1. Product identification

Product: high-pressure sensor

Type: PS-HPS5 420 bar

Order number: 0 261 547 001

Offer drawing: 0 261 A22 940
Geometric specifications and installation instructions can be found in the offer drawing (AZ).

Customer: different

Other applicable documents: Installation instruction 0261 Y08

Application: 521 according to application

Remarks: checklist Provisional, generic TKU
This provisional TKU documents the current status of the agreed specifications. It will be confirmed when the product validation has been completed with a positive result.

No.	Page	the change	Date	created / prepared	checked / checked	approved / approved	approved / approved	approved / approved
01	-	**first edition / First Edition**	April 26th 2016	DGS-ES/EPP2 Jenner	DGS-ES/EPP5 signed Hettenbach April 29, 2016	DGS-ES/EPP5 iV Hettenbach April 29, 2016	DGS-ES/ EPP-HPS signed O.Stoll April 29, 2016	DGS-ES/ NE-PS signed P.Traub May 2, 2016

Contents

2nd General Product Description

2.1 function of the sensor

The high-pressure sensor is designed to measure the pressure in a rail (fuel distribution pipe) of a car with direct gasoline injection. To do this, it is screwed into the rail via a screw connection and thus comes into contact with the fuel in the rail (see Fig. 1 for the principle, see 3.9.1 for details on the interface design, see 4.5.2 for details on the screw connection).

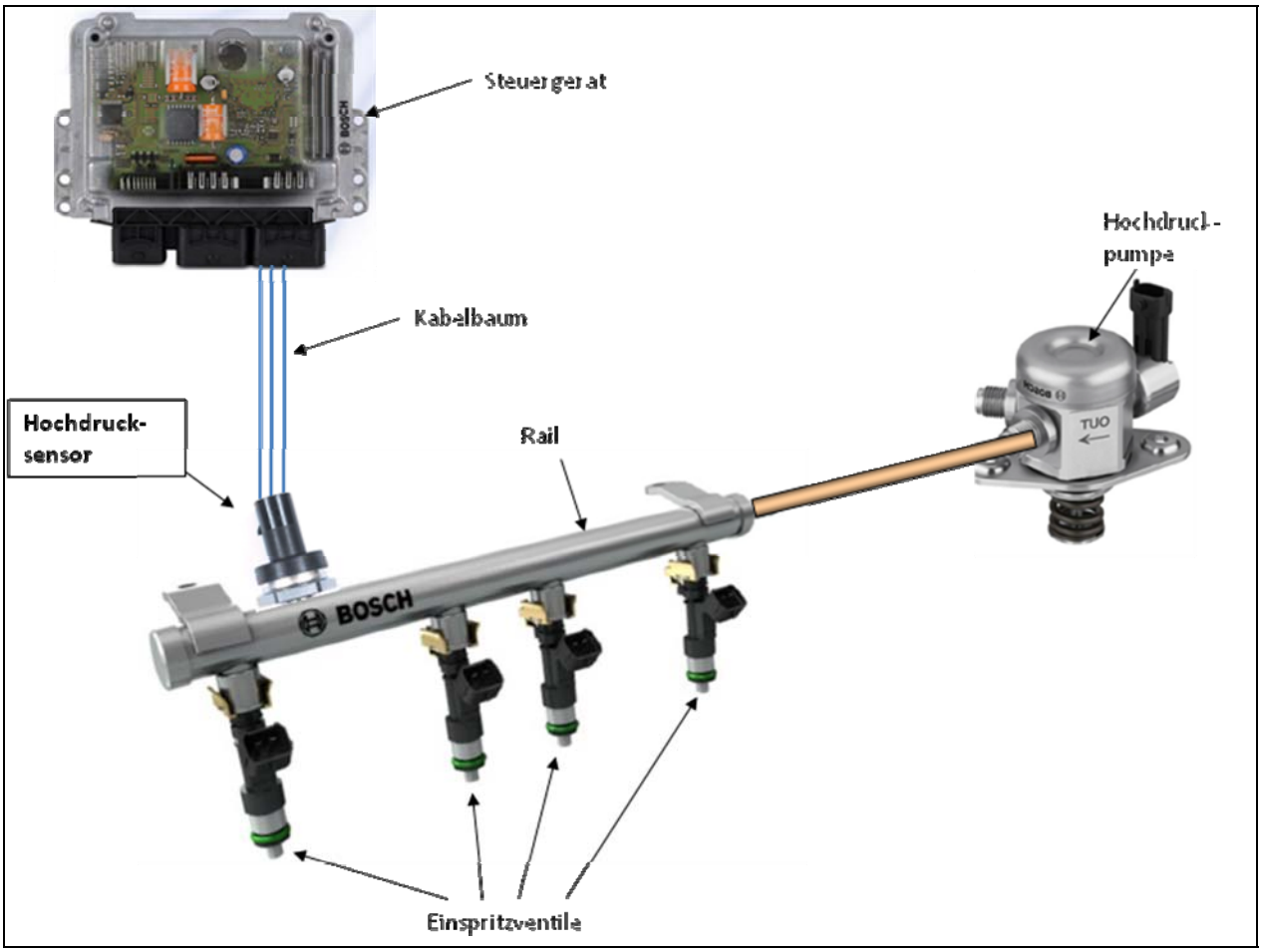


Fig. 1: Schematic diagram for installing the high-pressure sensor in the rail.

The high pressure sensor is designed to measure pressures in the specified pressure range relative to the ambient pressure.

