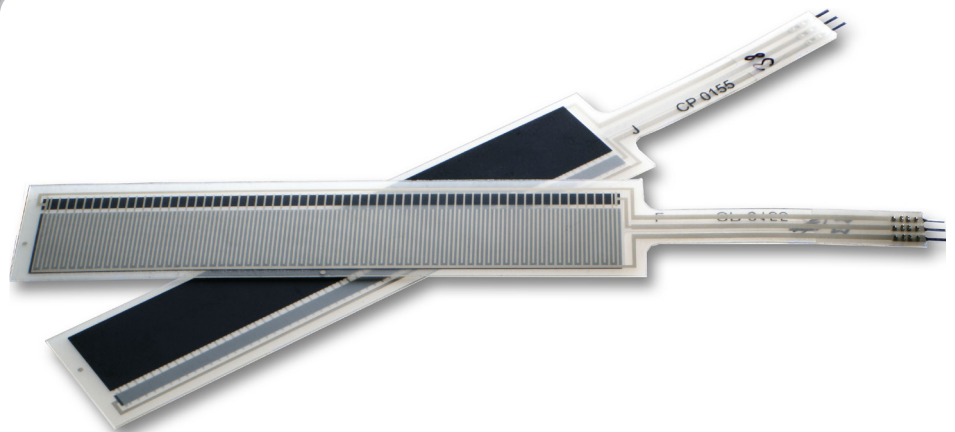
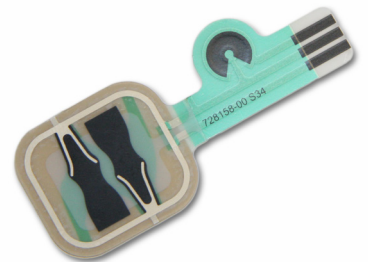
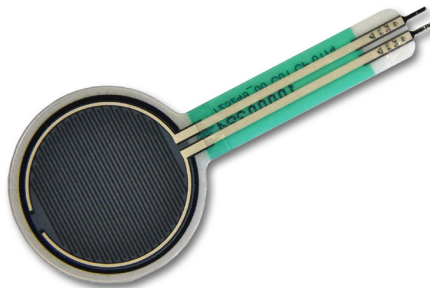


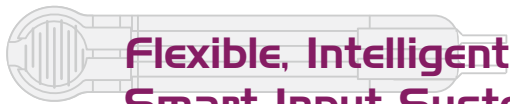
Customized Input Sensing - CIS Solutions



Standard Single Sensors

Linear Potentiometer (Linpot) Sensors

High Dynamic Force Sensing Resistor Sensors



Flexible, Intelligent and Tailor-made Solutions for your Smart Input Systems

IEE develops Customized Input Sensing (CIS) solutions for a variety of automotive, consumer and medical applications, such as Human-Machine Interfaces (HMI) in cars, pressure sensors in shoes, or press buttons for consumer electronics such as cell phones.

Thanks to our Force Sensing Resistor (FSR) foil-type contact technology, we can create slim, pressure-activated sensors. The shape of each sensor can be adapted to suit any geometrical environment. In addition, different sensor functionalities can be combined in the one device, providing a wider range of functions for the end-consumer.

By adapting substrates, spacer, cell form, inks and print geometry, this technology can be ideally adapted for a range of uses where space is limited and complex functionality is required.

Standard Sensors for Testing

IEE produces standard, off-the-shelf sensors that can be used for testing (both the technology and the business solution) without the need for made-to-order development. These allow you to quickly create initial mock-ups or demonstrators.

FSR Technology

FSR uses variable resistance to detect pressure applied to a sensor cell. This technology is very reliable and can be incorporated into thin and flexible applications. FSR also allows a high degree of design freedom and adapts to a simple electronic interface.

All of our FSR Sensors:

- Are simple and easy to integrate
- Have a highly repeatable force reading
- Are cost-effective
- Are ultra thin

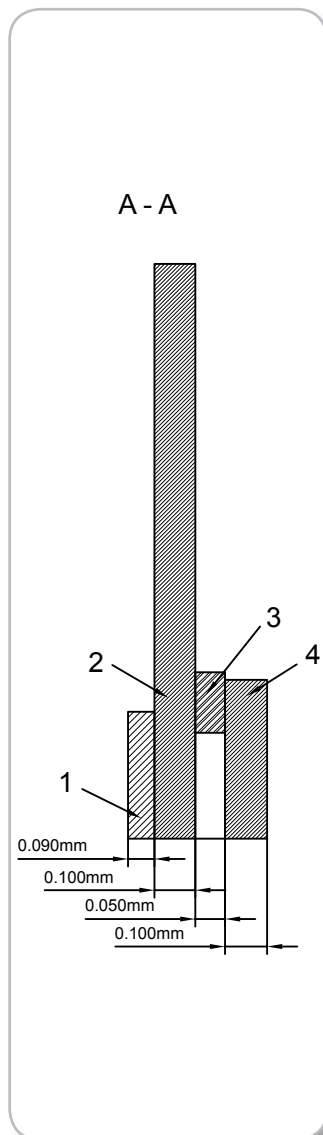
In this data sheet, you will find key information, as well as scale diagrams, for the following standard CIS sensors:

Content	Page
Standard Single Sensors	4
CP 149	9
CP 150	10
CP 151	11
CP 152	12
CP 153	13
CP 154	14
CP 174	15
Linear Potentiometer (Linpot) Sensor	16
CP 155	21
High Dynamic FSR Sensors	22
HD 001	29
HD 002	30

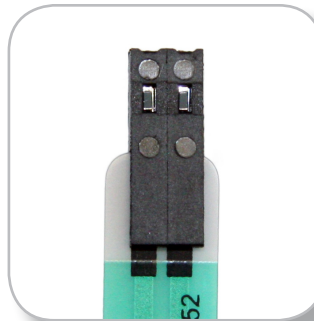
With our pressure sensing technology, we can create tailor-made solutions in almost any shape and size, on a relatively short time frame. If you require something other than our standard sensors for your project, please e-mail consumer@iee.lu.



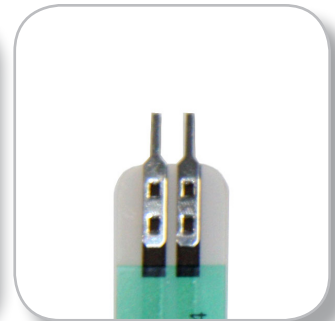
Options for Single Sensors



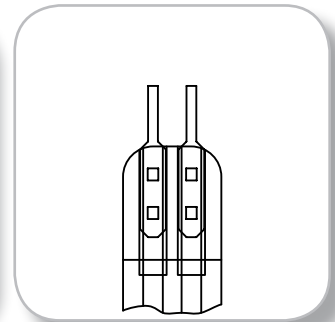
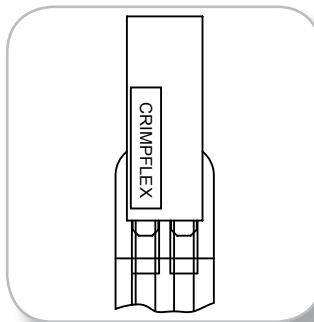
- 1 Top substrate male crimp (optional)
- 2 Spacer substrate
- 3 Bottom substrate
- 4 Backing adhesive (optional)



Housing (optional)



Male crimp (optional)



Standard Single Sensors



CP 149
CP 150
CP 151
CP 152
CP 153
CP 154
CP 174



Our standard FSR sensors:

- Have an actuation force as low as 0.1 N
- Have a sensitivity range to 10 N
- Are robust; up to 10 M actuations



Force Sensing Resistor (FSR)

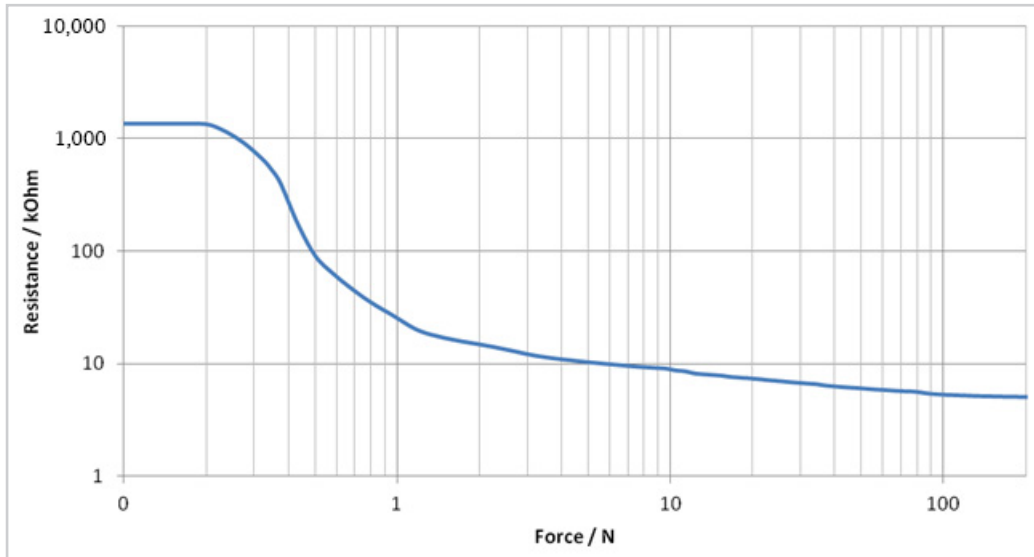
Our standard CP sensors are available in different configurations, depending on the connection method and whether or not backing adhesive is present.

