Produkt / Product: **Medium pressure sensor for liquid and gaseous media with integrated temperature measurement**

Typ / Type: **DS-M1-TF**

Bestellnummer/ Part Number: **0 261 230 340**

Angebotszeichnung/ Offer Drawing: 0 261 A12 776-000

Gültig ab / Valid from: Presumably from SOP onwards

Bemerkung / Comment:

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1		First version	03.05.11	Gez. i.A. Stegmaier 03.05.11	Gez. Habibi 03.05.11	Gez. Didra 03.05.11		
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1.1. Technical principle

The piezoresistive sensor element and suitable circuitry for signal amplification and temperature compensation are integrated on a silicon chip. The pressure of the measurement medium is applied via the pressure port to the back side of the silicon diaphragm, which is resistant to the measured medium. The integration of reference vacuum in silicon chip allows for the measurement of the absolute pressure. The temperature measurement element is a thermistor (NTC resistor), which is hermetically sealed from the measured medium. The sealing of the mechanical interface is done by a metallic cone gasket.

1.2. Maximum ratings of pressure sensor

Parameter	Symbol	Value	Unit
Supply voltage [1)]	$U_{S.max.}$	16	V
Max. permissible overload pressure	$p_{max.}$	2000	kPa
Burst pressure	p_{burst}	4000	kPa

1) Overvoltage duration limited to $t \leq 1$ min if $U_S > 8$ V.

The output is short-circuit resistant against ground and supply voltage when the supply voltage is limited to a maximum of 16 V, for a duration of 1 min and the temperature is restricted to room temperature.
At U_S= 5 V, the sensor is reverse polarity protected for 5 min at room temperature when maximum current is limited to 0.3 A.

1.3. Operating characteristics of pressure sensor

Parameter	Symbol	Value min.	Value typ.	Value max.	Unit
Pressure measuring range	p_e	0		1000	kPa
Operating temperature	T	-40		+140	°C
Supply voltage	U_S	4.75	5.0	5.25	V
Current consumption at U_S = 5 V	I_S	6.0	10.0	15.0	mA
Load current at output	I_L	-1.0		0.5	mA
Load resistance to U_S or to ground [1)]	$R_{pull\text{-}up}$ $R_{pull\text{-}down}$	5.0 10.0	680 480		kΩ kΩ
Load capacitance	C_L			12	nF
Resistance of NTC at 25°C (new part)	R_{NTC}	1950	2038	2128	Ω
Pressure response time	$t_{10/90}$		< 5		ms
Response time to U_S	$t_{10/90}$		< 5		ms
Response time of temperature signal in oil bath, 20°C ... 100°C	t_{63}		9		s
Lower limit at U_S = 5 V	$U_{out,min.}$	0.25	0.3	0.35	V
Upper limit at U_S = 5 V [2)]	$U_{out,max.}$	4.65	4.7	4.75	V
Output resistance to ground; U_S open [3)]	R_{lo}	2.4	4.7	8.2	kΩ
Output resistance to U_S; ground open [3)]	R_{hi}	3.4	5.3	8.2	kΩ

1) Minimum and maximum values given do not imply diagnostic capability; diagnostic capability, however, is present when the typical load resistances are used.

2) With 10 kΩ pull-down resistor and temperature > 100°C the range of the upper limit may be increased by 10 mV.

3) Valid only for measurement voltage < 0.8 V and ambient temperature ≤ 110°C.

1.4. Transfer function of pressure sensor

$$U_{out} = (c_1 \cdot p + c_0) \cdot U_S$$

where U_{out} = signal output voltage in V
U_S = supply voltage in V
p_e = relative pressure in kPa
c_0 = 0.1
c_1 = 0.0008 kPa^{-1}

