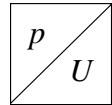


Piezoresistive absolute-pressure sensors in thick-film technology

Measurement of pressures in gases up to 250 kPa



- Thick-film pressure-measuring element ensures a high degree of measurement sensitivity.
- Thick-film sensor element and IC on the same substrate guarantee problem-free signal transmission.
- Integrated evaluation circuit for signal amplification, temperature compensation, and characteristic-curve adjustment
- Sensor enclosed by robust housing.



Design and function

The heart of this sensor is the "sensor bubble" (pressure-measuring element) produced using 100% thick-film techniques.

It is hermetically sealed on a ceramic substrate and contains a given volume of air at a reference pressure of approx. 20 kPa. Piezo-resistive thick-film strain gauges are printed onto the bubble and protected with glass against aggressive media. The strain gauges are characterized by high measurement sensitivity (gauge factor approx. 12), as well as by linear and hysteresis-free behavior. When pressure is applied, they convert mechanical strain into an electric signal. A full-wave bridge circuit provides a measurement signal which is proportional to the applied pressure, and this is amplified by a hybrid circuit on the same substrate. It is therefore impossible for interference to have any effect through the leads to the ECU. DC amplification and individual temperature compensation in the $-40^{\circ}\text{C} \dots +125^{\circ}\text{C}$ range, produce an analog, ratiometric (i.e. proportional to the supply voltage U_V) output voltage U_A . The pressure sensors are resistant to gauge pressures up to 600 kPa.

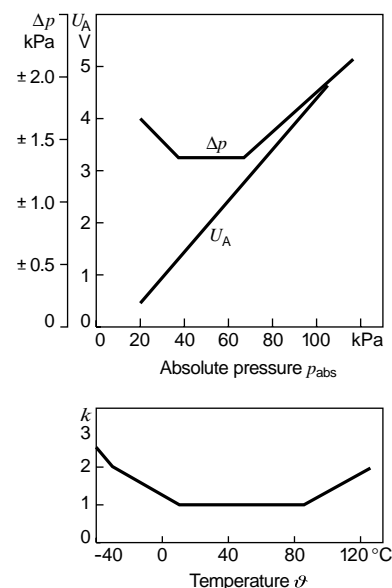
Outside the temperature range $10^{\circ}\text{C} \dots 85^{\circ}\text{C}$ the permissible tolerance increases by the tolerance multiplier. To protect the sensors, the stipulated maximum values for supply voltage, operating-temperature, and maximum pressure are not to be exceeded.

Explanation of symbols

- U_V Supply voltage
 U_A Output voltage
 Δp Permissible accuracy in the range $10^{\circ}\text{C} \dots 85^{\circ}\text{C}$
 k Tolerance multiplier
 ϑ Temperature
 p_{abs} Absolute pressure

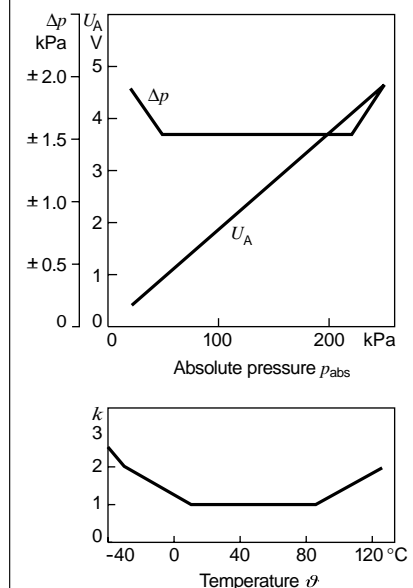
Characteristic curves 1 ($U_V = 5 \text{ V}$).

$$U_A = U_V \cdot \left(0,01 \frac{p_{\text{abs}}}{\text{kPa}} - 0,12 \right)$$



Characteristic curves 2 ($U_V = 5 \text{ V}$).

$$U_A = U_V \cdot \left(\frac{0,85}{230} \cdot \frac{p_{\text{abs}}}{\text{kPa}} + 0,0061 \right)$$

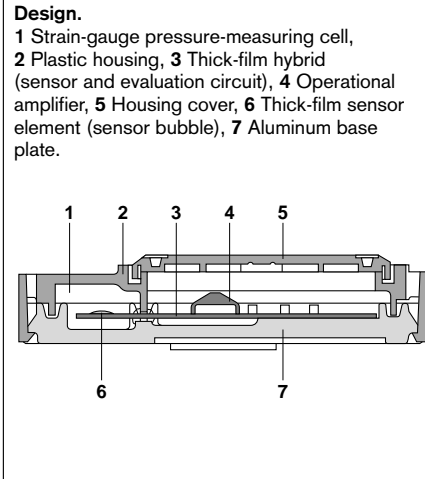
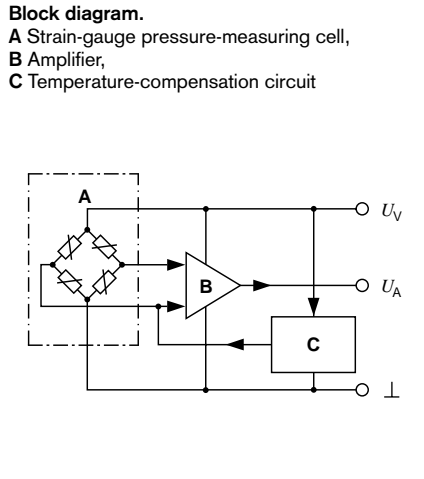


Technical data / Range

Part number	0 261 230 004	0 281 002 119
Characteristic curve	1	2
Measuring range	kPa	20...105
Max. pressure (1 s, 30 °C)	kPa	600
Pressure-change time	ms	≤ 10
Supply voltage U_V	V	4.75...5.25
Max. supply voltage	V	16
Input current I_V	mA	< 10
Load impedance R_L	kΩ	> 50
Operating temperature range	°C	-40...+125
Degree of protection	IP 54 A	-

Accessories

Connector	1 237 000 039
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Installation instructions

A hose forms the connection between the sensor and the gas pressure to be measured. Upon installation, the sensor pressure connection should point downwards to prevent the ingress of moisture.