Sensor Type	Detection Area Dimension	Force Probe Diameter	Test Weight Load	Typical Resistance at Test Load
CP 149	circular, Ø 6 mm	4 mm	500 g	30 kΩ > RL > 3 kΩ
CP 150	8.1 × 7.5 mm	6 mm	1,100 g	15 kΩ > RL > 5 kΩ
CP 151	circular, Ø 12 mm	6 mm	1,100 g	15 kΩ > RL > 5 kΩ
CP 152	circular, Ø 15.2 mm	6 mm	1,100 g	15 kΩ > RL > 5 kΩ
CP 153	22.3 × 21.6 mm	6 mm	1,100 g	15 kΩ > RL > 5 kΩ
CP 154	40.6 × 40.3 mm	6 mm	1,100 g	15 kΩ > RL > 5 kΩ
CP 174	circular, Ø 24.8 mm	6 mm	1,100 g	15 kΩ > RL > 5 kΩ



Typical Response Curve

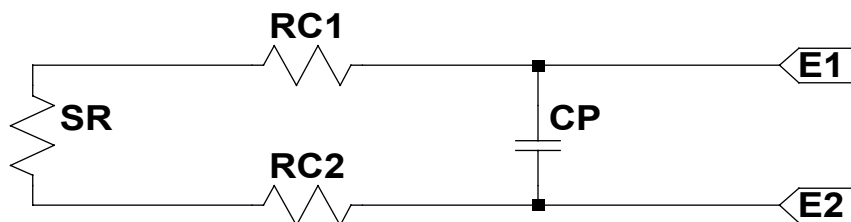
Example curve for one CP 149 sensor



Response curve depends on actuator shape, material and design
Measurements performed with a 4 mm probe diameter covered with a 2 mm thick rubber of 65 Shore A



Simplified Sensor Equivalent Circuit



Use an ohmmeter with PC interface option for dynamic data recording. An ordinary ohmmeter will be sufficient if you do not intend to record data.

- E1* Electrode 1 pad
- E2* Electrode 2 pad
- CP* Parasitic parallel capacitance of the sensor sandwich
- RC1* Conductor resistance of electrode 1 side
- RC2* Conductor resistance of electrode 2 side
- SR* Sensor resistance



Sensor Characteristics

Sensor Description	
Sensor type	Pressure Sensitive Single Sensor
Typical applications/devices	Infinitely variable resistive user interface
Number of active areas/cells	1
Dimensions and available connectors	See layout drawings on the following pages
Manufacturing Tolerances	
Length and width tolerances	According DIN 7151 IT 14
Thickness	Nominal value +/- 12 %
Total manufacturing tolerance	+/- 0.8 mm
Base Materials	
Topside substrate	PET film
Laminating adhesive	Acrylic
Backside substrate	PET film
Backing adhesive	(upon request) Acrylic
Operating Parameters	
Standby resistance (no load)	$R_{NL} > 1 \text{ M}\Omega$
Typical activation resistance range	$1 \text{ M}\Omega > R_L > 2 \text{ k}\Omega$
for a pressure range of	0.5-100 N/cm ² (i.e. per cm ² of activated area)
Typical conductor lead resistance	$\leq 25 \Omega$
Typical lifetime when used according to application advice	> 1,000,000 cycles @ 1 kg/cm ² and 1 Hz
Typical sensor response time on single activation	2-3 ms (mechanical)
Current density	< 1 mA/cm ² (of activated area)
Parasitic capacitance	< 1 nF
Power dissipation	< 1 mW/cm ² (of activated area)
Operating Conditions	
Nominal operating voltage	1.5 V. Use pulsed voltage (duty cycle < 2 %) for extended lifetime and heavy duty conditions
Operating temperature range	-40 to +85 °C (-40 to 185 °F)
Operating humidity range	$\leq 95 \text{ \% R.H.}$
Standard Test Criteria at Time of Delivery	
Standby resistance	$R_{NL} > 1 \text{ MW @ RT and } 5 \text{ V DC}$
Measuring device	IEE load applicator (see table on page 5 for load values)
Force probe surface material	Rubber pad
Thickness of pad	2 mm +/- 0.2 mm
Rubber hardness	65 Shore A (+/- 10 Shore A)



Important Application Information

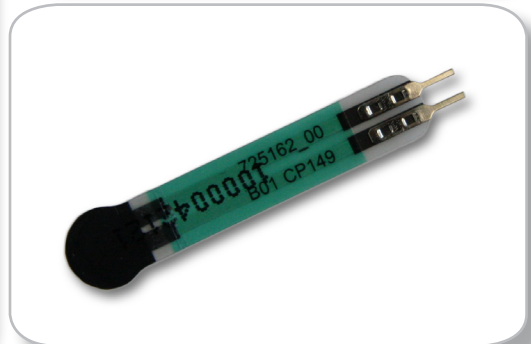
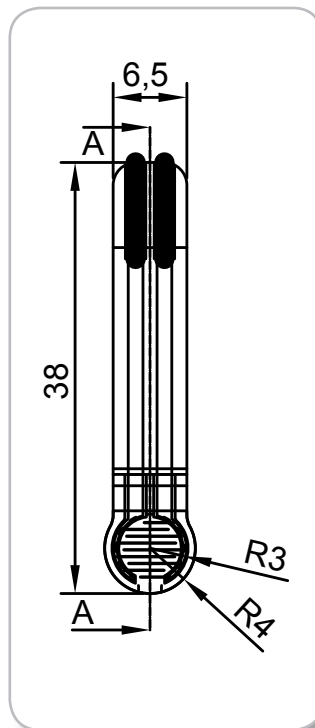
Typically, you should mount the sensor onto an even, smooth, and hard support surface, for example a plastic, glass or metal plate.

- Always place the actuator perpendicular to the sensor surface in the centre of the active area. You should avoid offset mounting. Ensure that the actuator is smaller than the active area of the sensor. If this is not feasible, use a soft activator for force transmission and distribution, for example a soft rubber with hardness ≤ 25 Shore A.
- To avoid possible signal drift, do not expose the sensor to permanent load.
- To avoid mechanical pre-load and false signals, never bend the sensor in the active area.
- To avoid broken conductor lines, do not bend the connection tail to a radius of < 5 mm.
- All sensors feature an air vent. Take care not to block it and to avoid liquids from penetrating through it.