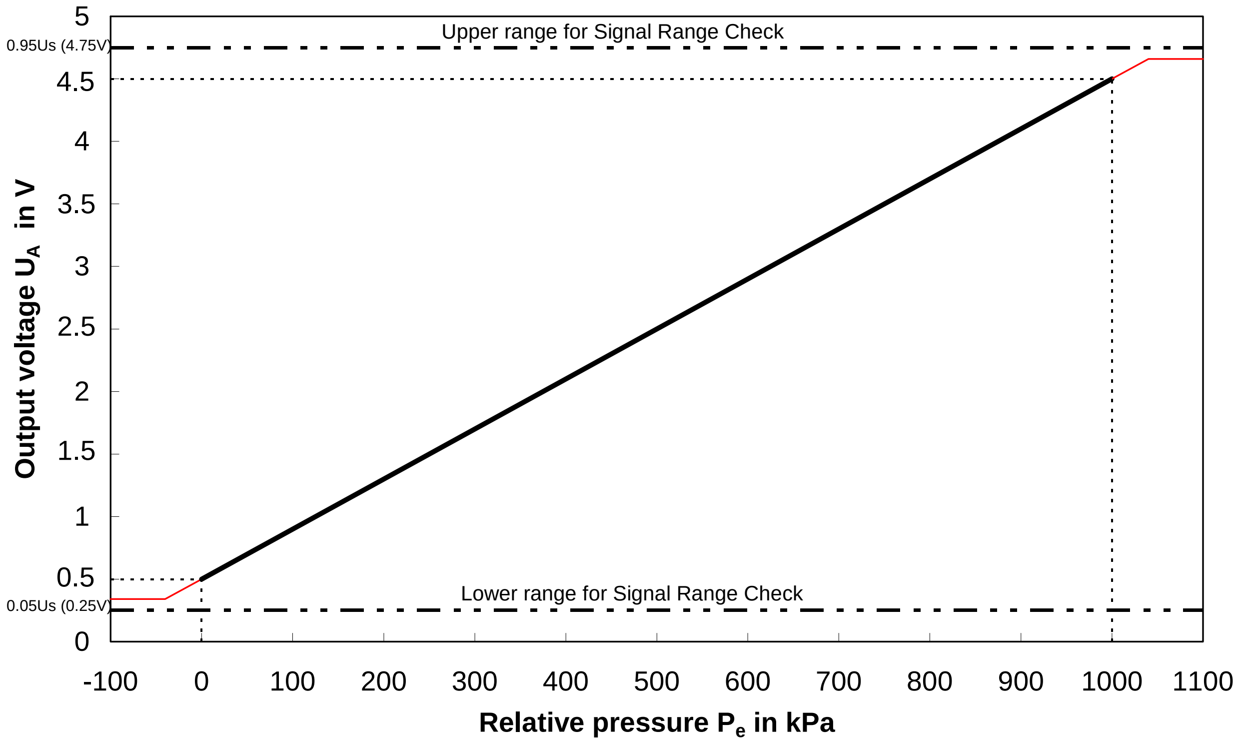
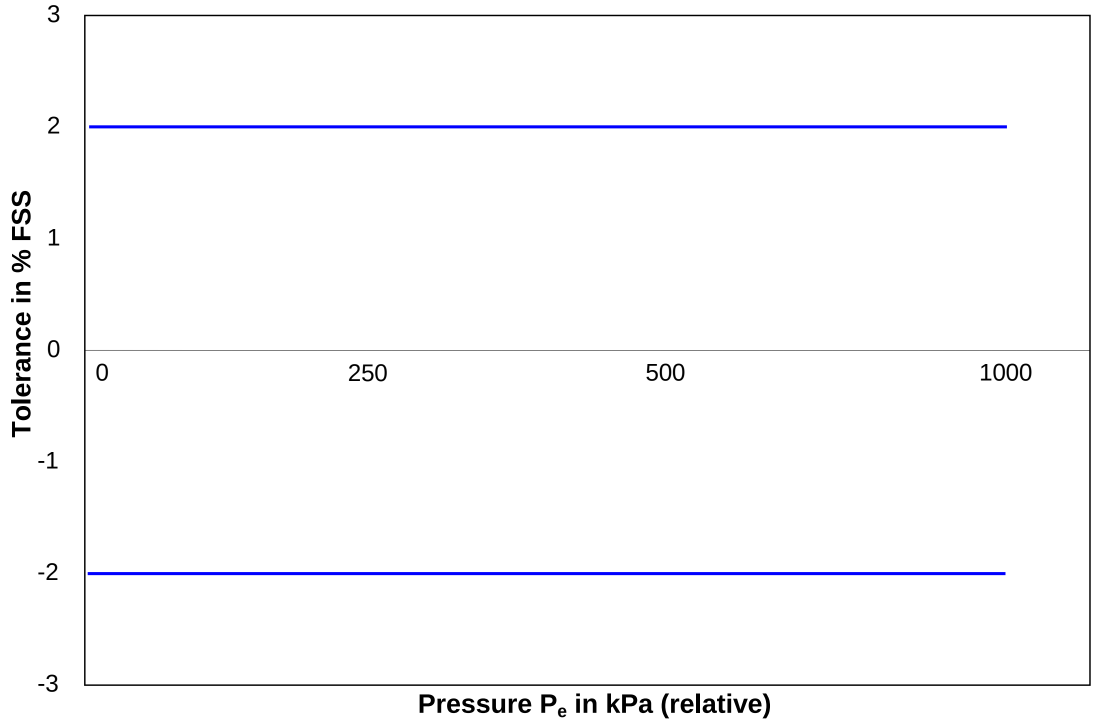