The high-pressure sensor is designed for use in passenger cars. For other applications (e.g. off-highway applications), the suitability of the sensor for the loads occurring over the operating period must be assessed and approved by Bosch.

2.2 Technical Principle

The pressure difference between the pressure in the fuel-filled rail and the ambient pressure is converted into an electrical signal by measuring the deflection of a thin steel membrane. A resistance bridge is applied to this membrane using thin-film technology. The bridge is supplied with a 3.3V voltage and detunes when pressure is applied, ie when the membrane is deflected. This means that it delivers a voltage signal at the bridge tap that is ratiometric to the pressure (see Fig. 2).

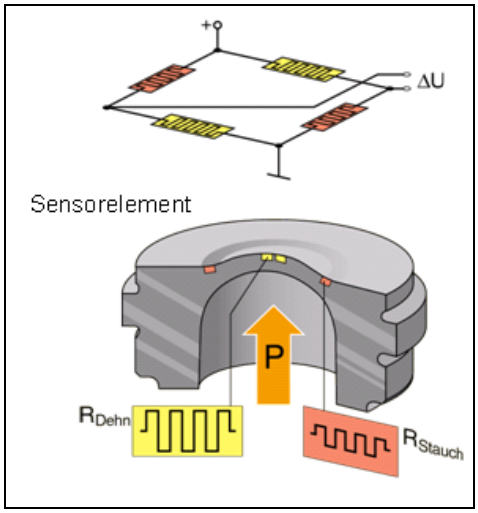


Fig. 2: Principle of pressure conversion through a resistance bridge on a sensor element membrane.

The bridge signal is further processed by an electronic evaluation circuit. This amplifies, scales and digitizes the voltage signal of the measuring bridge. The pressure signal is then sent out via the connector interface together with other information (see section 3.9) in the form of a digital message in accordance with the SENT standard [1]. Various EMC measures (EMC = ElectroMagnetic Compatibility) are provided to avoid interference from electromagnetic influences. The SENT message is transmitted to a control unit for further evaluation via a mating connector and a cable harness (no longer part of the sensor described here) (see Fig. 3).

The high-pressure sensor transmits pressure values as well as additional information such as the level of the voltage supply and possible error states. The sensor does not make its own decisions about how to handle this information; this happens in the control unit.

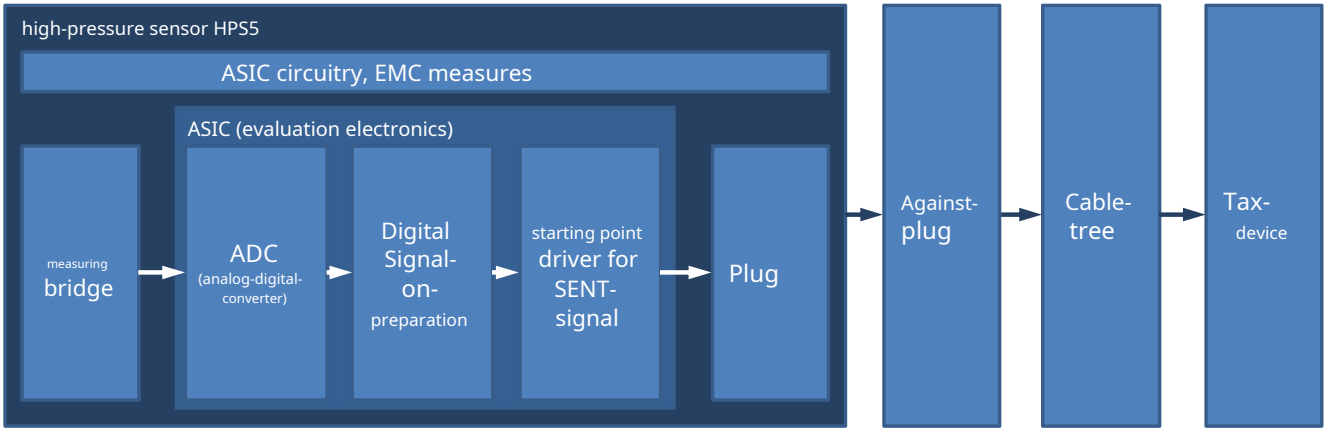


Fig. 3: Signal chain from the measuring bridge to the control unit.

The structure of the high pressure sensor is shown in Fig. 4: The sensor element with the measuring bridge is welded onto a threaded piece. A hexagon is also welded onto the threaded piece, with which the sensor is screwed into the rail (see section 4.5.2). The circuit board with the evaluation electronics is glued to the hexagon. The connection between the sensor element and the circuit board is made using bonded connections. Contact springs are installed on the circuit board to establish the connection to the plug. The plug, which is provided with a metal pot for EMC shielding, is in turn welded onto the hexagon.

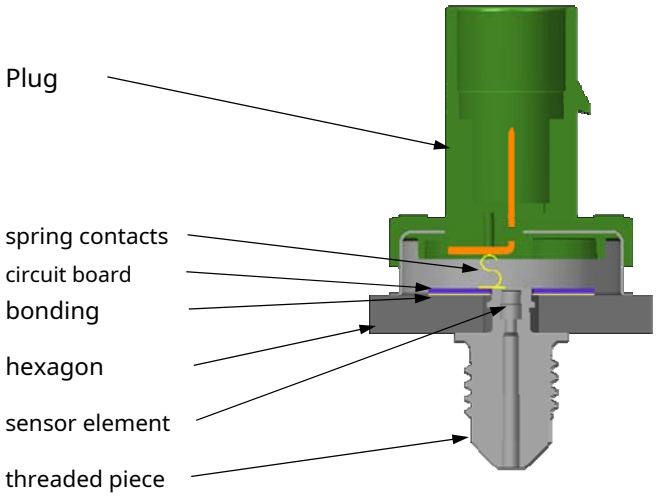


Fig. 4: Structure of the high pressure sensor.