Single Sensor CP 149

Sensor Reference	Backing Adhesive	Crimp Type	Housing
CP 149 NN	No	No crimps	No
CP 149 NS	No	Male	No
CP 149 NH	No	Female	Yes
CP 149 AN	Yes	No crimps	No
CP 149 AS	Yes	Male	No
CP 149 AH	Yes	Female	Yes

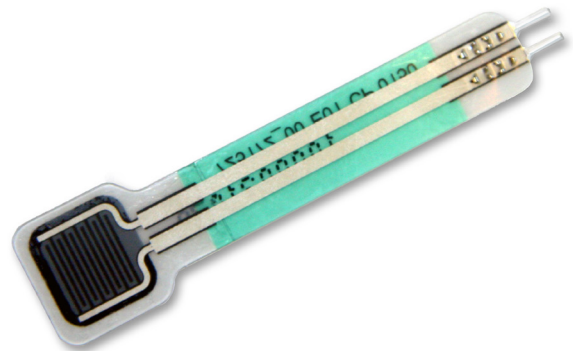
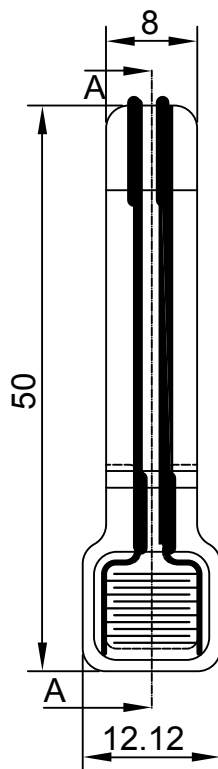


Active area = Radius 3 mm



Single Sensor CP 150

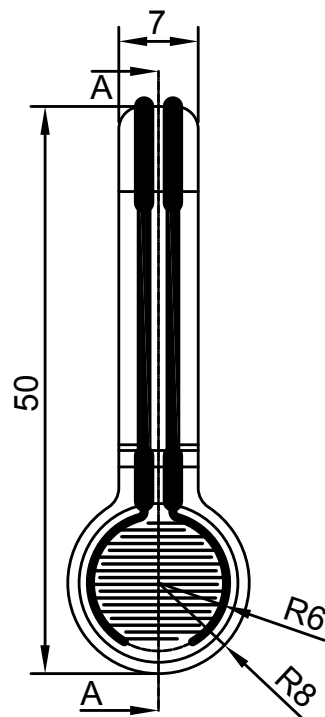
Sensor Reference	Backing Adhesive	Crimp Type	Housing
CP 150 NN	No	No crimps	No
CP 150 NS	No	Male	No
CP 150 NH	No	Female	Yes
CP 150 AN	Yes	No crimps	No
CP 150 AS	Yes	Male	No
CP 150 AH	Yes	Female	Yes



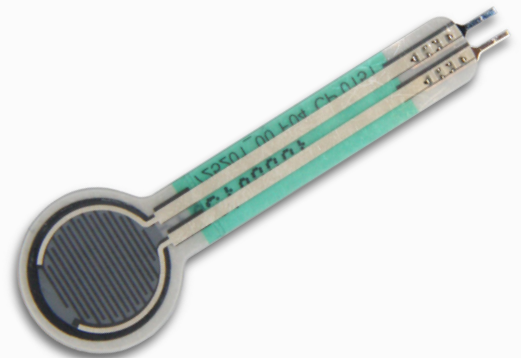


Single Sensor CP 151

Sensor Reference	Backing Adhesive	Crimp Type	Housing
CP 151 NN	No	No crimps	No
CP 151 NS	No	Male	No
CP 151 NH	No	Female	Yes
CP 151 AN	Yes	No crimps	No
CP 151 AS	Yes	Male	No
CP 151 AH	Yes	Female	Yes



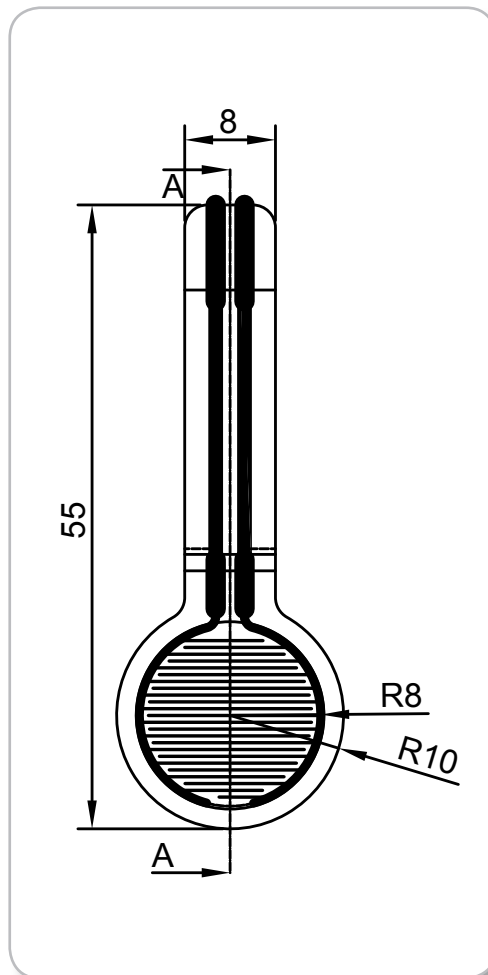
Active area = Radius 6 mm



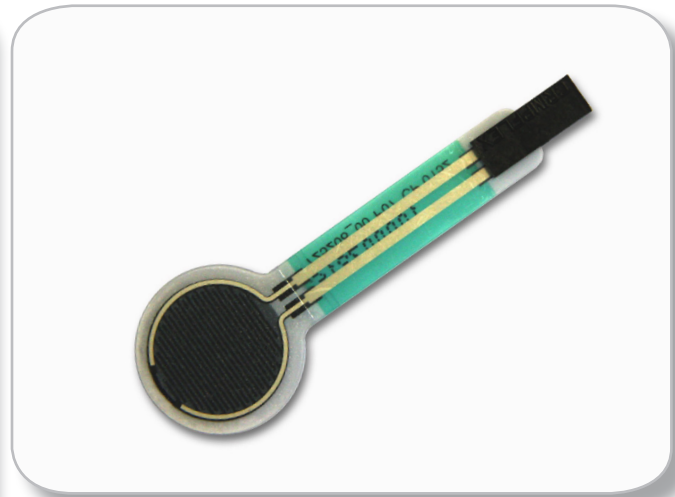


Single Sensor CP 152

Sensor Reference	Backing Adhesive	Crimp Type	Housing
CP 152 NN	No	No crimps	No
CP 152 NS	No	Male	No
CP 152 NH	No	Female	Yes
CP 152 NF	No	Female	No
CP 152 AN	Yes	No crimps	No
CP 152 AS	Yes	Male	No
CP 152 AH	Yes	Female	Yes
CP 152 AF	Yes	Female	No



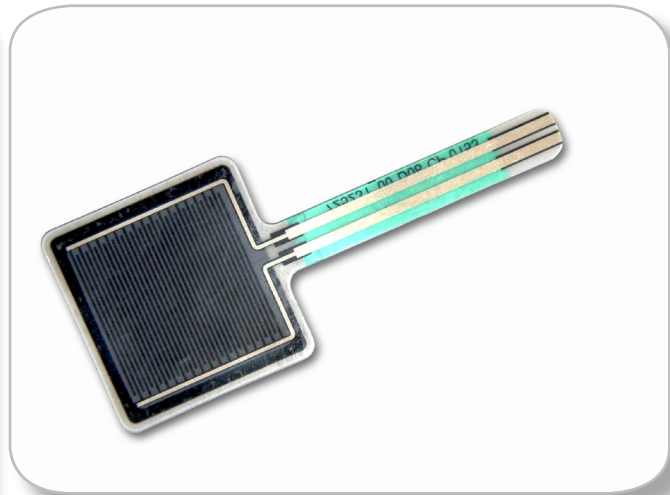
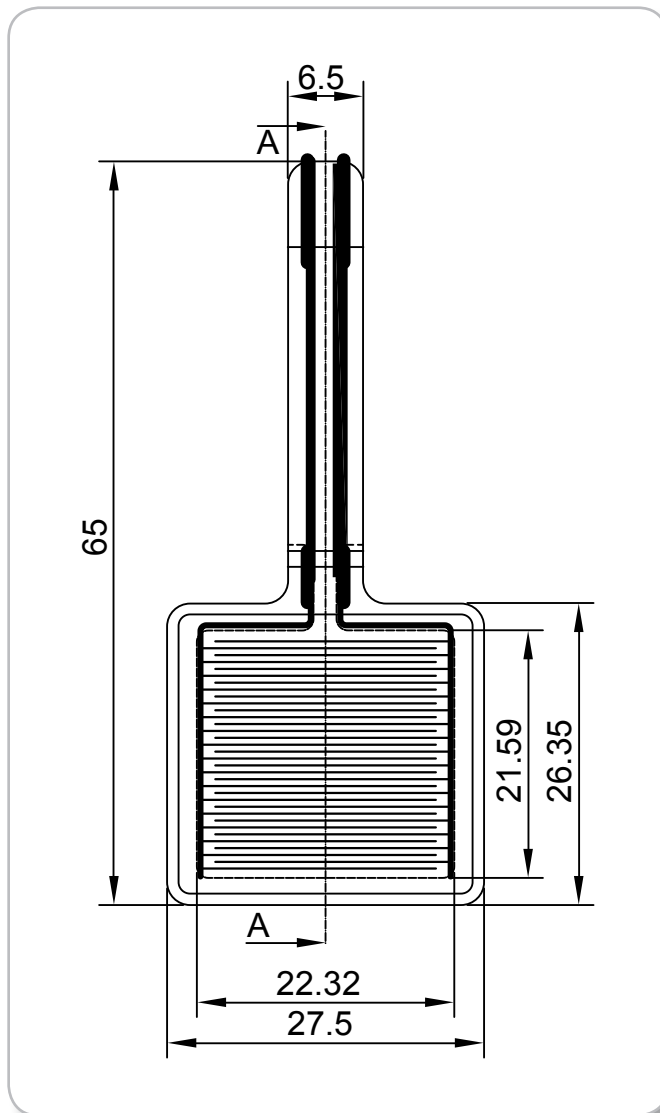
Active area = Radius 8 mm