Figure 1. Output characteristic at U_S= 5.000 V

1.5. Accuracy of pressure signal



Tolerance band within core temperature range of +25°C to +85°C

Figure 2: Tolerance band over pressure range

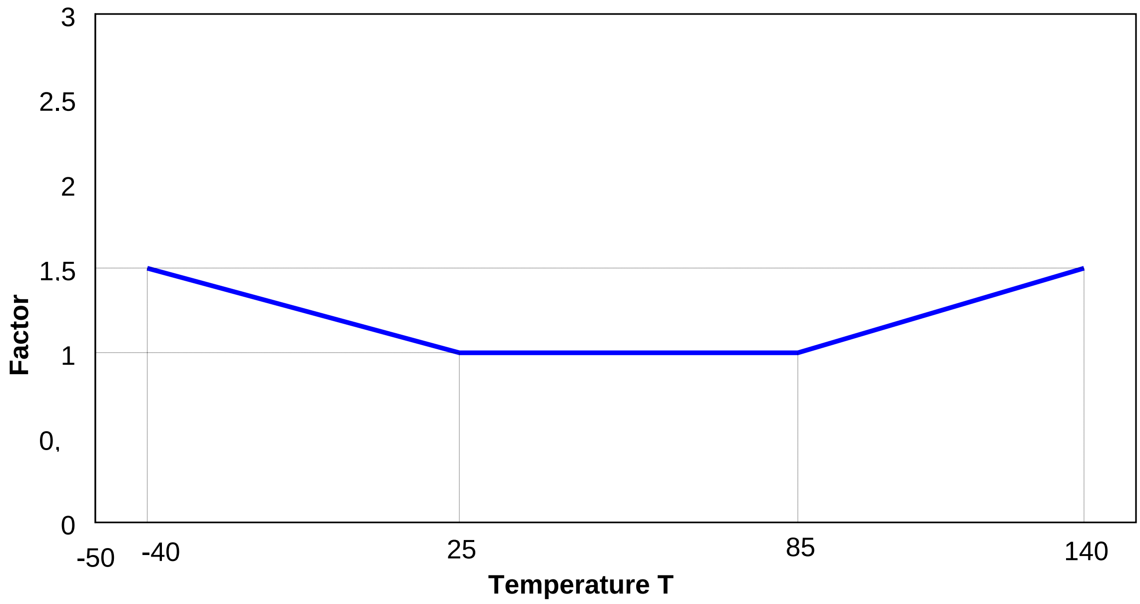


Figure 3: Temperature-dependent tolerance expansion

1.6. Maximum ratings of temperature sensor

Power rating at 25°C: 32 mW

1.7. Data of temperature sensor

Specified temperature range: -40 to +140°C
Operating voltage: Operation with a 3.16 kΩ series resistor at 5 V in the control unit
Nominal resistance at 20 °C: 2.482 kΩ ± 4.7 % (new part)
Temperature response time τ_{63} in oil bath : ≤ 9 s