2.3 Intended Use

The use of the high-pressure sensor within the conditions described in this TKU and the associated agreed documents (environmental, usage, installation conditions and loads) is a prerequisite for a promise by Bosch that the product is suitable for the intended or usual use stipulated in the contract or that it has a certain condition or quality. All contractual requirements - including those mentioned above - are considered to be fulfilled if the product has passed the test scope in accordance with the TKU and the agreed documents. It is the customer's responsibility to ensure that the product is used in the vehicle. Bosch must be notified of all changes to the product's environment that deviate from the TKU and the agreed documents, as well as use under application conditions not approved by Bosch. Such use or application of the product may only take place after Bosch has approved the changed environment or deviation. This applies in particular to applications that place special demands on reliability, service life and safety.

Product safety can only be guaranteed if the permissible conditions are observed.

Service and repairs or replacement of the product may only be carried out by authorized personnel.

2.4 product labels

The type part number, the date of manufacture and a consecutive Bosch number are indicated on the sensor connector (see offer drawing).

Furthermore, a data matrix code is applied to the connector, see Fig. 5 (ECC Type: 200, Symbol Size: 18x18, Image Polarity: Light on Dark).

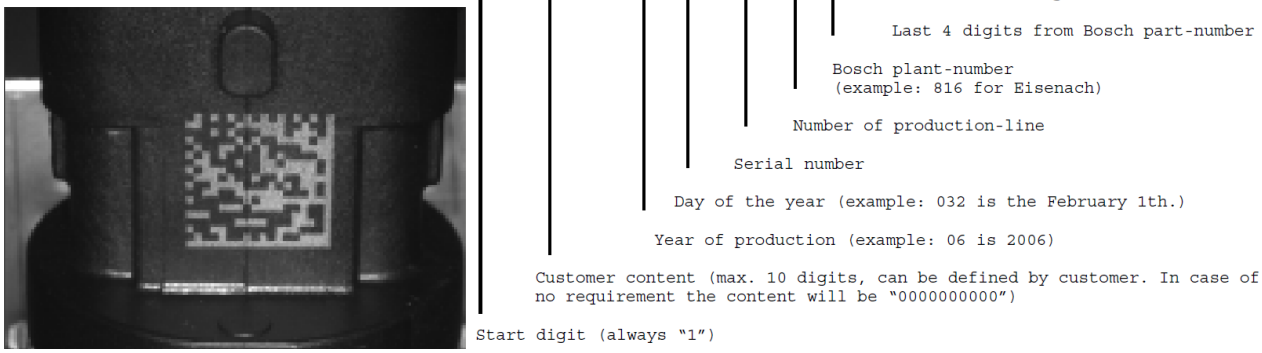


Fig. 5: Example of the data matrix code on the connector.

The sensor is further identified via the SENT signal, see section 3.9.3.

2.5 dimensions and mass

Dimensions and weight of the sensor: see offer drawing

2.6 power consumption/output

The high pressure sensor has a typical current consumption of 12mA at a supply voltage of 5V, i.e. a power loss of typically 60mW.

2.7 General handling instructions for transport, installation location, assembly, commissioning and decommissioning, storage

2.7.1 Transport

The high-pressure sensor must be transported in appropriate packaging. If the sensor is dismantled, it must be noted that there may still be residual test fluid in the rail. The packaging must then be designed in such a way that no test fluid can get into the connector area during transport..

2.7.2 Installation location, assembly

As described in section 2.1, the pressure sensor is designed to be mounted on the rail. The rail is usually electrically connected to the engine ground. The high-pressure sensor is mounted radially or axially on the rail and is designed in such a way that it seals the interface to the rail (see also section 3.9.1).

When installing the sensor in the rail as standard, please observe the instructions in section 3.8.

2.7.3 Commissioning and decommissioning

If a high-pressure sensor already installed in the vehicle is taken out of service or an existing or new high-pressure sensor is installed, various safety, disassembly and assembly instructions must be observed, see section 4.5.3.

2.7.4 Storage

The high-pressure sensor may be stored for a maximum of 5 years after delivery from the Bosch factory before installation in the vehicle. The storage conditions under 4.5.4 must be observed. Once the maximum storage period has expired, the sensor must be examined by Bosch at a cost.

2.7.5 General information on safe operation

Product safety can only be guaranteed if the permissible conditions are observed.

2.7.6 General information on service, repair and maintenance

Service and repairs or replacement of the product may only be carried out by authorized personnel. The installation instructions must be observed (see chapter 4.5.2).

3. system description (operating conditions, installation instructions)

3.1 system

The high pressure sensor is designed to measure pressures in the rail of passenger cars with gasoline direct injection systems using approved fuels.

The use of the high-pressure sensor described here in diesel applications (common rail systems) is not possible due to the higher pressures prevailing there. For these applications, a rail pressure sensor (RPS) can be used that is designed for the corresponding pressures.