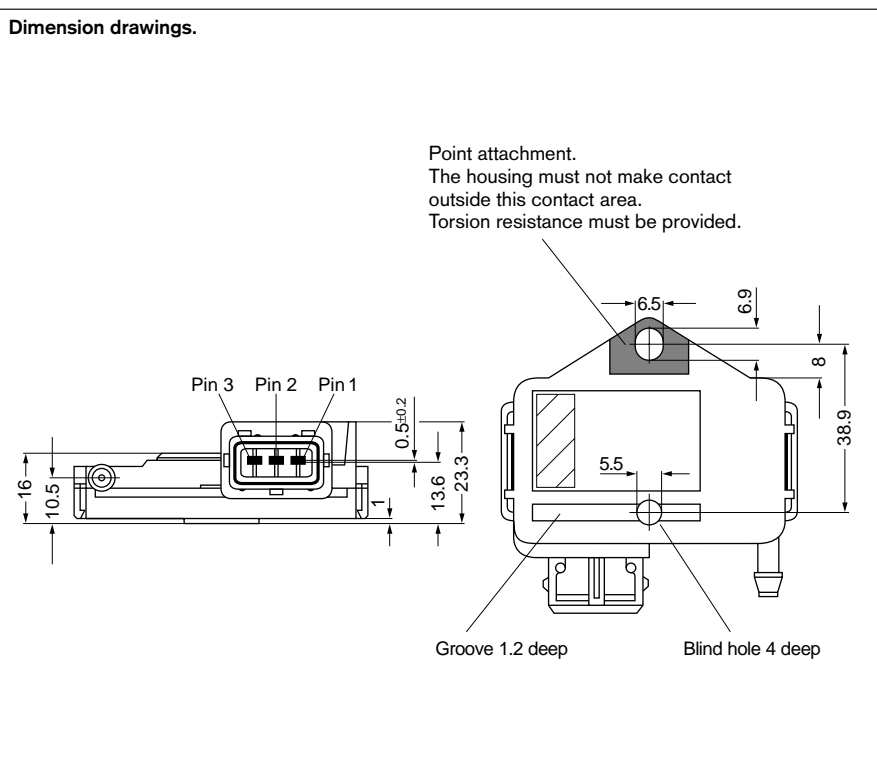
The angular position referred to the vertical must be $+20^{\circ}$... -85° , preferably 0° .

Suggested fastening:
 M6 screw with spring washer.

Connector-pin assignment

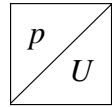
- Terminal 1 $+U_V$
- Terminal 2 Ground
- Terminal 3 U_A

Dimension drawings.



Absolute-pressure sensors in micromechanical hybrid design

Measurement of pressures in gases up to 400 kPa



- High accuracy.
- EMC protection better than 100 V m⁻¹.
- Temperature-compensated.
- Version with additional integral temperature sensor.



Applications

This sensor is used to measure the absolute intake-manifold pressure. On the version with integral temperature sensor, the temperature of the drawn-in air flow is also measured.

Design and function

The piezoresistive pressure-sensor element and suitable electronic circuitry for signal-amplification and temperature compensation are mounted on a silicon chip. The measured pressure is applied from above to the diaphragm's active surface. A reference vacuum is enclosed between the rear side and the glass base. Thanks to a special coating, both pressure sensor and temperature sensor are insensitive to the gases and liquids which are present in the intake manifold.

Installation information

The sensor is designed for mounting on a horizontal surface of the vehicle's intake manifold. The pressure fitting together with the temperature sensor extend into the manifold and are sealed-off to atmosphere by O-rings. By correct mounting in the vehicle (pressure-monitoring point on the top at the intake manifold, pressure fitting pointing downwards etc.) it is to be ensured that condensate does not collect in the pressure cell.

Range

Pressure range kPa (p ₁ ...p ₂)	Characteristic curve ¹⁾	Features	Dimension drawing ²⁾	Order No.
10...115	1		1	B 261 260 136³⁾
10...115	1		2	0 261 230 052
20...250	1		1	0 281 002 487
10...115	1	Integral temperature sensor	3	0 261 230 030
20...250	1	Integral temperature sensor	3	0 261 230 042
20...300	1	Integral temperature sensor	3	0 281 002 437
50...350	2	Integral temperature sensor	3	0 281 002 456
50...400	2	Integral temperature sensor	3	B 261 260 508³⁾

¹⁾ The characteristic-curve tolerance and the tolerance expansion factor apply for all versions, see Page 36

²⁾ See Page 37

³⁾ Provisional draft number, order number available upon enquiry. Available as from about the end of 2001

Accessories

Plug housing	Qty. required: 1 ⁴⁾	1 928 403 966
Plug housing	Qty. required: 1 ⁵⁾	1 928 403 736
Contact pin	Qty. required: 3 or 4 ⁶⁾	1 928 498 060
Individual gasket	Qty. required: 3 or 4 ⁶⁾	1 928 300 599

⁴⁾ Plug housing for sensors without integral temperature sensor

⁵⁾ Plug housing for sensors with integral temperature sensor

⁶⁾ Sensors without temperature sensor each need 3 contacts and gaskets. Sensors with integral temperature sensor each need 4 contacts and gaskets

Technical data

			min.	typ.	max.
Operating temperature	ϑ_B	°C	-40	-	+130
Supply voltage	U_V	V	4.5	5.0	5.5
Current consumption at $U_V = 5\text{ V}$	I_V	mA	6.0	9.0	12.5
Load current at output	I_L	mA	-1.0	-	0.5
Load resistance to U_V or ground	$R_{\text{pull-up}}$	k Ω	5	680	-
	$R_{\text{pull-down}}$	k Ω	10.0	100	-
Response time	$t_{10/90}$	ms	-	1.0	-
Voltage limitation at $U_V = 5\text{ V}$					
Lower limit	$U_{A\text{ min}}$	V	0.25	0.3	0.35
Upper limit	$U_{A\text{ max}}$	V	4.75	4.8	4.85

Limit data

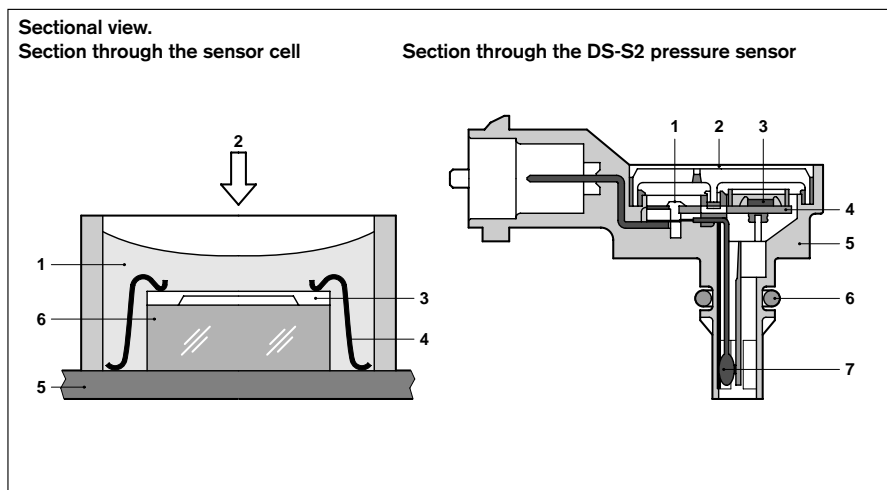
Supply voltage	$U_{V\text{ max}}$	V	-	-	+16
Storage temperature	ϑ_L	°C	-40	-	+130

Temperature sensor

Measuring range	ϑ_M	°C	-40	-	+130
Measured current	I_M	mA	-	-	1 ¹⁾
Nominal resistance at +20 °C		k Ω	-	2.5±5%	-
Thermal time constant	t_{63}	s	-	-	10 ²⁾

¹⁾ Operation at 5 V with 1 k Ω series resistor

²⁾ In air with a flow rate of 6 m·s⁻¹



Section through the sensor cell.