1.8. Characteristic of temperature sensor

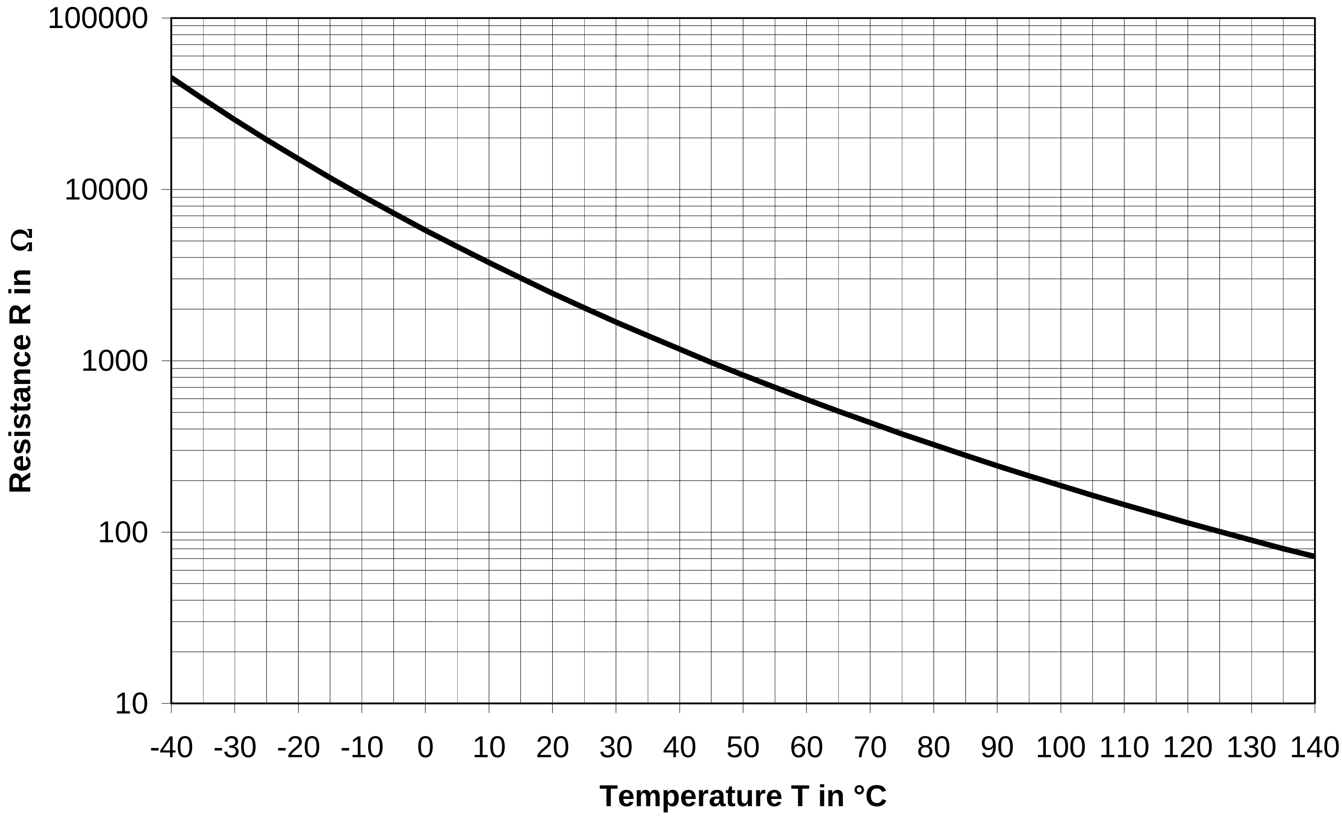


Figure 4. NTC resistance as a function of temperature

Measurement of resistance in engaged condition with measuring current ≤ 0.1 mA according to following table:

Temp.	Resistance R in Ω			Tolerance	Test limits at T ± 1 K	
T in °C	nominal	minimum	maximum	in K	minimum	maximum
-40	**44864**	41559	48413	± 1.4	39236	51354
-35	**33676**	31294	36226	± 1.3	29602	38358
-30	**25524**	23790	27374	± 1.3	22546	28929
-25	**19525**	18251	20879	± 1.3	17327	22025
-20	**15067**	14123	16067	± 1.3	13430	16919
-15	**11724**	11019	12468	± 1.3	10495	13108
-10	**9195**	8665	9754	± 1.3	8265	10238
-5	**7266**	6864	7689	± 1.3	6558	8059
0	**5784**	5477	6106	± 1.2	5239	6390
5	**4636**	4400	4882	± 1.2	4215	5103
10	**3740**	3558	3930	± 1.2	3412	4102
15	**3037**	2895	3184	± 1.2	2780	3319
20	**2480**	2369	2595	± 1.2	2278	2702
25	**2038**	1950	2128	± 1.1	1877	2213
30	**1683**	1614	1755	± 1.1	1555	1823
35	**1398**	1343	1454	± 1.1	1295	1509
40	**1167**	1123	1212	± 1.1	1084	1256
45	**978.9**	943.9	1015	± 1.1	912.1	1051
50	**825.0**	796.9	853.8	± 1.0	770.8	883.5
55	**698.5**	675.8	721.7	± 1.0	654.2	746.1
60	**594.0**	575.6	612.7	± 1.0	557.7	632.9
65	**507.2**	492.2	522.4	± 1.0	477.3	539.1
70	**434.9**	422.7	447.2	± 0.9	410.2	461.2
75	**374.3**	364.3	384.4	± 0.9	353.8	396.1
80	**323.4**	315.2	331.6	± 0.9	306.4	341.4
85	**280.4**	273.7	287.1	± 0.9	266.2	295.4
90	**244.0**	238.5	249.5	± 0.8	232.1	256.6
95	**213.0**	208.5	217.6	± 0.8	203.0	223.5
100	**186.6**	182.9	190.3	± 0.8	178.1	195.4
105	**164.0**	160.5	167.5	± 0.8	156.4	171.8
110	**144.5**	141.3	147.8	± 0.9	137.8	151.5
115	**127.8**	124.8	130.8	± 1.0	121.7	134.0
120	**113.3**	110.5	116.1	± 1.1	107.9	118.9
125	**100.7**	98.1	103.3	± 1.1	95.8	105.7
130	**89.8**	87.4	92.2	± 1.2	85.4	94.3
135	**80.2**	78.0	82.5	± 1.3	76.3	84.3
140	**71.9**	69.8	74.0	± 1.3	68.3	75.6

Table 1: Output characteristic of the temperature sensor

2. Conditions of use

2.1. Application

The medium-pressure sensor DS-M1 described within this technical customer information is designed for the measurement of the relative pressure of gaseous and liquid media and as well as the temperature of the medium. The sensor is solely designed for the use in vehicles. The sensor is designed to measure the pressure within the vehicle and optimized for the following gaseous and liquid media: gasoline, diesel fuel, engine oil, transmission fluid, CNG, coolant R134 and air. For other applications or media, the sensor function must be assured and validated with additional tests and needs to be approved and released by Robert BOSCH GmbH. The use of the product is only permitted under the operating specified conditions specified in this document. Any change in the product's operating environment must be communicated to and released by Bosch. This particularly applies for applications subject to special reliability, robustness and safety requirements

If according to the supply agreement between the customer and Bosch, Bosch will be responsible for delivered products being fit for the use or purpose intended and/or having a defined level of quality, such responsibilities are subject to the application of the product conforming to the agreed upon environment, installation and stress conditions, as such that are referenced in the technical specification of Bosch (TKU). When the product during the Bosch release procedures has successfully met the test specifications agreed to, or provided by, the customer, it is deemed to fully cover all requirements, if any, for which the product be fit for the use or purpose intended and/or have a defined level of quality. The customer shall be responsible for the system application, which includes ensuring that the product application and all environmental, installation and stress conditions to which the product will be exposed are covered by such testing. The customer shall be responsible for making sure that the product will not be exposed to conditions in excess of those referenced in such testing specifications.