The use of the high-pressure sensor in CNG systems (CNG = Compressed Natural Gas) is possible, but is described in another TKU. The use of other media and in off-highway applications must be checked on a case-by-case basis and approved by Bosch.

3.2 Operating Conditions - Fuels

The high-pressure sensor described in this document is used to measure the fuel pressure in the rail of motor vehicles. It is only approved for use in high-pressure petrol injection systems on petrol engines with unleaded fuel in accordance with standards EN228 (Europe), ASTM D4814 (USA), JIS K2202 (Japan), for petrol with ethanol content in accordance with standard DNC 71 - E20...26 (Brazil), E85 suitability in accordance with A ASTM D 5798 (E85, USA, 2007), SS-155480 (E85, Sweden, 2005), DIN 51625 (E85, Germany, 2008) and E100 in accordance with ANP N°36 2005, pr.EN 15293 (EU draft), with methanol content M15 in accordance with provisional local standard GB/T 23510 and for comparable petrol in accordance with country-specific standards with properties that meet the limit values of the above standards in motor vehicles.

The use of methanol fuel M85 is not permitted.

3.3 Operating conditions - pressure

The high-pressure sensor described here is designed, depending on the version, for use in gasoline direct injection systems with a system pressure of up to 35 MPa. The characteristics and the maximum load capacity depend on the type used and are described in Fig. 6.

The system must be designed hydraulically in such a way that the specified overpressures are not exceeded after any throttling. Side effects such as cavitation must be taken into account. Cavitation must be avoided in every operating state.

Size	Sign	Value	Unit
Typical system pressure	P_{sys}	16, 20, 35	MPa
measuring range (0 MPa...p_n)	p_n	14...20, 21...28, 30...42	MPa
Max. overpressure (max. 15 min. at p_n...p_{max})	p_{max}	28, 40, 56	MPa
burst pressure (static) (max. 15 min. at p_n...p_{burst})	p_{burst}	200, 250, 375	MPa

Fig. 6: Permissible system pressures.

3.4 Operating conditions - temperatures

The sensor is designed for use in the engine compartment (direct engine mounting) and the corresponding ambient temperatures with a typical temperature distribution:

Temperatur	Verteilung
-40 °C	6 %
23 °C	20 %
85 °C	65 %
135 °C	8 %
140 °C	1 %

Fig. 7: Permissible ambient temperatures.

They are the ones in Fig.**7**
specified ambient temperatures are permissible.

Size	Sign	Value	Unit
Minimum operating temperature above life	T_{min}	- 40	°C
Maximum operating temperature temperature1)	$T_{operating\ max}$	140	°C
Maximum permissible Temperature (250h above Life)1)	T_{max}	150	°C

1) To determine the continuous operating temperature, the specifications must be evaluated.

3.5 Operating conditions – Vibration load

The permissible vibration loads for the sensor are shown in Fig. 8. These have been verified through testing and apply to the mating connector shown on the offer drawing. The values apply to the mounting point of the sensor on the rail (measuring point M1) and on the hexagon of the sensor (measuring point M3).

Car applications:

measuring place	fundamental frequency Peak-hold FFT	effective value RMS (0 - 5kHz)	effective value RMS (0 - 2kHz)	PSD
M1	s=0.25mm at 70-147Hz a=210m/s² at 147-1350Hz a=175m/s² at 1350-2000Hz	127m/s²	-	5(m/s²)²/Hz at 10Hz 5(m/s²)²/Hz at 100Hz 0.25(m/s²)²/Hz at 300Hz 10(m/s²)²/Hz at 500Hz 10(m/s²)²/Hz at 2000Hz
M3	s=0.25mm at 70-147Hz a=210m/s² at 147-1350Hz a=175m/s² at 1350-2000Hz	127m/s² (for sensor)	127m/s² (for plugs)	5(m/s²)²/Hz at 10Hz 5(m/s²)²/Hz at 100Hz 0.25(m/s²)²/Hz at 300Hz 10(m/s²)²/Hz at 500Hz 10(m/s²)²/Hz at 2000Hz

Fig. 8: Maximum permissible vibration loads.

When measuring in the engine, the loads on M3 are often higher than on M1. However, only a lower load is permitted for M3 (load on the connector) than for M1 (load on the sensor itself). The vibration load measurements should be carried out with a sampling frequency of 10-15kHz, a block size of 2048 values and an evaluation according to Hanning.

The design of the vibration load is based on Bosch experience and refers to the speed collectives specified in ISO 16750-3 and the typical acceleration curve over the speed. If the maximum acceleration occurs below the nominal speed, the TKU values are not applicable.

If the values are complied with, Bosch recommends that Bosch carry out a vibration measurement in the vehicle. If the values are exceeded, a Bosch vibration measurement in the vehicle and subsequent approval by Bosch are mandatory.

3.6 Operating conditions - supply voltage

The use of the high-pressure sensor is permitted for the supply voltages specified in Fig. 9.

Size	Sign	Value	Unit
supply voltage standard	U_S	4.75...5.25	V
Max. supply voltage (max. 1h)	$U_{S,max}$	18	V
short circuit signal line to GND or to supply voltage (max. 8h) while simultaneously supplying $U_S$with $U_{S, short}$	$U_{S, short}$	0...18	V
Max. current at Reversal of two plug cable (max. 5 min.@25°C)	I_{max}	260	mA

Fig. 9: Permissible supply voltage and error cases.