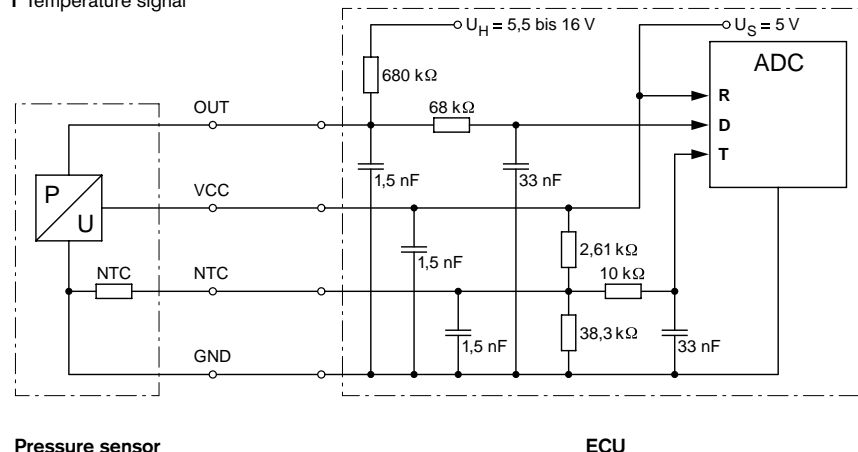
1 Protective gel, 2 Pressure, 3 Sensor chip, 4 Bonded connection, 5 Ceramic substrate, 6 Glass base.

Section through the pressure sensor.

1 Bonded connection, 2 Cover, 3 Sensor chip, 4 Ceramic substrate, 5 Housing with pressure-sensor fitting, 6 Gasket, 7 NTC element.

Signal evaluation: Recommendation.

R Reference
D Pressure signal
T Temperature signal

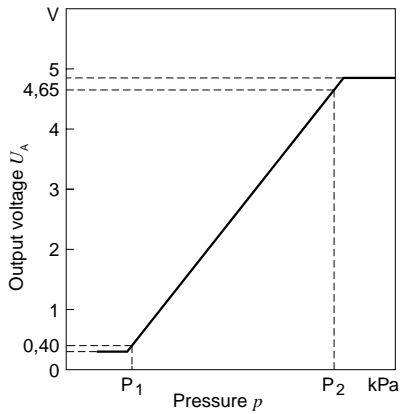


Signal evaluation: Recommendation.

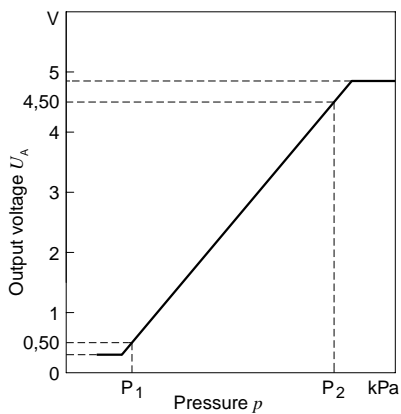
The pressure sensor's electrical output is so designed that malfunctions caused by cable open-circuits or short circuits can be detected by a suitable circuit in the following electronic circuitry. The diagnosis areas situated outside the characteristic-curve limits are provided for fault diagnosis. The circuit diagram shows an example for detection of all malfunctions via signal outside the characteristic-curve limitation.

Absolute-pressure sensors in micromechanical hybrid design (contd.)
Measurement of pressures in gases up to 400 kPa

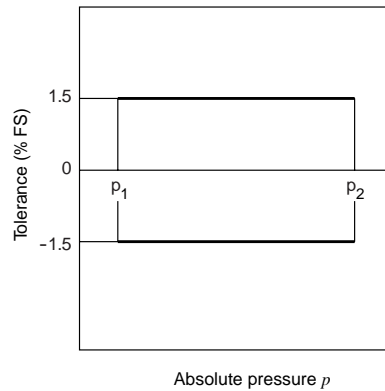
Characteristic curve 1 ($U_V = 5.0$ V).



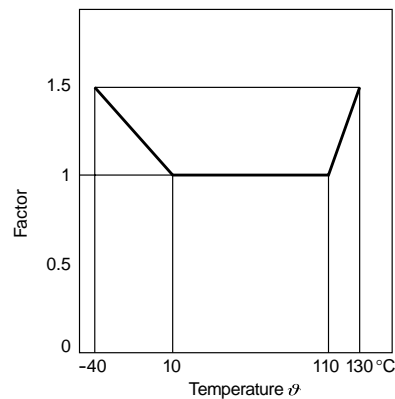
Characteristic curve ($U_V = 5.0$ V).



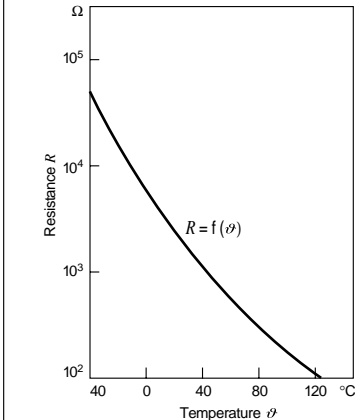
Characteristic-curve tolerance.



Tolerance-expansion factor.



Temperature-sensor characteristic curve.

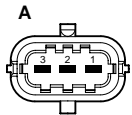
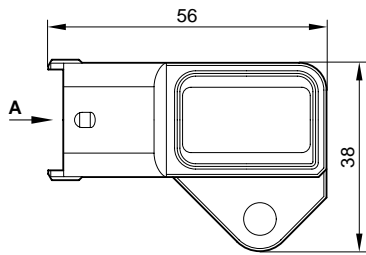
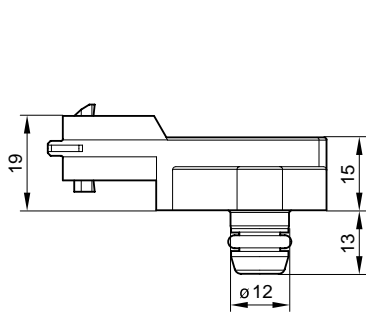


Explanation of symbols.

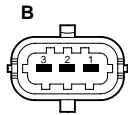
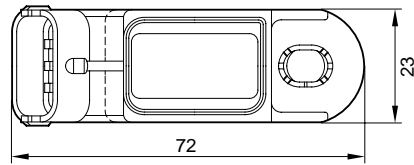
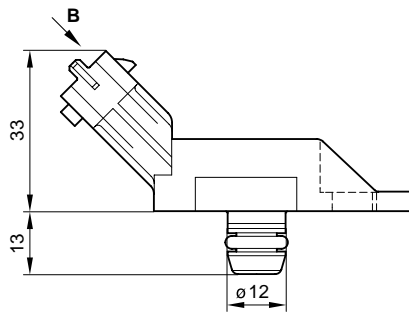
- U_A Output voltage
- U_V Supply voltage
- k Tolerance multiplier
- D After continuous operation
- N As-new state

Dimensions drawings.