Single Sensor CP 153

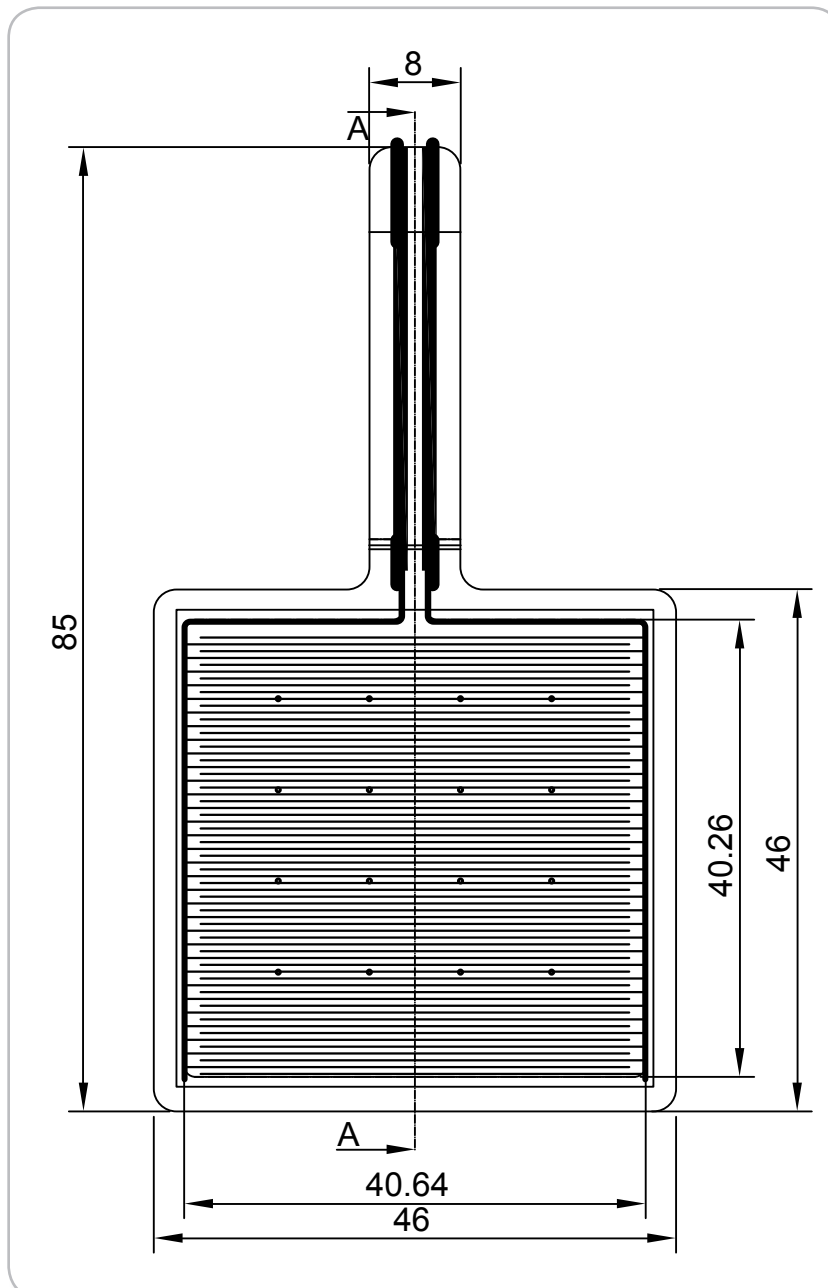
Sensor Reference	Backing Adhesive	Crimp Type	Housing
CP 153 NN	No	No crimps	No
CP 153 NS	No	Male	No
CP 153 NH	No	Female	Yes
CP 153 AN	Yes	No crimps	No
CP 153 AS	Yes	Male	No
CP 153 AH	Yes	Female	Yes





Single Sensor CP 154

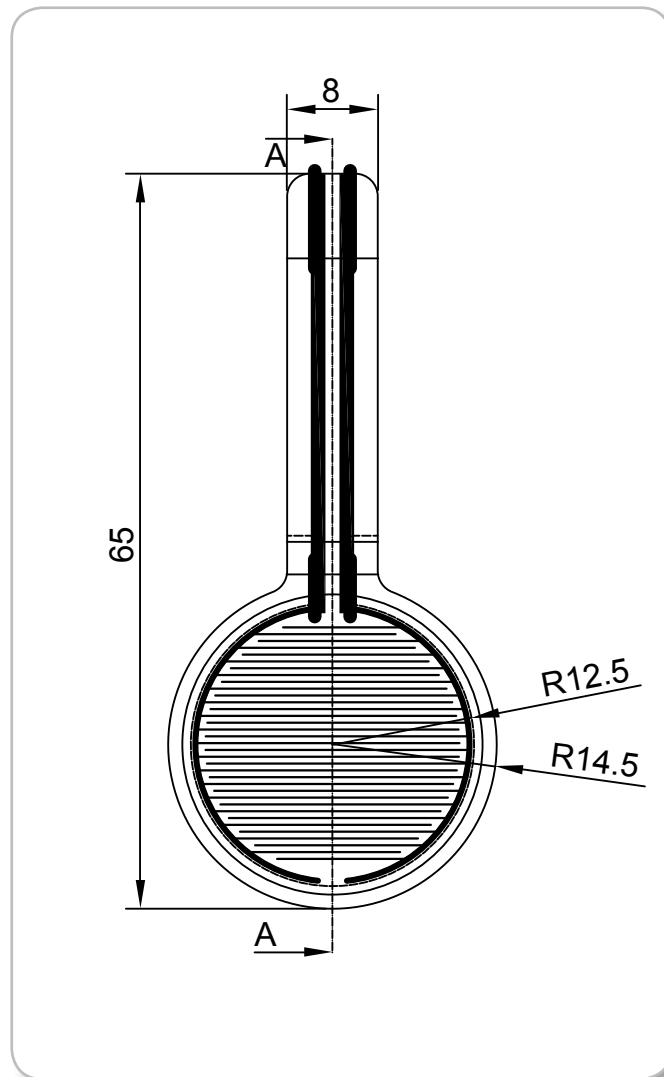
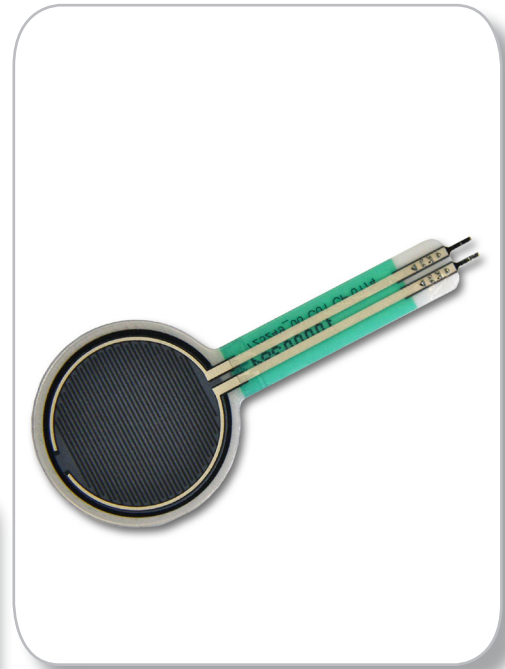
Sensor Reference	Backing Adhesive	Crimp Type	Housing
CP 154 NN	No	No crimps	No
CP 154 NS	No	Male	No
CP 154 NH	No	Female	Yes
CP 154 AN	Yes	No crimps	No
CP 154 AS	Yes	Male	No
CP 154 AH	Yes	Female	Yes