3.7 Operating conditions – Electromagnetic compatibility

The high-pressure sensor contains an electronic circuit and transmits a digital signal to a control unit, which evaluates this signal. When handling the sensor, care must be taken to ensure that no ESD damage occurs (see sections 4.5.2 and 4.5.3). When designing the installation location, care must also be taken to ensure that no electrical pulses or electrical fields are applied to the sensor, which could damage it. The EMC resistance of the sensor is ensured in accordance with the tests specified in section 4.6.13. So-called "hot plugging" of the sensor, i.e. connecting it to a connector that is already supplied with voltage, must be avoided.

Emissions from mobile transceivers in the short-range can exceed the specified customer requirements in terms of immunity to interference. At distances of less than or equal to 200 mm between the installed vehicle component and all possible positions of mobile transceivers - the latter in cars and commercial vehicles limited to the passenger compartment and trunk - malfunctions of the vehicle component cannot be ruled out.

If the customer intends to reduce the safety distance below 200 mm, it is his responsibility to check whether additional measures are required for this application and then to implement them.

3.8 installation position and tolerances

The design of the mechanical interface to the rail must be planned in accordance with the offer drawing, taking all tolerances into account. The high-pressure sensor must only be handled by the hexagon when screwing it in. Tools used during assembly, such as socket wrenches, may only be used on the hexagon. Tilting or jamming with the connector housing must be prevented. Open-end wrenches are not permitted for assembly. A gap must remain between the hexagon of the high-pressure sensor and the fuel rail (see offer drawing).

By suitable installation in the vehicle (see offer drawing for recommended installation position) it must be ensured that no water can collect on the membrane (danger: measuring bridge detuning in the event of frost, in the worst case membrane rupture).

3.9 hardware and software interfaces

3.9.1 Mechanical interface between high pressure sensor and rail.

The high-pressure sensor is screwed into the rail using an M10 threaded piece and sealed against the rail using a conical sealing seat.

The design of the mechanical interface of the rail must be provided in accordance with the tender drawing (geometric design and material selection). The boundary conditions specified in this document are only guaranteed for this design.

3.9.2 Mechanical interface on the connector

When selecting the mating connector, the information on the offer drawing must be observed. The interface between the sensor connector and the mating connector is then protected for the boundary conditions specified in this document.

If the mating connector on the wiring harness side does not comply with the specifications in the offer drawing, the customer is responsible for ensuring the durability. Bosch is then only responsible for the design of the device-side connector (interface) in accordance with the customer's specifications. Bosch accepts no responsibility or warranty for the connector, in particular for its electrical function, durability and tightness, as this is used at the customer's request.

scope / subject matter	responsibility Bosch	responsibility customer
connector on the wiring harness	No	Yes
specification connector	No	Yes
plug version component side	Yes	No

Fig. 10: Distribution of responsibilities for connector interfaces according to customer requirements

3.9.3 Electrical interface

3.9.3.1 Electrical interface standard

The high pressure sensor outputs a digital signal according to the SENT standard (SENT Standard J2716 Jan 2010 [1]; SENT = Single Edge Nibble Transmission for Automotive Applications).

3.9.3.2 Wiring of the sensor

The sensor must be wired by the control unit according to the SENT standard [1] and supplied with a supply voltage of 5V.

The connector pins of the high pressure sensor are described in the offer drawing.

3.9.3.3 Signal flow and configuration of the SENT interface

The block diagram of the signal flow is in Fig. 11 shows this.

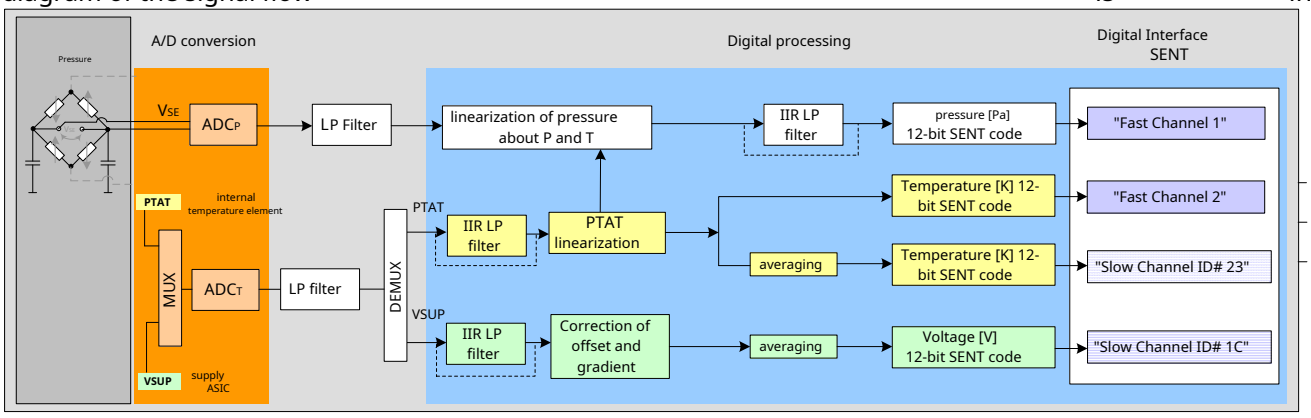


Fig. 11: Block diagram of the signal flow from the measuring bridge to the digital interface (here for a p/T sensor).

The assignment of the transmitted data in the SENT protocol is carried out according to the SENT standard [1].

The configuration of the SENT protocol of the sensor described in this TKU is described in Appendix [2].