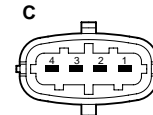
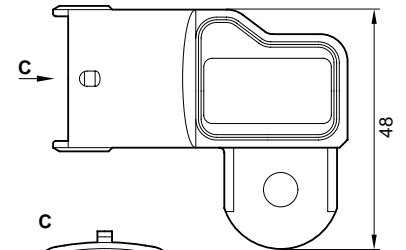
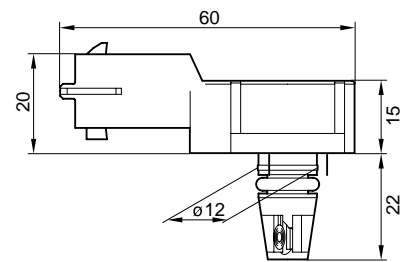
- ①
 Connector-pin assignment
 Pin 1 +5 V
 Pin 2 Ground
 Pin 3 Output signal



- ②
 Connector-pin assignment
 Pin 1 +5 V
 Pin 2 Ground
 Pin 3 Output signal

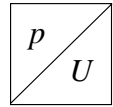


- ③
 Connector-pin assignment
 Pin 1 Ground
 Pin 2 NTC resistor
 Pin 3 +5 V
 Pin 4 Output signal



Piezoresistive absolute-pressure sensor with moulded cable

Measurement of pressures in gases up to 400 kPa



- Pressure-measuring element with silicon diaphragm ensures extremely high accuracy and long-term stability.
- Integrated evaluation circuit for signal amplification and characteristic-curve adjustment.
- Very robust construction.



Applications

This type of absolute-pressure sensor is highly suitable for measuring the boost pressure in the intake manifold of turbo-charged diesel engines. They are needed in such engine assemblies for boost-pressure control and smoke limitation.

Design and function

The sensors are provided with a pressure-connection fitting with O-ring so that they can be fitted directly at the measurement point without the complication and costs of installing special hoses. They are extremely robust and insensitive to aggressive media such as oils, fuels, brake fluids, saline fog, and industrial climate.

In the measuring process, pressure is applied to a silicon diaphragm to which are attached piezoresistive resistors. Using their integrated electronic circuitry, the sensors provide an output signal the voltage of which is proportional to the applied pressure.

Installation information

The metal bushings at the fastening holes are designed for tightening torques of maximum 10 N·m.

When installed, the pressure fitting must point downwards. The pressure fitting's angle referred to the vertical must not exceed 60°.

Tolerances

In the basic temperature range, the maximum pressure-measuring error Δp (referred to the excursion: 400 kPa–50 kPa = 350 kPa) is as follows:

Pressure range 70...360 kPa

As-new state	±1.0 %
After endurance test	±1.2 %

Pressure range < 70 and > 360 kPa (linear increase)

As-new state	±1.8 %
After endurance test	±2.0 %

Technical data / Range

Part number	0 281 002 257
Measuring range	50...400 kPa
Basic measuring range with enhanced accuracy	70...360 kPa
Resistance to overpressure	600 kPa
Ambient temperature range/sustained temperature range	–40...+120 °C
Basic range with enhanced accuracy	+20...+110 °C
Limit-temperature range, short-time	≤ 140 °C
Supply voltage U_V	5 V ± 10 %
Current input I_V	≤ 12 mA
Polarity-reversal strength at $I_V \leq 100$ mA	– U_V
Short-circuit strength, output	To ground and U_V
Permissible loading	
Pull down	≥ 100 kΩ
	≤ 100 nF
Response time $t_{10/90}$	≤ 5 ms
Vibration loading max.	20 g
Protection against water	
Strong hose water at increased pressure	IPX6K
High-pressure and steam-jet cleaning	IPX9K
Protection against dust	IP6KX

Throughout the complete temperature range, the permissible temperature error results from multiplying the maximum permissible pressure measuring error by the temperature-error multiplier corresponding to the temperature in question.

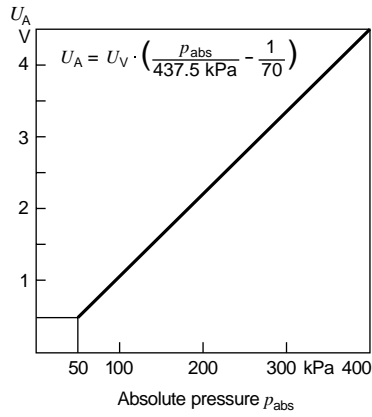
Basic temperature range	+20...+110 °C	1.0 ¹⁾
	+20... – 40 °C	3.0 ¹⁾
	+110...+120 °C	1.6 ¹⁾
	+120...+140 °C	2.0 ¹⁾

¹⁾ In each case, increasing linearly to the given value.

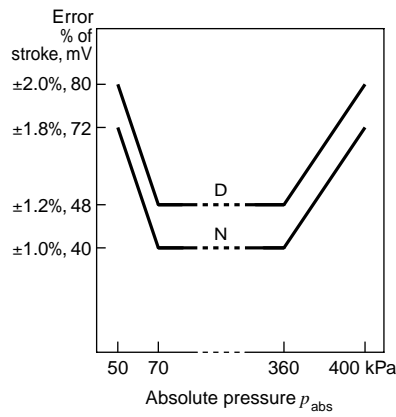
Accessories

Connector	1 237 000 039
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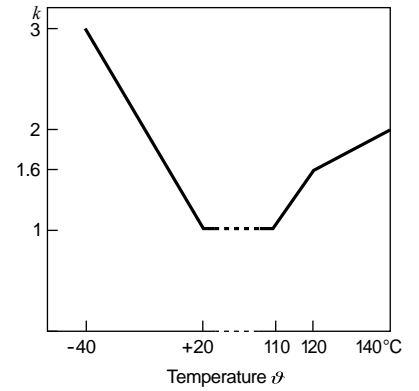
Characteristic curve ($U_V = 5\text{ V}$).



Maximum permissible pressure-measuring error.



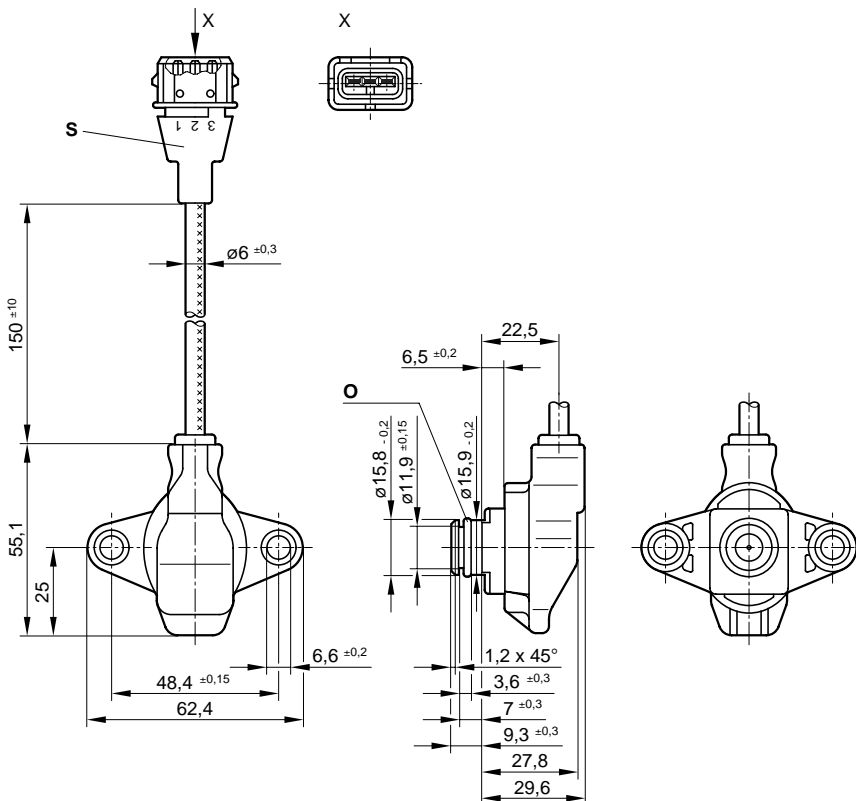
Temperature-error multiplier.