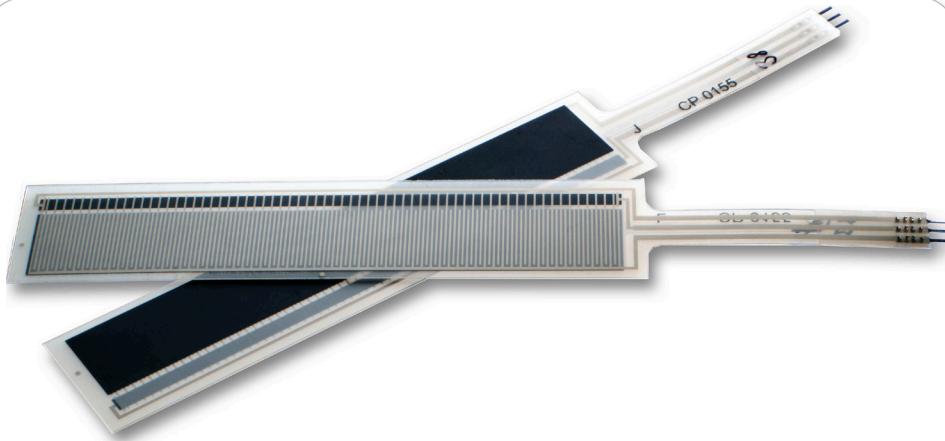
Single Sensor CP 174

Sensor Reference	Backing Adhesive	Crimp Type	Housing
CP 174 NN	No	No crimps	No
CP 174 NS	No	Male	No
CP 174 NH	No	Female	Yes
CP 174 AN	Yes	No crimps	No
CP 174 AS	Yes	Male	No
CP 174 AH	Yes	Female	Yes



Active area = Radius 12.5 mm

Linear Potentiometer (Linpot)



CP 155



Technology

Our Linpot sensors:

- Have an actuation force as low as 0.1 N
- Have a sensitivity range to 10 N
- Are robust; up to 10 M actuations
- Can detect position and activation force



Sensor Configurations

Linear Potentiometer (Linpot)

IEE also offers a standard FSR-based linear potentiometer.

With this sensor, you can detect the activation pressure as well as the position of a single activation point along the length of the sensor.

Sensor Type	Detection Area Dimension	Force Probe Diameter	Test Weight Load	Typical Resistance at Test Load
CP 155	105 × 15 mm	6 mm	1100 g	30 kW > R _t > 10 kW



Simplified Sensor



Recommended sensor read out:

1. R1 not connected for position measurement
2. Positive current injection for SR (pressure) measurement
3. R1 not connected for position measurement (optional, could be omitted)
4. Negative current injection for SR (pressure) measurement

The voltage measured at the end of state (2) is temporarily stored in order to subtract the voltage from state (4) at the end of this cycle. This voltage difference is proportional to the FSR-wiper resistance and inversely proportional to the applied force.

The time delay between output state switching and ADC sampling must be long enough for voltage settling in the circuit capacitors. This delay should be $4 \times R1 \times CP$ for the resistance measurement during states (2) and (4), typically 0.01 to 0.1 ms, where CP is the total capacitance of the sensor and the circuit. During the remaining time, typically 10 ms, the wiper carries no current (1) and the voltage stabilizes to a good accuracy for position reading. The $R1 \times CP$ time constant can easily be determined from the buffer (B1) output signal, displayed on an oscilloscope. The update frequency is a function of the reaction time, required for the application. Over-sampling can be considered for noise suppression by numerical low-pass filters.

Linpot



Sensor Characteristics

Sensor Description	
Sensor type	Co-ordinate & Pressure Sensing Sensor
Typical applications/devices	Proportional input controls/software definable keypads
Number of active areas/cells	1
Dimensions and available connectors	See layout drawings on the following pages
Manufacturing Tolerances	
Length and width tolerances	According to DIN 7151 IT 14
Thickness	Nominal value +/- 12 %
Total manufacturing tolerance	+/- 0.8 mm
Base Materials	
Topside substrate	PET film
Laminating adhesive	Acrylic
Backside substrate	PET film
Backing adhesive	(upon request) Acrylic
Operating Parameters	
Standby resistance (no load)	$R_{NL} > 1 \text{ M}\Omega$
Typical activation resistance range	$1 \text{ M}\Omega > R_L > 5 \text{ k}\Omega$
for a pressure range of	0.5-100 N/cm ² (i.e. per cm ² of activated area)
Typical Fix resistor value	5 – 10 k Ω
Typical conductor lead resistance	$\leq 25 \Omega$
Typical lifetime when used according to application advice	> 1,000,000 cycles @ 1 kg/cm ² and 1 Hz
Typical sensor response time on single activation	2-3 ms (mechanical)
Current density	< 1 mA/cm ² (of activated area)
Parasitic capacitance	< 1 nF
Power dissipation	< 1 mW/cm ² (of activated area)
Geometrical resolution	< 0.1 mm (depending on actuator)
Linearity	Better than 5% FS (depending on actuator)
Operating Conditions	
Nominal operating voltage	5 V, other driving voltages on demand
Operating temperature range	-40 to +70 °C (-40 to 158 °F)
Operating humidity range	$\leq 55 \%$ R.H. (high humidity grades on demand)
Standard Test Criteria at Time of Delivery	
Standby resistance	$R_{NL} > 1 \text{ MW} @ \text{RT and } 5 \text{ V DC}$
Measuring device	IEE load applicator (see table on page 17 for load values)
Force probe surface material	Rubber pad
Thickness of pad	2 mm +/- 0.2 mm
Rubber hardness	65 Shore A (+/- 10 Shore A)
Force test position	Centre of detection area
Fix resistor	$10 \text{ k}\Omega > R_{FIX} > 5 \text{ k}\Omega$



Important Application Information

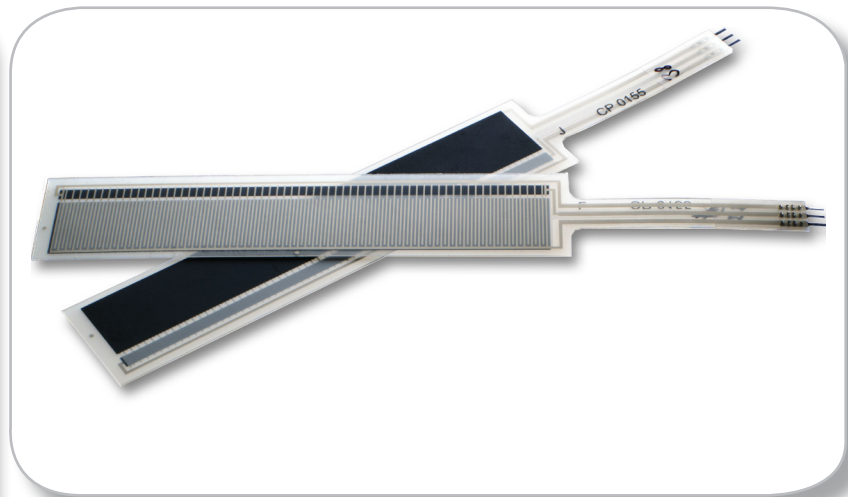
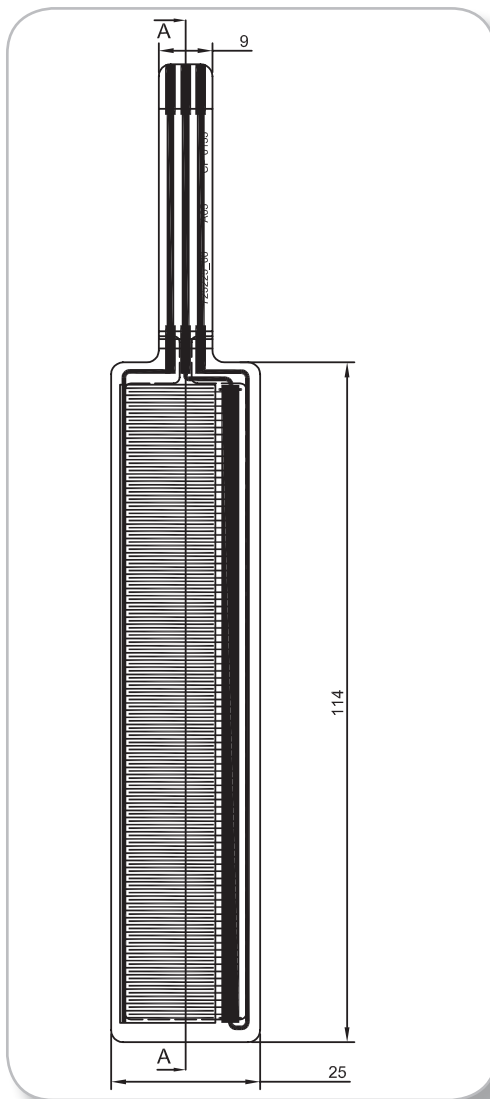
Typically, you should mount the sensor onto an even, smooth, and hard support surface, for example a plastic, glass or metal plate.