2.2. Installation instructions

The medium-pressure sensor with integrated thermistor is designed to be mounted in the engine compartment. Sealing of the mounting interface is performed by the conical area on the sensor port. Other sealing methods such as washer sealing on flat area of the thread part below ø15.5mm is possible. Bosch assures mechanical robustness, while the customer takes responsibility for sealing. It must be assured that no liquid media accumulates and freezes in the cavity of the silicon diaphragm. As a result of freezing liquid media at the sensor diaphragm, the silicon diaphragm can burst.

The connector housing must not be twisted in relation to the pressure port during installation. Tools for installation are to be only used on the hexagon.

The optimum mounting location, e.g. for mounting on the fuel rail, should be selected according to fluidic aspects so that a maximum incident flow of the thermistor is achieved in all operating conditions.

During transport and assembly, it is to be ensured that the connector area, the area around the nose of the thermistor and the sealing area at the port as well as all areas of the sensor in contact with measurement media during operation remain free of solid and liquid contaminations and that the sealing area is not damaged.

Dropped sensors (even with protection cap) must not be used.

In case a customer specified connection system is used, the customer will be responsible for the durability of the connection system and release of the connector system. The supporting points, attachment and permissible bending radii for the electrical cable harness lie within the customer's responsibility. Bosch takes no responsibility for the concept of the plug connection and connection system, neither for its function in relationship with other components. The customer releases Bosch from all claims regarding design of plug connection and connection system, including product liability claims.

2.3. Signal evaluation

The pressure sensor supplies an analogue output signal which is ratiometric to the supply voltage and proportional to the pressure. An RC low-pass filter with for τ = 2 ms is recommended as an input circuit for the following electronics in order to suppress possibly disturbing harmonic vibrations.
Robert Bosch GmbH recommends evaluating the NTC-signal by a reference series resistor of 1.0 kΩ ± 1.0%.

2.4. Error diagnosis

The analogue electrical output of the pressure sensor is designed in such a way that malfunctions due to cable breaks or short circuits can be detected in the subsequent electronics. The diagnostic capability has to be ensured through suitable circuitry. BOSCH recommends using either a 480 kΩ pull-down resistor or a 680 kΩ pull-up resistor in the control unit.

For error diagnosis the diagnostic bands outside the clamping limits are provided. Since the sensor characteristic of the upper operating range is limited, overpressure conditions can be distinguished from errors. Due to the measurement concept using a micromechanical device (piezoresistive and analogue), one cannot rule out that a failure (e.g. due to ESD damage or a burst diaphragm) may occur with an output signal within the plausible range.