Dimension drawings.

S 3-pole plug

O1 O-ring dia. 11.5x2.5 mm HNBR-75-ShA



Explanation of symbols

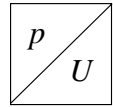
- U_V Supply voltage
- U_A Output voltage (signal voltage)
- k Temperature-error multiplier
- p_{abs} Absolute pressure
- g Acceleration due to gravity
9.81 m · s⁻²
- D After endurance test
- N As-new state

Connector-pin assignment

- Pin 1 U_A
- Pin 2 +5 V
- Pin 3 Ground

Medium-resistant absolute-pressure sensors Micromechanical type

Measurement of pressure in gases and liquid mediums up to 600 kPa



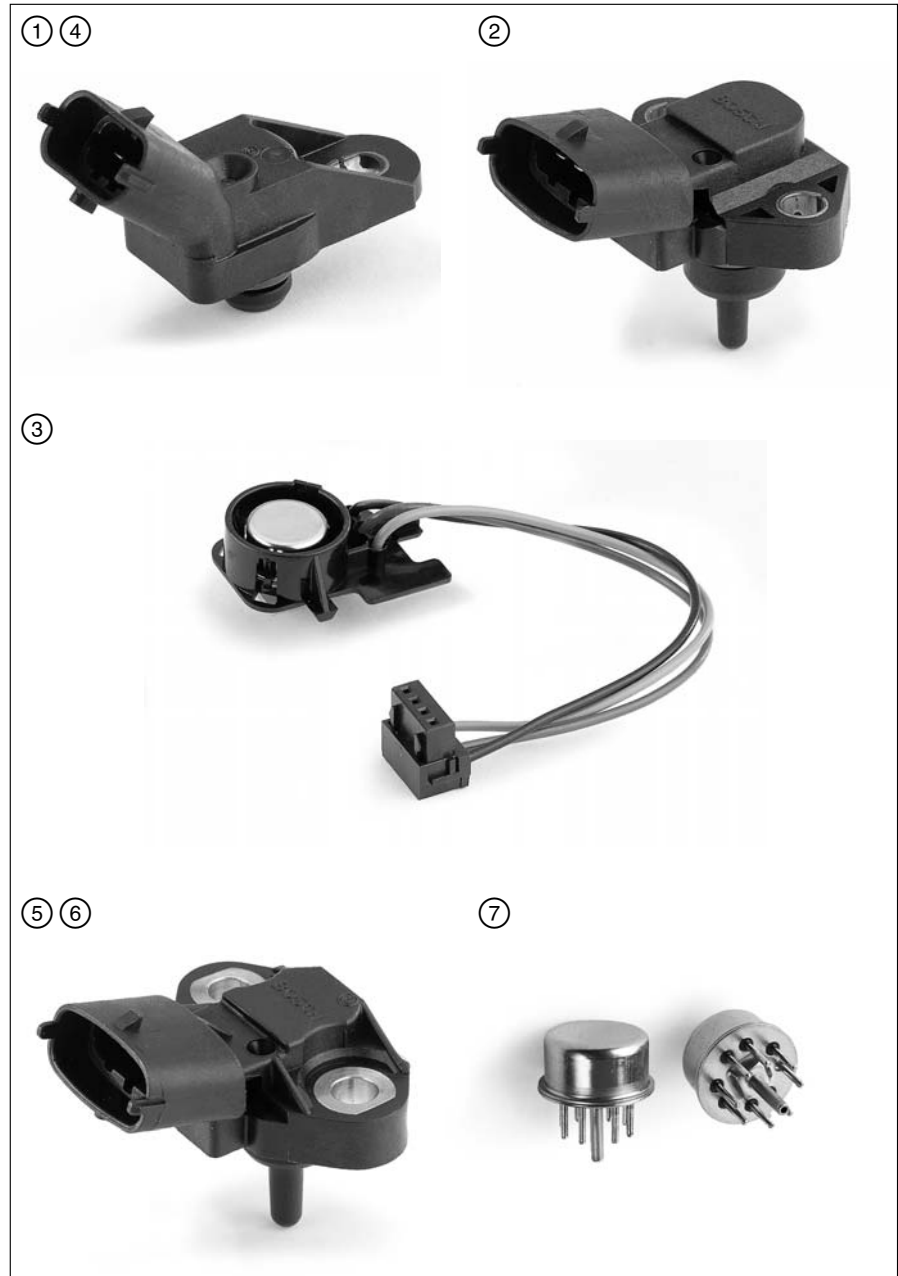
- Delivery possible either without housing or inside rugged housing.
- EMC protection up to $100 \text{ V} \cdot \text{m}^{-1}$.
- Temperature-compensated.
- Ratiometric output signal.
- All sensors and sensor cells are resistive to fuels (incl. diesel), and oils such as engine lube oils.

Applications

These monolithic integrated silicon pressure sensors are high-precision measuring elements for measuring the absolute pressure. They are particularly suitable for operations in hostile environments, for instance for measuring the absolute manifold pressure in internal-combustion engines.

Design and function

The sensor contains a silicon chip with etched pressure diaphragm. When a change in pressure takes place, the diaphragm is stretched and the resulting change in resistance is registered by an evaluation circuit. This evaluation circuit is integrated on the silicon chip together with the electronic calibration elements. During production of the silicon chip, a silicon wafer on which there are a number of sensor elements, is bonded to a glass plate. After sawing the plate into chips, the individual chips are soldered onto a metal base complete with pressure connection fitting. When pressure is applied, this is directed through the fitting and the base to the rear side of the pressure diaphragm. There is a reference vacuum trapped underneath the cap welded to the base. This permits the absolute pressure to be measured as well as protecting the front side of the pressure diaphragm. The programming logic integrated on the chip performs a calibration whereby the calibration parameters are permanently stored by means of thyristors (Zener-Zapping) and etched conductive paths. The calibrated and tested sensors are mounted in a special housing for attachment to the intake manifold.



Signal evaluation

The pressure sensor delivers an analog output signal which is ratiometric referred to the supply voltage. In the input stage of the downstream electronics, we recommend the use of an RC low-pass filter with, for instance, $t = 2 \text{ ms}$, in order to suppress any disturbance harmonics which may occur. In the version with integrated temperature sensor, the sensor is in the form of an NTC resistor (to be operated with series resistor) for measuring the ambient temperature.

Installation information

When installed, the pressure connection fitting must point downwards in order that condensate cannot form in the pressure cell.