3.9.3.4 Error diagnosis

In the event of an error in the fast channel, error codes are output instead of data values (pressure or temperature) for error diagnosis; these are shown in Fig. 12.

transmission	SAE J2716 definition	Description HPS5
4095	production status	Is used for the production state (eg when manufacturing process errors occurred)
4094	Freely definable OEM/supplier	Not used
4093	Reserved	Not used
4092	Reserved	Not used
4091	Temporary error the sensor	Pressure measurement of the sensor element and front-end error
4090	functionality of the sensor and signal processing	signal processing and signal peripherals
4089	No valid value	Due to reduced accuracy of the pressure signal, error message sent
0	initialization	The initialization value is transmitted until the first valid pressure and temperature value (at least once after reset)

Fig. 12: Error codes transmitted via the fast channel.

Further error detail is described via information sent in the slow channel. The allocation of error cases between fast channel and slow channel as well as the associated priorities are described in Appendix [2].

3.9.3.5 Behavior after reset and initialization

In the event of certain errors (see section 3.9.3.4), a reset is triggered in the sensor. After a reset and during the subsequent initialization of the sensor, the SENT message "Initialization 0" is sent exactly once as soon as transmission is possible. As soon as pressure values and temperature values are available, they are sent.

There are two types of resets (see Appendix [2]):

Hard resets: are executed immediately upon request

Soft resets: are only executed if the error condition is still present after approx. 400ms after power-on AND the cause of the error could be reported under ID1 in the slow channel.

Attempting to trigger a reset within 400ms after power-on will result in continuous transmission of ID1 until the error condition is removed or the reset is triggered after 400ms.

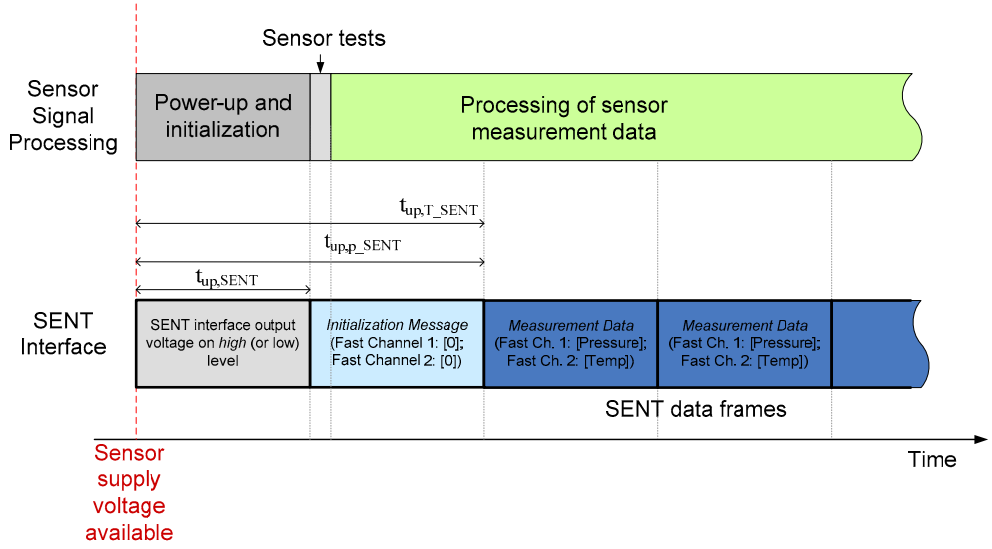


Fig. 13: Behavior after reset. Values for the specified times are defined in the appendix [2].

3.9.3.6 Behavior after undervoltage and overvoltage

The HPS5 sensor can detect undervoltage or overvoltage in the supply line. An undervoltage is detected when the supply voltage falls below a measured voltage threshold ($U_{messunder}$) falls. Overvoltage is detected when the supply voltage exceeds a voltage threshold ($U_{messover}$) lies.

The undervoltage/overvoltage detection is designed to detect permanent undervoltage/overvoltage (e.g. due to faulty cables or connectors) and temporary undervoltage/overvoltage. The specified undervoltage and overvoltage thresholds are defined in Appendix [2].

4th Technical data

4.1 transfer functions of the signals

4.1.1 Transfer function pressure signal

The measured pressure is transmitted as a digital value as shown in Fig. 14.

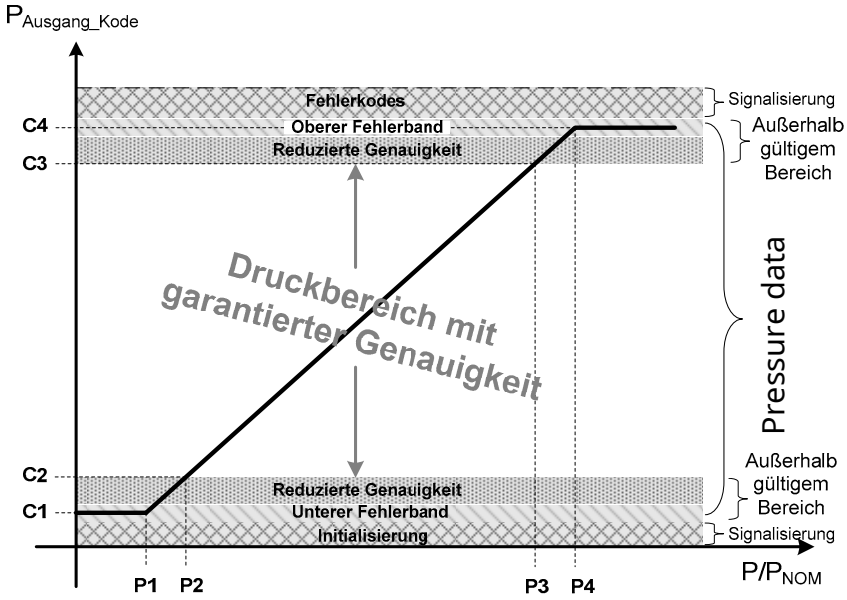


Fig. 14: Mapping of pressure values in [kPa] to 12-bit data values.