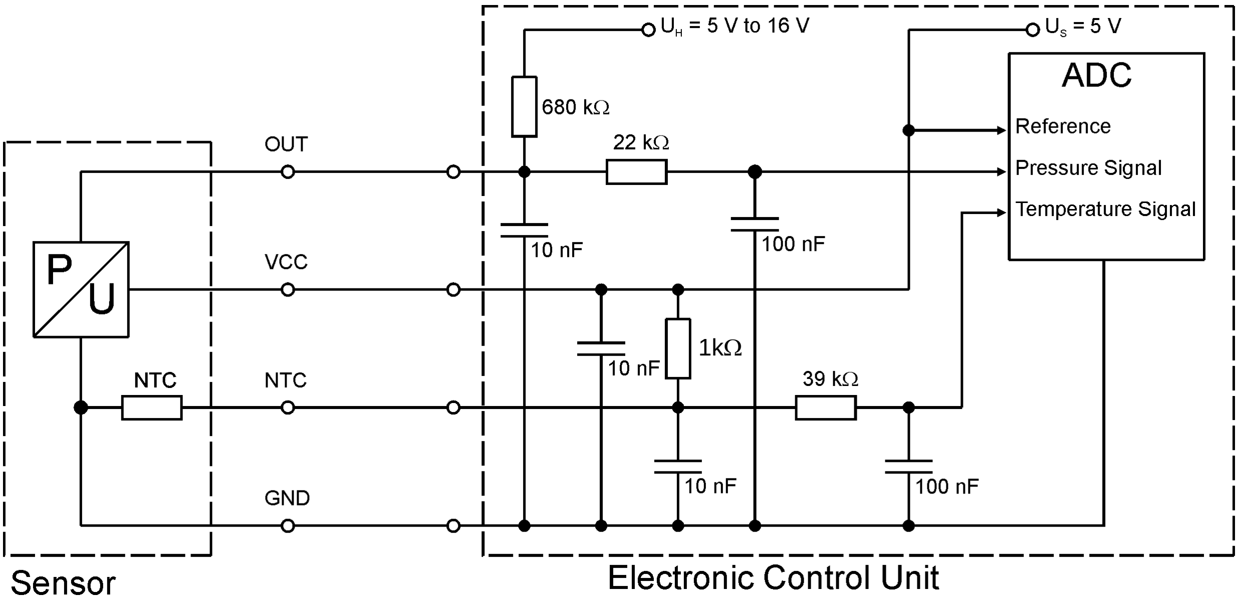


Figure 5. Example for signal evaluation with load resistor to U_H = 5 V

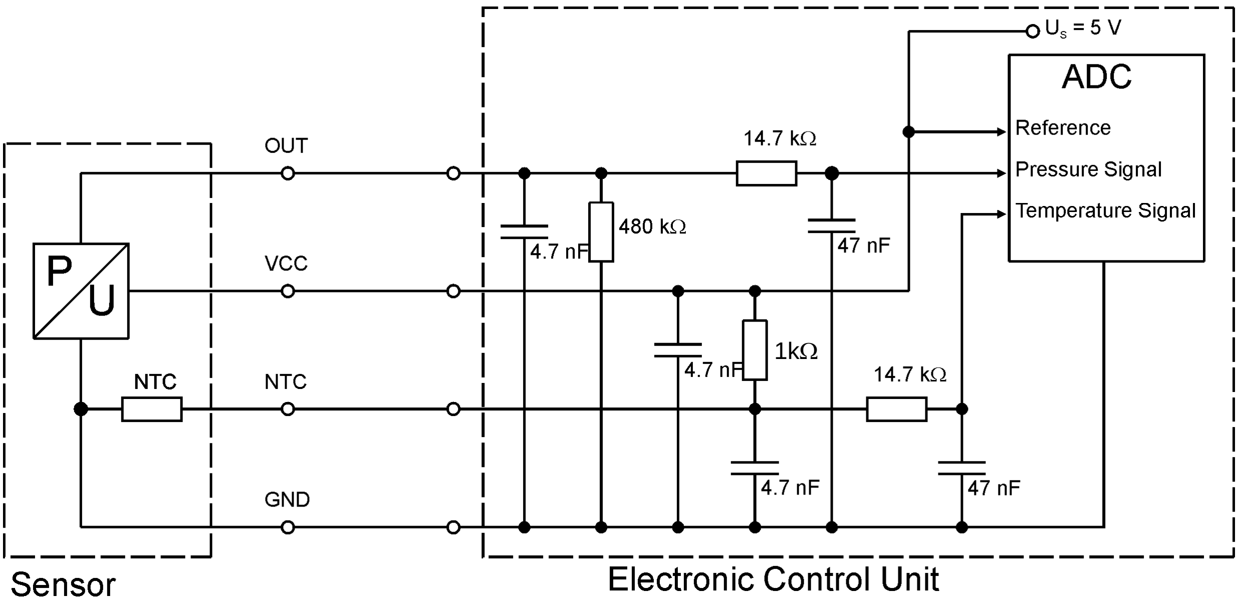


Figure 6. Example for signal evaluation with load resistor to ground

2.5. Storage conditions

Dust, water or other corrosive fluid must not enter into the connector interface. In case of silver plated pins, no sulphur oxide containing atmosphere.

The following storage conditions and maximum storage durations are permissible:
4 weeks between −30°C and +80°C and between 0 and 60% rel. humidity (transport conditions), additionally 10 years between 0 and 40 °C and between 30 and 60% rel. humidity (storage conditions) without additional testing to verify sensor performance. The sensor is to be stored in a dry and dust-free place. It is to be ensured that the plug connection is not contaminated with liquid or solid substances and the sealing areas are not damaged. These storage conditions do not alter the output characteristics nor the function of the sensor. After exceeding the maximum storage duration, the sensors are to be sent to Robert BOSCH GmbH for inspection.

2.6. Handling instructions

The following issues shall be observed under all circumstances to avoid damage or pre-damage to the sensor when at the user’s premises:

- The maximum permissible pressure limit shall not be exceeded when leak-testing.
- During immersion testing, both connector and pressure port shall be protected from ingress by water.
- Reverse-polarity and overvoltage shall be avoided when subjecting the sensor to electrical testing.
- The supplier shall be given appropriate instructions if the sensor is to be installed at the supplier’s premises.

3. Test Data and Test Methods

3.1. Functional test of pressure sensor

Ambient temperature: (23 ± 5) °C

Supply voltage: $U_S = (5.000 \pm 0.250)$ V
If the supply voltage U_S differs from the nominal value 5.000 V, the measured output voltage U_{out} must be converted to the nominal value with factor 5.000 V/U_S.

Output voltage at:

p_e =	0.0 kPa:	$U_{out} = (0.500 \pm 0.080)$ V
p_e =	1000.0 kPa:	$U_{out} = (4.500 \pm 0.080)$ V

3.2. Functional test of temperature sensor

Values of NTC resistor at -10°C, 20°C and 80°C according to table 1, chapter 1.8.
After endurance testing these test limits may be exceeded by at most 5%.

3.3. Leakage test

The leak test is carried out with helium or air. The parts shall be mounted similar to the position in the vehicle. Test duration for pressure loss and helium leakage test per test specimen shall be 30 s.