Construction

Sensors with housing:

This version is equipped with a robust housing. In the version with temperature sensor, the sensor is incorporated in the housing.

Sensors without housing:

Casing similar to TO case, pressure is applied through a central pressure fitting. Of the available soldering pins the following are needed:

- Pin 6 Output voltage U_A ,
- Pin 7 Ground,
- Pin 8 +5 V.

Range

Pressure sensor integrated in rugged, media-resistant housing

Pressure range kPa (p1...p2)	Chara. curve ¹⁾	Features	Dimension drawing ²⁾		Part number
20...115	1	–	4	1	0 261 230 020
20...250	1	–	4	1	0 281 002 137
10...115	1	Integrated temperature sensor	2	2	0 261 230 022
20...115	1	Integrated temperature sensor	2	2	0 261 230 013
20...250	1	Integrated temperature sensor	2	2	0 281 002 205
50...350	2	Integrated temperature sensor	5	(5) ³⁾	0 281 002 244
50...400	2	Integrated temperature sensor	–	–	0 281 002 316
50...600	2	Integrated temperature sensor	6	6	0 281 002 420
10...115	1	Hose connection	1	(1) ³⁾	0 261 230 009
15...380	2	Clip-type module with connection cable	3	3	1 267 030 835

**Pressure-sensor cells in casings similar to transistors
Suitable for installation inside devices**

Pressure range kPa (p1...p2)	Chara. curve ¹⁾	Features	Dimension drawing ²⁾		Part number
10...115	1	–	7	7	0 273 300 006
15...380	2	–	7	7	0 273 300 017
15...380	2	–	8	(7) ³⁾	0 261 230 036
20...105	1	–	7	7	0 273 300 001
20...115	1	–	7	7	0 273 300 002
20...250	1	–	7	7	0 273 300 004
50...350	2	–	7	7	0 273 300 010
50...400	2	–	7	7	0 273 300 019
50...400	2	–	8	(7) ³⁾	0 261 230 033
50...600	2	–	7	7	0 273 300 012

¹⁾ The characteristic-curve tolerance and the tolerance extension factor apply to all versions, refer to Page 42.

²⁾ See Page 43/44 ³⁾ For similar drawing, see dimension drawing on Pages 43/44

⁴⁾ To be obtained from AMP Deutschland GmbH, Amperestr. 7–11, D-63225 Langen, Tel. 061 03/7 09-0, Fax 061 03/7 09 12 23, E-Mail: AMP.Kontakt@tycoelectronics.com

Accessories

**For 0 261 230 009, .. 020;
0 281 002 137**

Plug housing	1 928 403 870
Contact pin	2-929 939-1 ⁴⁾
Individual gasket	1 987 280 106

**For 0 261 230 013, .. 022;
0 281 002 205, ..420**

Plug housing	1 928 403 913
Contact pin	2-929 939-1 ⁴⁾
Individual gasket	1 987 280 106

For 0 281 002 244

Plug housing	1 928 403 913
Contact pin	2-929 939-6 ⁴⁾
Individual gasket	1 987 280 106

For 0 281 002 420

Plug housing	1 928 403 736
Contact pin	1 928 498 060
Individual gasket	1 928 300 599

Note

Each 3-pole plug requires 1 plug housing, 3 contact pins, and 3 individual gaskets. 4-pole plugs require 1 plug housing, 4 contact pins, and 4 individual gaskets.

Technical data

		min.	typical	max.
Supply voltage U_V	V	4.5	5	5.5
Current input I_V at $U_V = 5$ V	mA	6	9	12.5
Load current at output	mA	–0.1	–	0.1
Load resistance to ground or U_V	k Ω	50	–	–
Lower limit at $U_V = 5$ V	V	0.25	0.30	0.35
Upper limit at $U_V = 5$ V	V	4.75	4.80	4.85
Output resistance to ground U_V open	k Ω	2.4	4.7	8.2
Output resistance to U_V , ground open	k Ω	3.4	5.3	8.2
Response time $t_{10/90}$	ms	–	0.2	–
Operating temperature	$^{\circ}$ C	–40	–	+125

Limit data

Supply voltage U_V	V	–	–	16
Operating temperature	$^{\circ}$ C	–40	–	+130

Recommendation for signal evaluation

Load resistance to $U_H = 5.5...16$ V	k Ω	–	680	–
Load resistance to ground	k Ω	–	100	–
Low-pass resistance	k Ω	–	21.5	–
Low-pass capacitance	nF	–	100	–

Temperature sensor

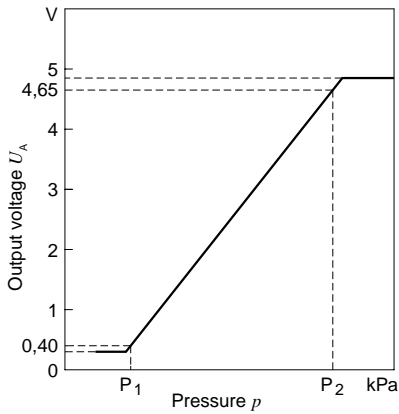
Measuring range	$^{\circ}$ C	–40	–	+125
Nominal voltage	mA	–	–	1 ⁵⁾
Measured current at +20 $^{\circ}$ C	k Ω	–	2,5 \pm 5 %	–
Temperature time constant t_{63} ⁶⁾	s	–	–	45

⁵⁾ Operation with series resistor 1 k Ω .

⁶⁾ In air with airflow speed 6 m \cdot s⁻¹.

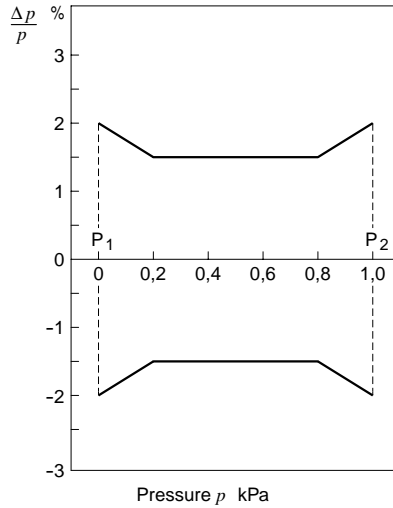
Micromechanical TO-design absolute-pressure sensors (contd.)
 Measurement of pressures in gases and liquid media up to 600 kPa

Characteristic curve 1 ($U_V = 5.0$ V).

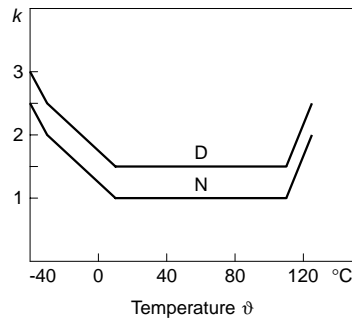


Characteristic curve 2 ($U_V = 5.0$ V).

