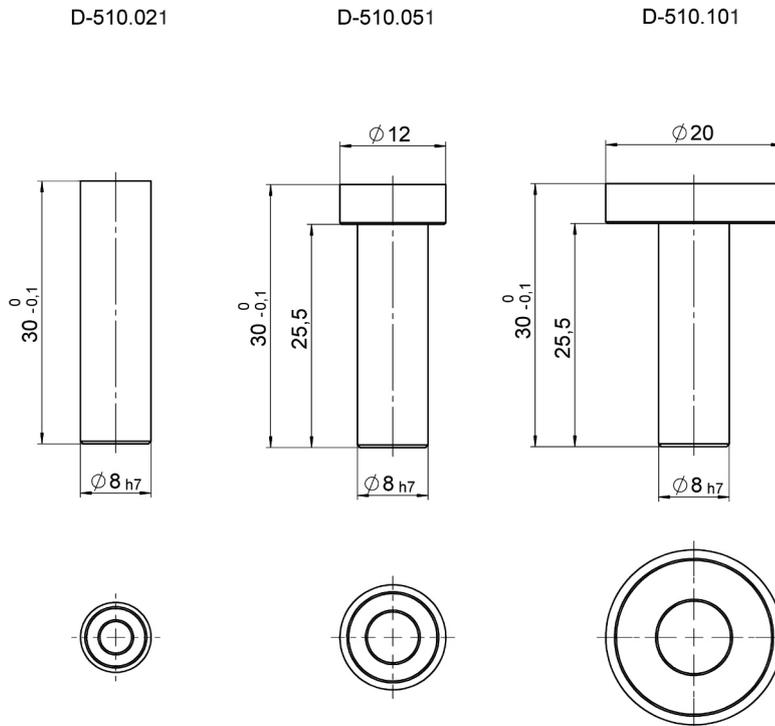
\* Extended measuring range available with E-852.10, two measuring ranges are calibrated respectively. Extension factors: 1, 2, 2.5, 5.

\*\* Static: Bandwidth 10 Hz, dynamic: Bandwidth 10 kHz, with E-852 evaluation electronics

\*\*\*Linearity error in the nominal measuring range

## Dimensions

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.



Dimensions of the D-510.021, D-510.051, and D-510.101

## Customer Service

For inquiries and orders, contact your PI sales engineer or send us an email ([service@pi.de](mailto:service@pi.de)).

- If you have questions concerning your system, have the following information ready:
  - Product and serial numbers of all products in the system
  - Firmware version of the controller (if present)
  - Version of the driver or the software (if present)
  - Operating system on the PC (if present)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

## Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

In order to fulfil its responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

Any old PI equipment can be sent free of charge to the following address:

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Roemerstr. 1  
D-76228 Karlsruhe, Germany