Applied pressure:	Δp = 1000 kPa rel.
Max. permissible leakage rate in air:	0.5 ml/min
Max. permissible leakage rate for helium:	6.4×10^{-3} mbar l/sec

4. Endurance and Function Testing

4.1. General remarks

These tests cover the usual loads expected over the vehicle's life cycle. For critical loads, the conditions need to be verified through vehicle measurements. The tabulated endurance tests below have been qualified during release testing. A complete repetition of all tests during series production does not take place.

The product functionality in the full system must be assured by the customer through an appropriate vehicle test under realistic conditions of use.

New parts shall be used in each case for the tests to be performed.

For values of applicable temperature and supply voltage see chapter 3.

Evaluation: After completion of the tests, the output signal needs to be within the tolerance band (see 3.1; 3.2) and the sensor shall be within the permissible leak rate (see 3.3).
Further assessment criteria are specified in the given test description

4.2. Electromagnetic compatibility

The electromagnetic compatibility of the component is qualified solely during release testing. A requalification of the product during series production does not take place.
Unless defined otherwise, a deviation of ±100mV is permissible. Electromagnetic compatibility tests are performed with new parts.
<u>Function state A:</u>
During and after testing the sensor remains within its tolerance band and exhibits no failure.
<u>Function state C:</u>
During testing the component may show a failure or output voltage exceeding the defined tolerance band. After testing the sensor returns to normal operation (function state A).

4.2.1. Capacitive test with coupling clamp

The test set-up is based on ISO/DIS 7637-3. The capacitive test is carried out only at the signal lines, supply lines and ground lines (interference resistance against disturbances on signal, data and control lines). The test pulses 3a and 3b are set at the pulse generator with connected coupling clamp and are fed into it via coaxial supply line. Function state A within 2 ms after pulse.

4.2.2. Inductive test according to BCI method

The test set-up is based on ISO 11452-4. The test is to be carried out in open-loop operation. The specimen is to be operated with in the frequency band from 1-400 MHz.
Test level IV with test amperage of 100 mA and function state A as well as with test amperage of 200 mA and function state C is to be applied. For test amperage of 200 mA, the function failure profile is to be represented. The method of peak value monitoring is applied.

4.2.3. Field-coupled test / antenna in absorber hall

Based on ISO/DIS 11452-2. Antenna measurement will be carried out in the frequency range from 400 MHz up to 2 GHz. To be carried out with test field strength of 100 V/m and function state A. The method of peak value monitoring is applied.

4.2.4. Test of interference resistance against electrostatic discharge

The test is to be carried out according to ISO 10605. Differing from ISO 10605, an ESD simulator with a 150pF/330Ω human body model (HBM) is to be used. The components are to be tested without power supply (unpowered test). Air discharge and contact discharge (at all connection pins of the component). Function state A after test (after restart).

4.3. Temperature shock cycling

Lower dwell temperature:	- 40 ± 2°C
Upper dwell temperature:	+140 ± 2°C
Dwell time:	30 min
Transition time:	< 10s
Number of cycles:	1000