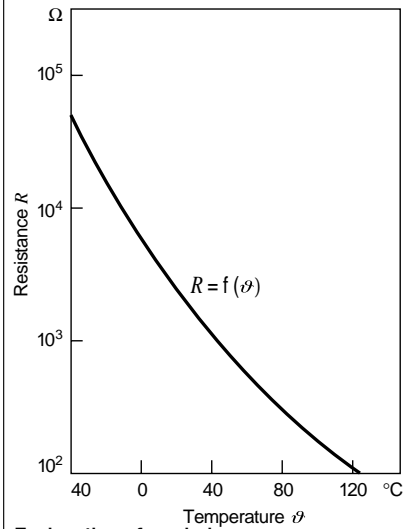
Characteristic-curve tolerance.



Tolerance extension factor.



Temperature-sensor characteristic curve.

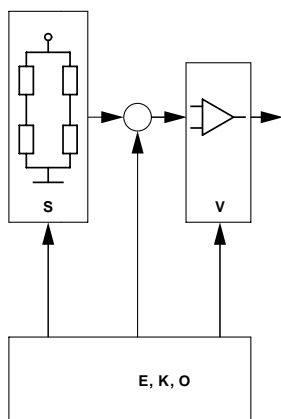


Explanation of symbols

- U_A Output voltage
- U_V Supply voltage
- k Tolerance multiplication factor
- D Following endurance test
- N As-new state

Block diagram.

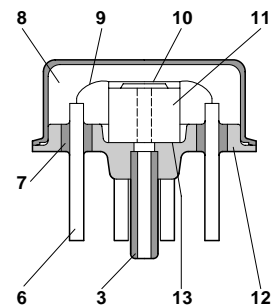
- E Characteristic curve: Sensitivity,
- K Compensation circuit
- O Characteristic curve: Offset,
- S Sensor bridge, V Amplifier



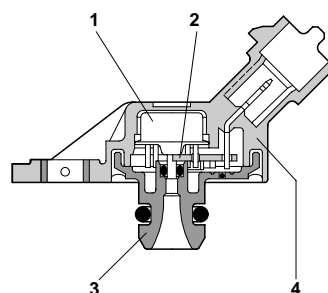
Sectional views.

Pressure sensor in housing.

- 1 Pressure sensor, 2 pcb, 3 Pressure fitting,
- 4 Housing, 5 Temperature sensor,
- 6 Electrical bushing, 7 Glass insulation,
- 8 Reference vacuum, 9 Aluminum connection (bonding wire),
- 10 Sensor chip, 11 Glass base,
- 12 Welded connection,
- 13 Soldered connection.

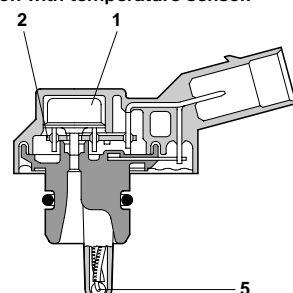


Section through the installed pressure sensor.



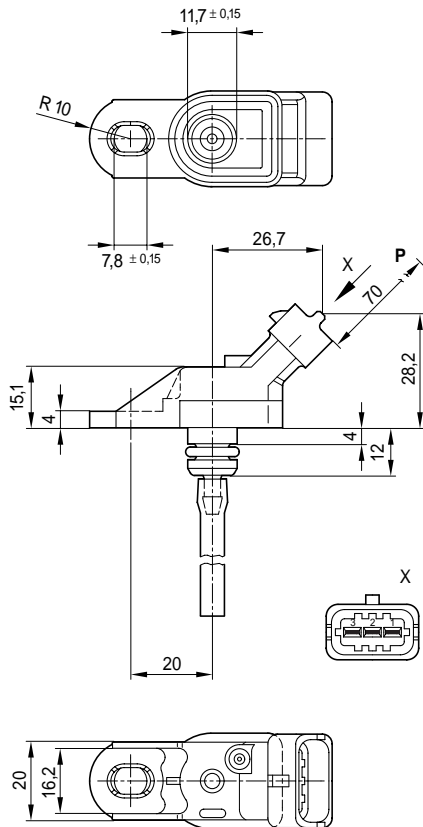
Installed pressure sensor.

Version with temperature sensor.

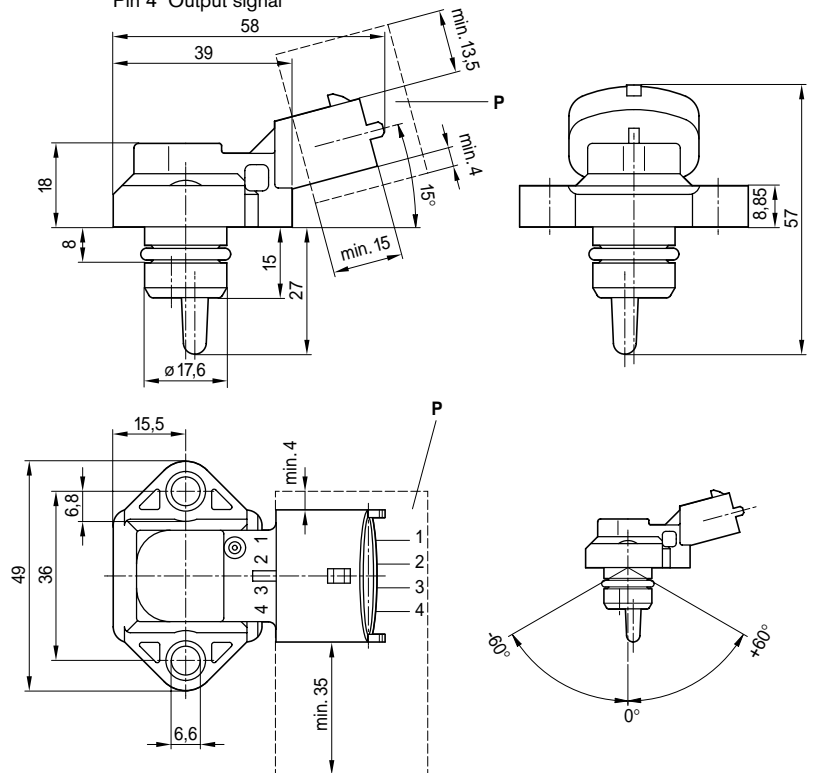


Dimension drawings. P Space required by plug and cable.

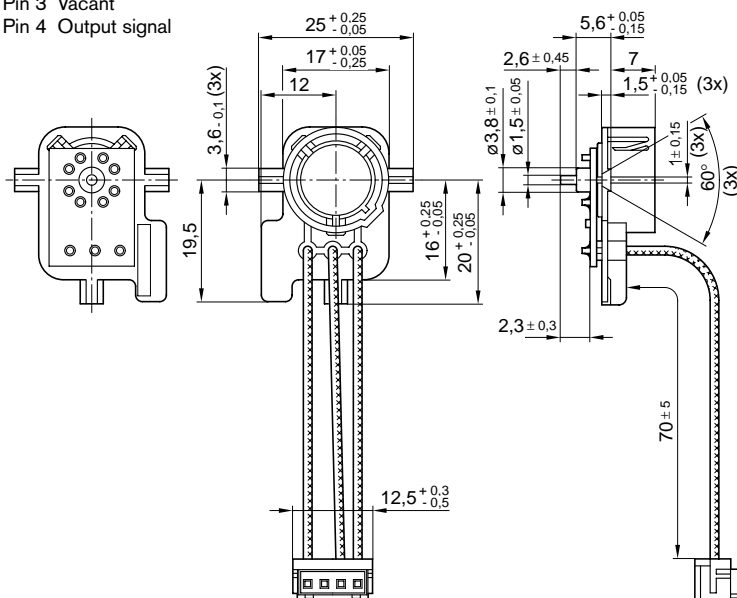
① **0 261 230 009**
 Connector-pin assignment
 Pin 1 +5 V
 Pin 2 Ground
 Pin 3 Output signal