The assignment of digital value to pressure is described in Appendix [2], the accuracy of the sensor is defined in section 4.2.1.

4.1.2 Transfer function temperature signal

According to the SENT specification [1], the temperature characteristic is encoded as a 12-bit signal. For the transfer function, see Appendix [2].

4.1.3 Transfer function supply signal

According to the SENT specification [1], the supply voltage is encoded as a 12-bit signal (transmission in the slow channel). For the transfer function, see Appendix [2].

4.2 tolerances of the sensor

4.2.1 Tolerances of pressure measurement

The tolerance of the pressure measurement is given in %FS, see Fig. 15. FS = “full scale” refers to the sensor nominal pressure $p_{nominal}$The relative tolerance depends on pressure and temperature and increases with the service life. The service life includes the entire service life specified under 4.4 or all tests specified under 4.6. The tolerances are statistically maintained with -3s per production batch. 100% sorted products may be delivered.

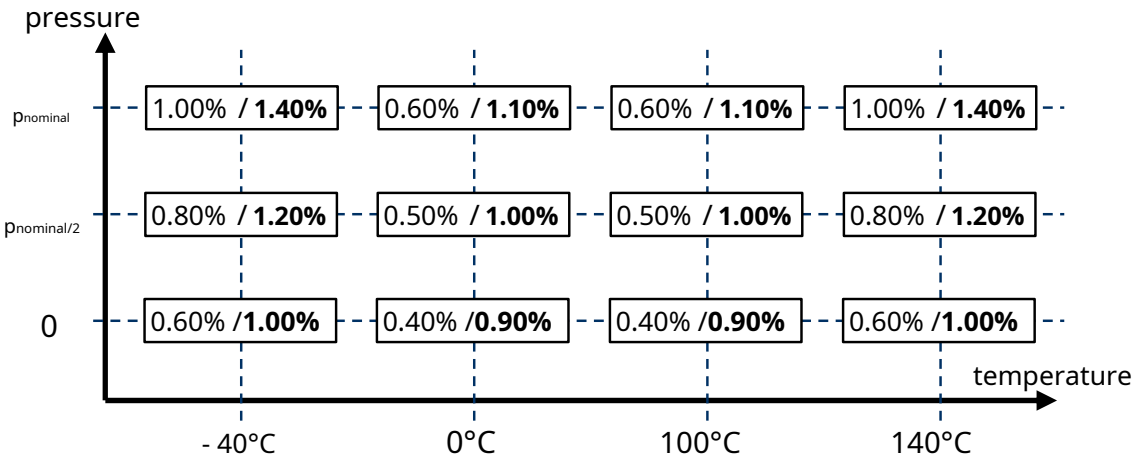


Fig. 15: Characteristic curve tolerance of the pressure measurement (normal=new condition/rich=after service life)

4.2.2 Tolerances of temperature measurement Must be

agreed on a case-by-case basis.

4.2.3 Tolerances of voltage measurement

The high pressure sensor transmits the level of the voltage supply with a tolerance of ±150mV.

4.3 Technical data of signal transmission

Fig. 16 shows the limits of important sensor sizes. These are statistically maintained with -3s per production batch. 100% sorted products can be delivered.

Size	Sign	Value		Unit
		min	max	
supply voltage	U_S	4.75	5.25	V
Quiescent current consumption at U_S[1]	I_S	9	15	mA
Output impedance for $0.1U_S < U_{Out} < 0.9U_S$	R_d		5	-
settling time to quiescent current consumption	t_{IDD}		2	ms
Time until first SENT data transmission (sending zero, assuming CRC is OK)	t_{up_SENT}	1.8	2.2	ms
period of autarky[2]	$t_{self\text{-}sufficient}$	10		µs
load capacitance against mass	C_L	Maximum capacitive load at the output see SAE International, "SENT—Single Edge Nibble Transmission for Automotive Applications", J2716 JAN2010, January 2010."		

Fig. 16: Data and limits of signal transmission.

4.4 service life information

Under the use and operating conditions described in this TKU, the product is designed for a maximum service life of 240,000 km or a maximum of 15 years (whichever occurs first).

The commercial warranty and liability are regulated independently of this in the delivery conditions.

4.5 Transport, assembly, commissioning/decommissioning, storage, service, maintenance

4.5.1 Transport conditions

Conditions deviating from the storage conditions are permitted for transport:

Duration:	max. 48 hours
Temperature:	- 40°C to +80°C
Relative humidity	0% to 80%

4.5.2 Installation

When screwing the high-pressure sensor into the rail, only hold it by the hexagon. A socket must be used for assembly. This must only be placed on the hexagon and must cover it securely.

[1] During an active SENT transmission, this value can change asymmetrically by up to 9 mA peak-to-peak.
[2] Autonomy time is the time that the sensor transmits data without supply voltage at the input, without reset starting from U_S = 4.5 V static.