Specimens with mating plug and installed in mounting interface

4.4. High-temperature storage

Duration:	1000h
Temperature:	+140°C
Medium:	Air

Sensor installed in mounting interface and in operation

4.5. Low-temperature storage

Duration:	100h
Temperature:	-40 °C
Medium:	Air

Sensor installed in mounting interface and in operation

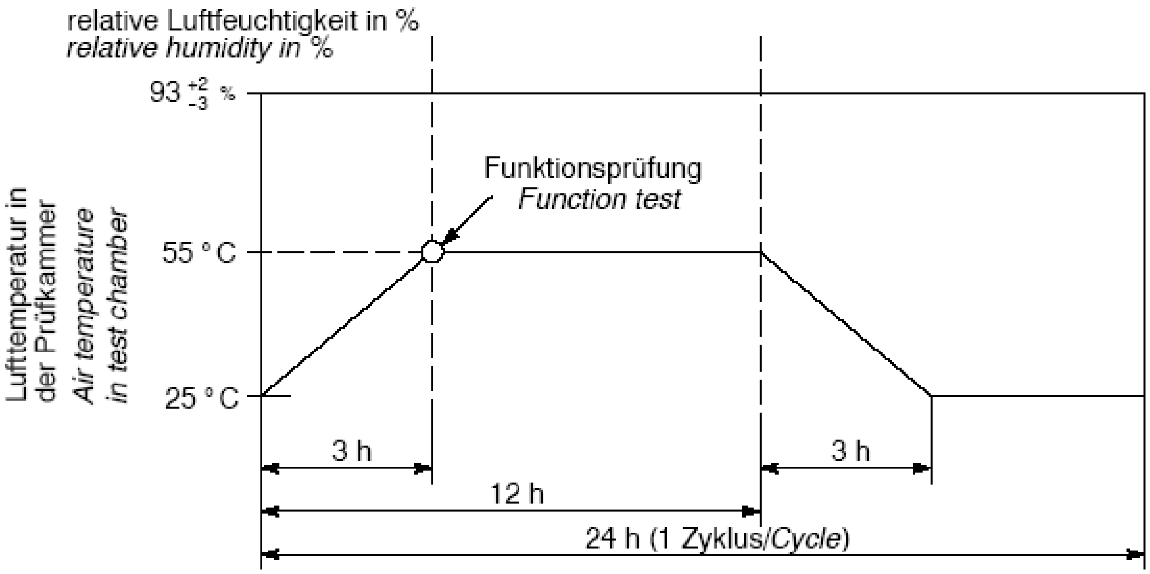
4.6. Functional endurance test

Hydraulic pressure cycles:
p_{min} = 500kPa to p_{max}= 2000kPa relative
Frequency: 10 Hz
Test duration: $2{\cdot}10^6$ pressure changes
Temperature profile: Temperature cycling between -40°C and +140°C
Temperature change rate: 6°C/minute
Dwell time at final temperature: 15 minutes
Test medium: Test oil
Sensor installed in mounting interface and in operation.

4.7. Humidity cycling test

Test based on IEC 60068-2-30, variant 1
Electrical operation mandatory
Humidity: Constant at 93% RH
Temperature profile: 6 cycles of temperature cycling between +25°C and +55°C
Temperature change rate: 0.17°C/ minute
=> 3 hours of rearrangement time between +25°C and +55°C
Dwell time at final temperature: 9 hours
Sensor installed in mounting interface

Figure 7: Temperature characteristic for humidity cycling test



4.8. High-temperature and high-humidity storage test

Humidity: Constant at 85% RH
Temperature: Constant at 85°C
Duration: 500h
Sensor installed in mounting interface and in operation

4.9. Vibration test

IEC 60068-2-6. Test sample with intended connector and short cable on vibration table. The values apply to the mount position of the sensor in the fixture.

BDK2.8 contacts:

Amplitude of deviation:	s = 0.35 mm in the range 70 Hz to 147 Hz
Amplitude of acceleration:	a = 300 m/s^2 in the range 147 Hz to 2000 Hz
Frequency change:	1 Octave/min
Excitation duration:	100 h per principal axis with the same test sample

4.10. Chemical resistance

Media:
CM50, CE85A, CM15A, CME15, Cw (according to SAE J1681), engine oil W30, transmission fluid, brake cleaner, brake liquid, $CaCl_2$, RME (rape seed methyl ester), diesel, coolant (R184)

Sensor equipped with mating plug

Test procedure:
1. Wet each specimen with a medium by brushing.
2. Store in air at +140°C (±3°C) for 2 hours in capsulated container.
3. Wipe of excessive media.
4. Perform plausibility check of the sensor signal and inspect visually.
5. Repeat the same procedure (point 1 to 4) with the identical specimen and the media six times (3 times a day for a period of two days).

Evaluation: functional curve, leak test. Internal corrosion not permissible.

4.11. Drop test

Non guided drop without mating plug

Number of specimens:	3
Height of fall:	1.0 m ± 0.05 m
Base:	Concrete

For each specimen, two drop tests are to be carried out in one axis and in both directions. By using three specimens, all six load directions are covered.
Assessment: If no significant external damage is visible, the sensor must function without fault.

4.12. Salt spray test

According to IEC 60068-2-11

NaCl pH:	6.5-7.2pH
Temperature:	35±2 °C
Duration:	6 cycles
Time:	240h (with connector)

Harness connector is plugged on the sensor and mounted inside a rail.

4.13. Hot water-jet test

According to ISO20653 (2006), IPX9K

- Water temperature:	80°C
- Water pressure:	100bar
- Distance:	100-150 mm
- Duration:	30 sec. / position
- Nozzle position:	0°, 30°, 60°, 90°
- Rotation speed of DUT:	5 ± 1 r / min

- No electrical operation
- Test in mounting interface

4.14. Immersion test

During the entire test, the specimen shall be electrically operated
The specimen is kept at upper temperature of 140°C for one hour;
Subsequently, the specimen is immersed completely in 0°C cold
5-% concentrated salt water.
Harness connector is plugged on the sensor and mounted inside a rail.

Rearrangement time:	≤ 5 seconds
Immersion time:	5 minutes
Number of cycles:	5
IP code:	IPX7

Evaluation: The specimen must be fully functional before, during and after testing.
There must have been no ingress of water.

5. Series accompanying tests (QZ-tests)

The following tests are performed to monitor and ensure series production quality:

- Vibration test

- Functional endurance test

- High temperature storage

- Temperature shock cycling test

- Water protection test

Test shortening is possible if test conditions are expanded.

6. Evaluation of Field Parts

Complaint parts are examined for their mechanical and electrical capability. In case of complaints, the product is declared free of fault if the following characteristic data are attained :

- For zero km complaints: Functional test according to chapter 3.
- For field returns: Functional test according to chapter 3 regarding endurance test limits.

If no concurrence between the analysis results and the cause of complaint of the customer is found, further actions may be defined commonly in order to reproduce customer results.

7. Test Scope for Sample Deliveries

For the sample phase and pre-series production, a 100% test of all sensors is carried out. Functional characterization of the sensors is performed with compressed air.