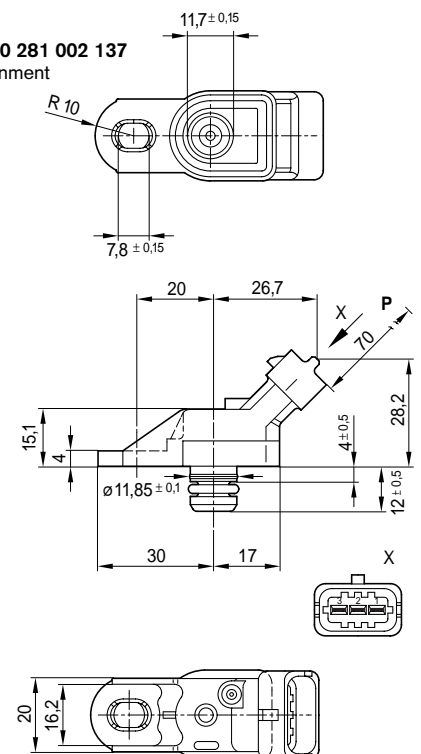
② **0 261 230 013, 0 261 230 022, 0 281 002 205**
 Connector-pin assignment
 Pin 1 Ground
 Pin 2 NTC resistor
 Pin 3 +5V
 Pin 4 Output signal



③ **1 267 030 835**
 Connector-pin assignment
 Pin 1 Ground
 Pin 2 +5V
 Pin 3 Vacant
 Pin 4 Output signal



④ **0 261 230 020, 0 281 002 137**
 Connector-pin assignment
 Pin 1 +5V
 Pin 2 Ground
 Pin 3 Output signal

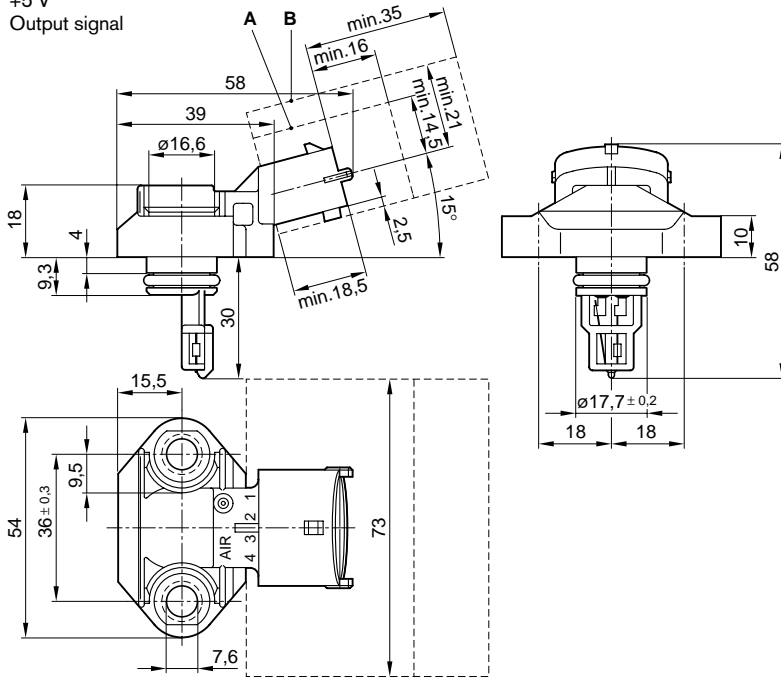


Micromechanical TO-design absolute-pressure sensors (contd.)
Measurement of pressures in gases and liquid media up to 600 kPa

Dimension drawings A Space required by plug and cable
 B Space required when plugging in/unplugging

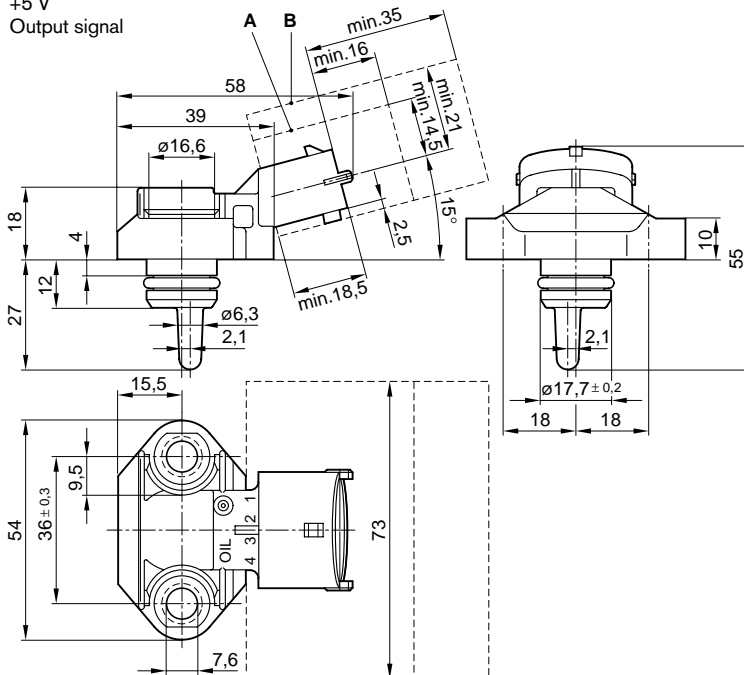
⑤ **0 281 002 244**

- Connector-pin assignment
- Pin 1 Ground
- Pin 2 NTC resistor
- Pin 3 +5 V
- Pin 4 Output signal



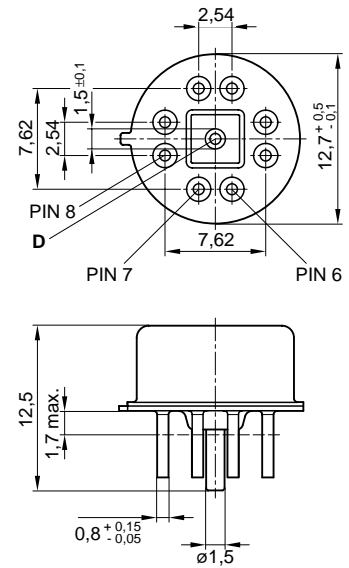
⑥ **0 281 002 246**

- Connector-pin assignment
- Pin 1 Ground
- Pin 2 NTC resistor
- Pin 3 +5 V
- Pin 4 Output signal



⑦ **0 273 300 ..**

- Sensor without housing
- D Pressure-connection fitting
- Pin 6 Output signal
- Pin 7 Soldered



⑧ **0 261 230 036 ..**

- D Pressure connection
- L In the area of the measuring surface