- Always place the actuator perpendicular to the sensor surface in the centre of the active area. You should avoid offset mounting. Ensure that the actuator is smaller than the active area of the sensor. If this is not feasible, use a soft activator for force transmission and distribution, for example a soft rubber with hardness ≤ 25 Shore A.
- To avoid possible signal drift, do not expose the sensor to permanent load.
- To avoid mechanical pre-load and false signals, never bend the sensor in the active area.
- To avoid broken conductor lines, do not bend the connection tail to a radius of < 5 mm.
- All sensors feature an air vent. Take care not to block it and to avoid liquids from penetrating through it.

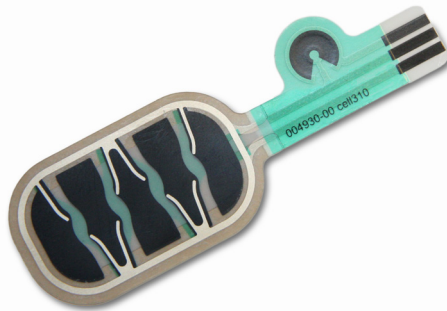
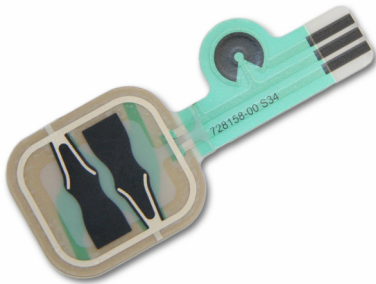


Linear Potentiometer CP 155

Sensor Reference	Backing Adhesive	Crimp Type	Housing
CP 155 NN	No	No crimps	No
CP 155 NS	No	Male	No
CP 155 NH	No	Female	Yes
CP 155 AN	Yes	No crimps	No
CP 155 AS	Yes	Male	No
CP 155 AH	Yes	Female	Yes



High Dynamic Force Sensing Resistor (HD-FSR)



HD 001
HD 002



Key Features

IEE's high-dynamic FSR sensors are the newest generation of cells, and have an improved FSR cell performance. Several sensor cells can be combined in a number of variants.

This technology can be ideally adapted for a range of uses where high sensor dynamic over a wide pressure range (from 100 mbar up to 7 bar) is required. The staggering of individual cell segments allows us to create a homogeneous repeatable cell response along the axis of staggering.

Two IEE high-dynamic standard sensor shapes can be used for testing. With the help of a standard printed fixed resistor you can also compensate variation, due to environmental influences, on the cell output.



Technology

HD-FSR incorporates the FSR pressure detecting technology with an individual triangular cell segmentation. This allows you to measure a change in resistance over a wide pressure range (from 100 mbar to 7 bar).

Each triangular segment can be seen as an independent, fully-functioning part of the whole cell. This allows a high degree of design freedom and segment interconnection.

Our HD-FSR sensors:

- Have an actuation force as low as 100 mbar
- Have a sensitivity range of up to 7 bar
- Are robust; up to 1 M actuations under highest humidity conditions (lifetime variation < 15%)

- Can be used in a slightly bent position
- Can be individually calibrated using a three-point interpolation of the pressure response curve
- Have a very low hysteresis compared with our standard sensors

With IEE's foil-type contact technology, we can create slim, pressure-activated sensors. The shape of each sensor can be adapted to suit numerous geometrical environments, and different sensor segment interconnections can be combined in one device.



Sensor Configurations

High Dynamic Force Sensing Resistor (HD-FSR)

Depending on the cell dimension, HD-FSR sensors are available in different configurations:

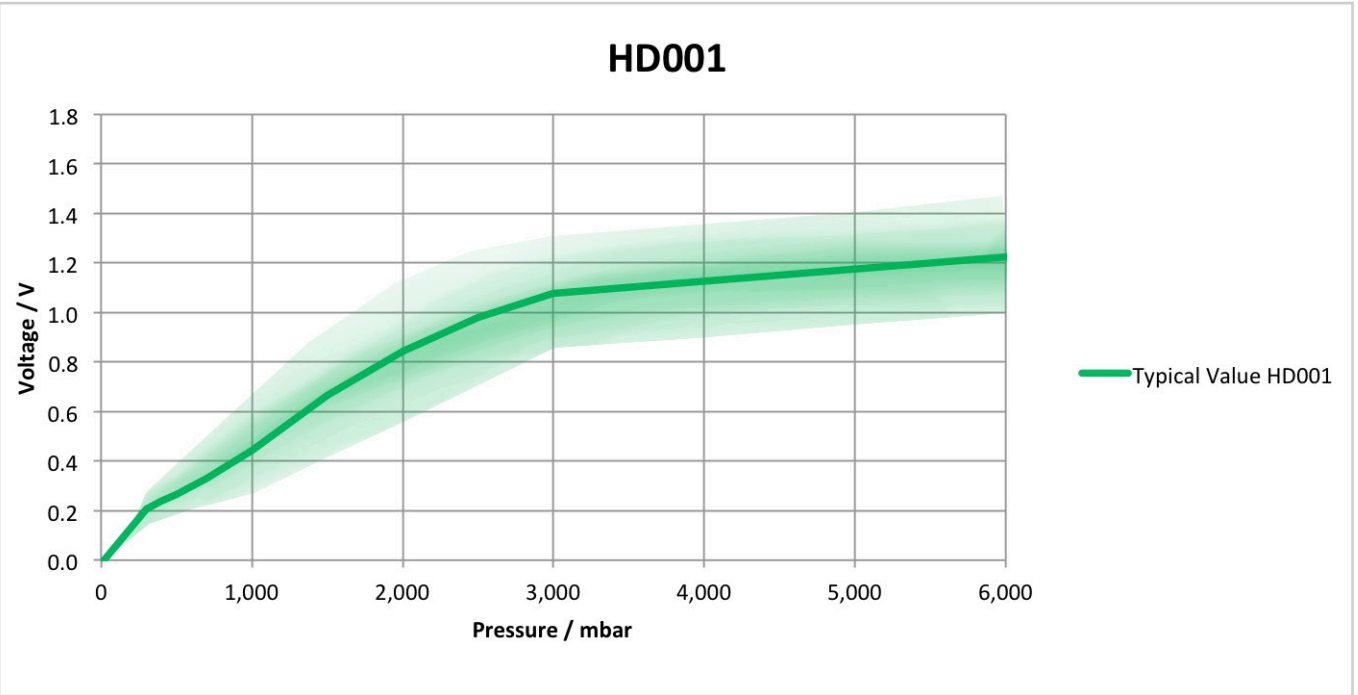
Sensor Type	Detection Area Dimension	Pressure Load	Rfix	Typical Resistance Value	Typical Value in Voltage Divider
HD 001	rectangular, 18.1 x 14.75 mm	500 mbar	$3\text{ k}\Omega < R_{\text{fix}} < 7\text{ k}\Omega$	$20\text{ k}\Omega < R_L < 120\text{ k}\Omega$	$0.16\text{ V} < V_{\text{fsr}} < 0.39\text{ V}$
		2,000 mbar		$5\text{ k}\Omega < R_L < 30\text{ k}\Omega$	$0.56\text{ V} < V_{\text{fsr}} < 1.13\text{ V}$
HD 002	rectangular, 31 x 14.75 mm	500 mbar	$2\text{ k}\Omega < R_{\text{fix}} < 4\text{ k}\Omega$	$9\text{ k}\Omega < R_L < 45\text{ k}\Omega$	$0.26\text{ V} < V_{\text{fsr}} < 0.53\text{ V}$
		2,000 mbar		$2\text{ k}\Omega < R_L < 15\text{ k}\Omega$	$0.67\text{ V} < V_{\text{fsr}} < 1.40\text{ V}$



Typical Response Curve

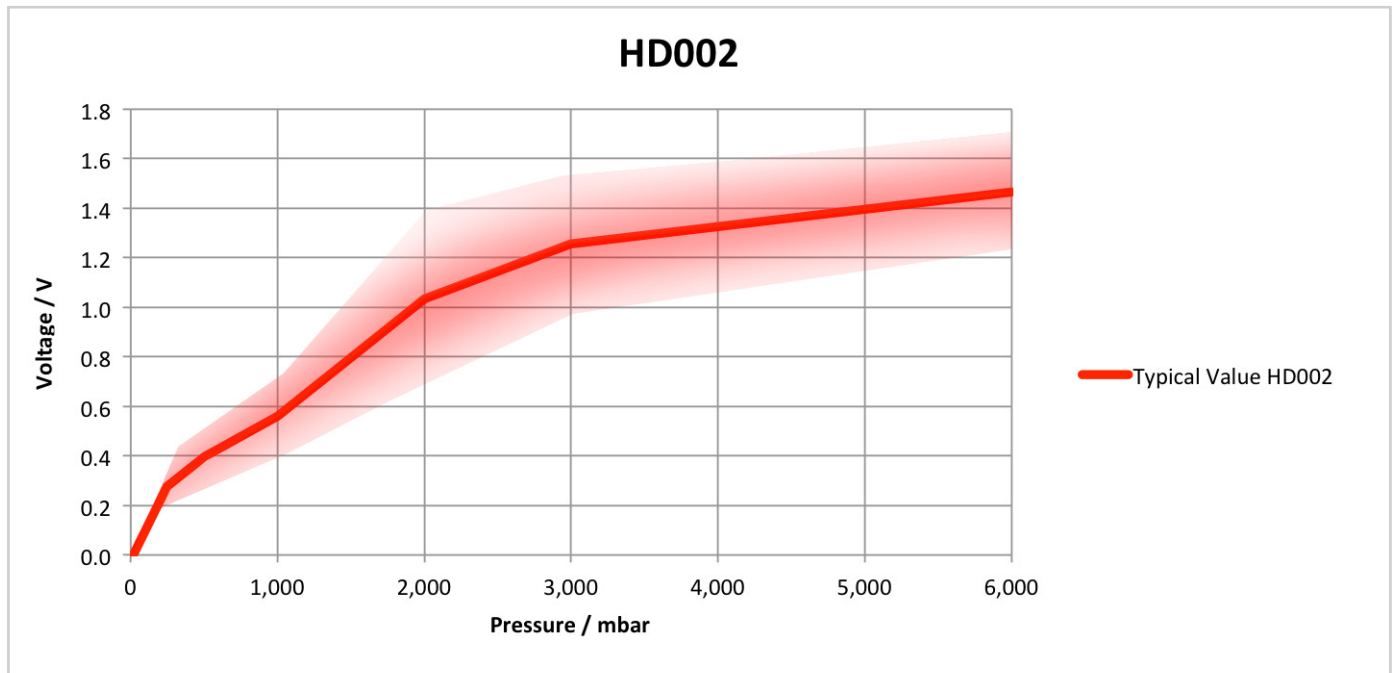
The typical response curve is based on the sensor equivalent circuit with a 3 V supply voltage (UBAT). The measurement voltage (UM) is shown in dependency of the applied pressure on

the sensor cell. Here the sensor cell is placed on a steel plate with the backing adhesive facing downwards. The overpressure is applied by a latex membrane bladder from the top.

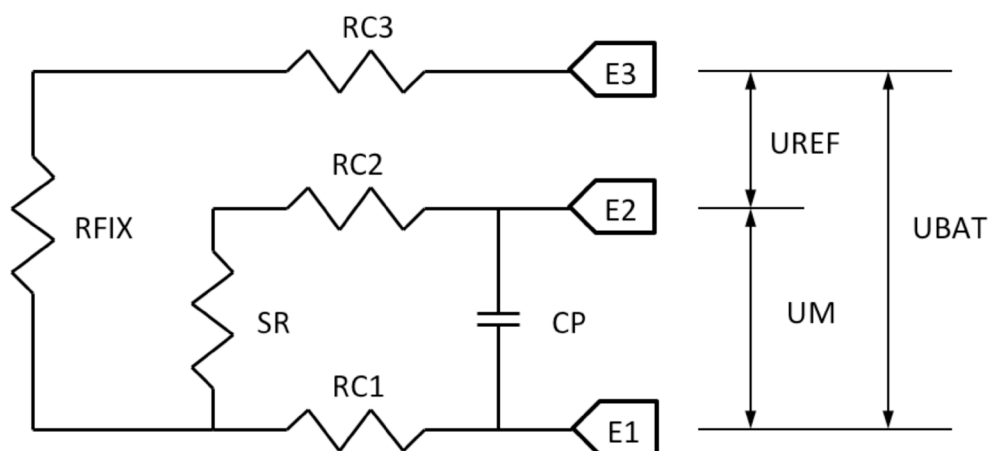




Typical Response Curve



Simplified Sensor Equivalent Circuit



Use an ohmmeter with PC interface option for dynamic data recording. An ordinary ohmmeter will be sufficient if you do not intend to record data.

- E1 Electrode 1 pad
- E2 Electrode 2 pad
- E3 Electrode 3 pad
- CP Parasitic parallel capacitance of the sensor sandwich
- RC1 Conductor resistance of electrode 1 side

- RC2 Conductor resistance of electrode 2 side
- RC3 Conductor resistance of electrode 3 side
- SR Sensor resistance
- RFIX Resistance of printed fixed resistor
- UBAT Supply Voltage
- UREF Reference Voltage
- UM Measurement Voltage

The measurement voltage U_M can be calculated with the following formula:

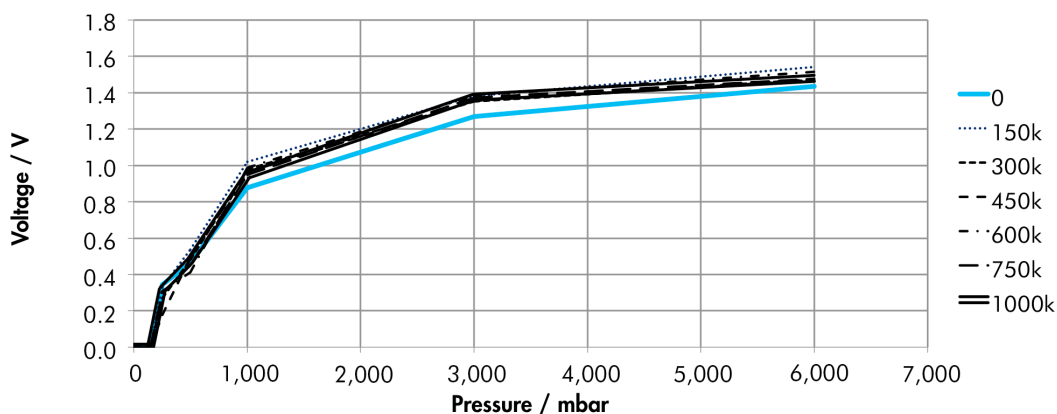
$$U_M = U_{BAT} \times R_{FIX} / (R_{FIX} + SR)$$

Typical: $U_{BAT} = 3 \text{ V}$

Typical Sensor Robustness

The typical cell response during its life-time under the described conditions

(1,000,000 cycles @ 7 bar, 1 Hz and 95% r.H.) is shown below:





Sensor Characteristics

Sensor Description	
Sensor type	Pressure Sensitive High Dynamic Single Sensor
Typical applications/devices	Dynamic user interface devices and high-dynamic pressure sensors for in-shoe measurements
Number of active areas/cells	1
Dimensions and available connectors	See layout drawings on the following pages
Manufacturing Tolerances	
Length and width tolerances	According to DIN 7151 IT 14
Thickness	Nominal value +/- 12 %
Total manufacturing tolerance	+/- 0.8 mm
Base Materials	
Topside substrate	PET film
Laminating adhesive	Acrylic
Backside substrate	PET film
Backing adhesive	Acrylic
Operating Parameters	
Standby resistance (no load)	$R_{NL} > 1 \text{ M}\Omega$ (between E1 and E2)
Typical activation resistance range	$1 \text{ M}\Omega > R_L > 2 \text{ k}\Omega$
for a pressure range of	20 mbar - 7 bar. See Typical Response Curve on page 24
Typical conductor lead resistance	$\leq 25 \Omega$
Typical lifetime when used according to application advice	$> 1,000,000$ cycles @ 7 bar, 1 Hz and 95% r.H.
Typical sensor response time on single activation	2-3 ms (mechanical)
Current density	$< 1 \text{ mA/cm}^2$ (of activated area)
Parasitic capacitance	$< 1 \text{ nF}$
Power dissipation	$< 1 \text{ mW/cm}^2$ (of activated area)
Operating Conditions	
Nominal operating voltage	3V according to simplified sensor equivalent circuit
Operating temperature range	-40 to +85 °C (-40 to 185 °F)
Operating humidity range	$\leq 95 \%$ R.H.
Standard Test Criteria at Time of Delivery	
Standby resistance	$R_{NL} > 1 \text{ MW}$ @ RT (between E1 and E2)
Measuring device	IEE overpressure membrane tester



Important Application Information

Typically, you should mount the sensor onto an even and smooth support surface, for example a plastic, glass or metal plate. Unlike the standard cells, the HD-FSR can also be mounted on slightly bent rubber or foam layers.

- To avoid mechanical pre-load and false signals, do not bend the sensor in the active area to a radius of < 120 mm.
- To avoid broken conductor lines, do not bend the connection tail to a radius of < 5 mm.
- All sensors feature an air vent. Take care not to block it and to avoid liquids from penetrating through it.
- All sensors feature a backing adhesive with a release liner. If you need to remove the liner, take care that surface and material properties match the backing adhesive.

The sensor can be read out with or without calibration, depending on the type of use and the accuracy required:

- To avoid additional process costs for individual cell calibration, all sensors can be read out without calibration by using the typical response curves shown on pages 24 and 25. This may be useful if you have a high volume market.
- To ensure high sensor accuracy and repeatability, all sensors can be calibrated by three-point pressure response curve interpolation. Thanks to the very high environmental and mechanical robustness of the new HD sensor, no recalibration is needed during the sensor's lifetime.

The sensor shows a very low hysteresis in the pressure response curve compared with the standard single cells described on pages 4 - 15 (about 20 %):

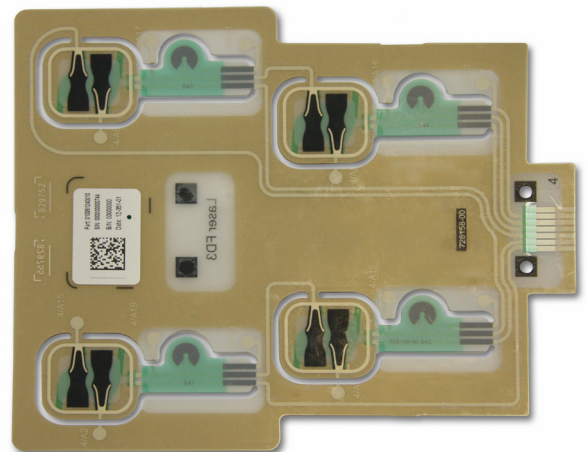
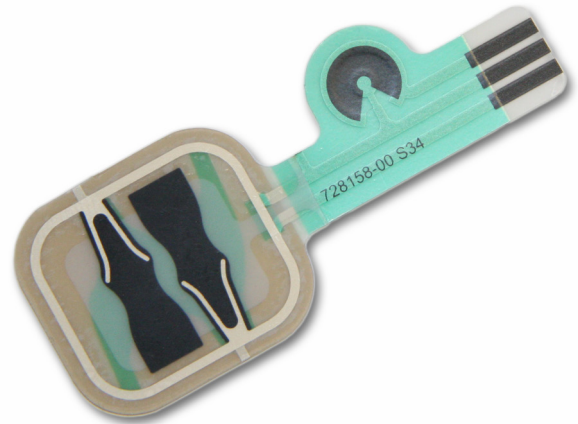
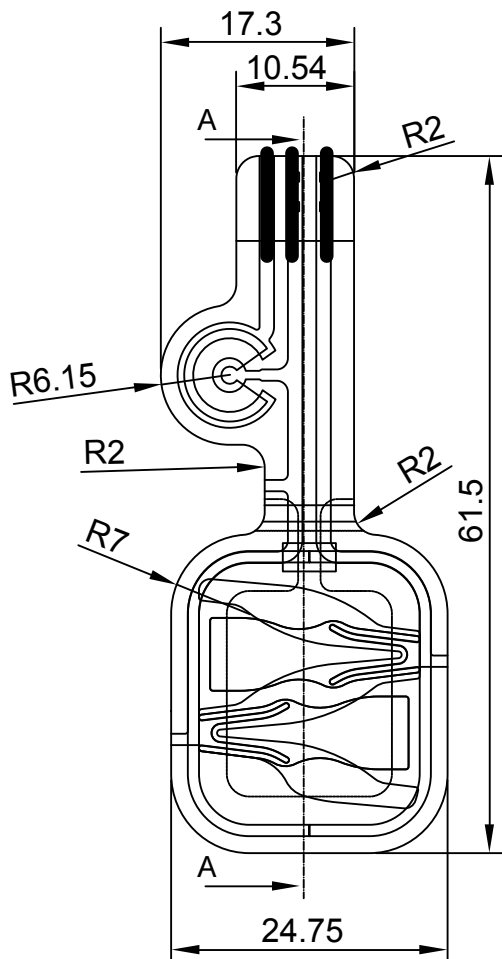
- Hysteresis for HD 001: 3 %
- Hysteresis for HD 002: 8 %

This is a significant advantage for applications where the pressure changes need to be monitored in a high frequency (e.g. monitoring of movements, impacts).



Single Sensor HD 001

Sensor Reference	Backing Adhesive	Crimp Type	Housing
HD 001 AN	Yes	No crimps	No
HD 001 AS	Yes	Male	No

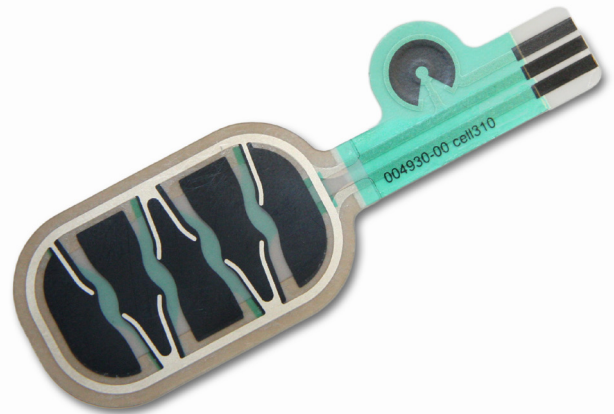
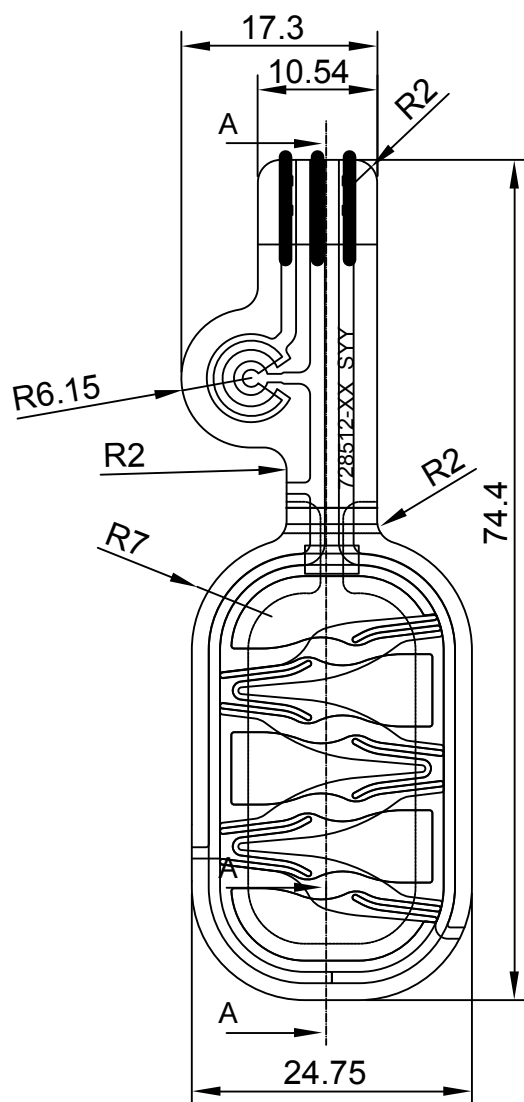


HD 001 AN-4



Single Sensor HD 002

Sensor Reference	Backing Adhesive	Crimp Type	Housing
HD 002 AN	Yes	No crimps	No
HD 002 AS	Yes	Male	No



For an indication of the construction of HD 002 AN-4, please refer to the image of HD 001 AN-4 on the previous page.