When installing the sensor, the plug must not be twisted relative to the pressure port. It must also be ensured that the sensor is not damaged (especially the sealing area to the rail). The plug area must not be contaminated with liquid or solid media. The penetration of foreign substances into or onto the pressure port during installation must be prevented.

The sensor thread and the sealing surface must be lubricated before screwing. Lubricants must be used as shown in the offer drawing.

After the high-pressure sensor has been screwed into its mounting location as described, it is tightened using the hexagon. The permissible tightening torque is specified in the offer drawing (usually in the range of 32.5±2.5Nm).

A specific high-pressure sensor may be screwed in and out of an associated rail a maximum of five times. It must be ensured that the sealing surfaces do not show any obvious damage.

If the sensor has to be replaced, for example because of a defect, a new sensor may be screwed into a given rail a maximum of ten times.

After screwing, a gap must remain between the hexagon of the high-pressure sensor and the rail. The size of the gap is specified for the respective sensor type on the offer drawing.

The contacts in the connector must not be touched during any assembly work (risk: ESD damage, ESD = electrostatic discharge). Electrical measurements on the pressure sensor may only be carried out with spring-loaded, clean plate or throat contacts (free of liquid and solid media). No "hot plugging" (= attaching the mating connector while voltage is applied) may be carried out during assembly (risk: EOS damage, electrical overstress).

When electrically testing the sensor, both polarity reversal and overvoltage must be excluded. The tests must be carried out using a voltage source with a current limit of max. 24mA.

Electrostatic painting of the sensor is not permitted (risk of ESD damage).

If immersion tests are carried out, the electrical connector and the pressure connection must be closed to protect against water ingress.

When testing for leaks, negative pressures in the area of the plug must be avoided. Applying a vacuum on the plug side can lead to outgassing in the gel of the plug housing and to subsequent penetration of liquid media into the interior of the plug.

4.5.3 Commissioning and decommissioning

See installation instructions 0 261 Y08 521.

4.5.4 Storage

The high pressure sensor must be stored under the following conditions:

temperature range	- 30°C ... +60°C
relative humidity	0 ... 80% RH
maximum storage period for original equipment	5 years

The sensor must be stored in a dry and dust-free place. Care must be taken to ensure that the plug area or the threaded part does not become contaminated with liquid or solid media. Sulfur-containing atmospheres must be avoided with silver-plated plug contacts.

These storage conditions do not lead to any change in the properties and function of the high-pressure sensor. Once the maximum storage period has been exceeded, the sensors must be sent back to Robert Bosch GmbH for inspection.

4.5.5 Service and Maintenance

The high-pressure sensor may be replaced in the vehicle according to the procedure described in the installation instructions 0 261 Y08 521. Repairing the sensor is not permitted.

The OEM's diagnostic concept must be taken into account, which in turn must take Bosch's diagnostic concept into account.

4.6 endurance tests

The product functionality in the overall system must be ensured by the customer through appropriate vehicle testing under realistic operating conditions.

The tests listed below are based on the mechanical and climatic stresses in the engine compartment when the high-pressure sensor is installed on the engine. Experience has shown that they cover the stresses to be expected over the vehicle's service life. In cases of doubt, the actual stresses that occur should be evaluated together with Bosch. The shaking conditions and temperatures at the sensor installation point should always be measured.

Unless otherwise stated, the tests were carried out once as part of the release testing. New parts with new mating connectors were used for each test.

After the endurance test, the test specimens meet the characteristic curve tolerances according to section 4.1.1 "after lifetime".

The product functionality in the overall system must be ensured by the customer through appropriate vehicle testing under realistic operating conditions.

4.6.1 Sinusoidal shaking test

The testing is carried out in accordance with IEC 68-2-6. The test specimens are mounted on an electrodynamic vibration table with the mating connector and cable tail provided. The following values apply to the mounting location of the sensor on the clamping device.

Amplitude of deflection:	s = 0.35 mm	in the area	70 Hz to 147 Hz 147
Amplitude of acceleration:	a = 300 m/s2	in the area	Hz to 1350 Hz 1350
	a = 250 m/s2	in the area	Hz to 2000 Hz
Frequency change:	1 octave/min		
Excitation duration:	100 h per spatial direction with the same test specimen		

4.6.2 Drop test

Guided fall from 1m height onto concrete according toISO 16750-3 (2007-08-01).One drop event per axis direction. The component must be fully functional or visually damaged afterwards.

4.6.3 Static tests

Burst pressure test:

- Burst pressure according to section 3.3 for 15 min. no
- leakage permitted (definition of leakage see 3.9.1)
- Sensor no longer functional after test

Static leak test:

- Minimum tightening torque; 150% nominal pressure for 15
- min. no leakage permitted (definition of leakage see 3.9.1)
- Sensor no longer functional after testing

Deformation, mechanical:

- Maximum tightening torque according to offer drawing Sensor
- characteristic curve according to specification after service life

Deformation, hydraulic:

- Maximum overpressure according to section 3.3 for 15 min.
- Characteristic curve according to specification after service life

4.6.4 High-pressure pulsation

10 million load cycles with the following pressure amplitude >> pnenn (Wöhler line estimation):

Variants with nominal pressure 140 bar – 200 bar: 400 bar

Variants with nominal pressure 210bar - 280bar: 560bar

Variants with nominal pressure 280bar - 420bar: 800bar

The test serves to ensure mechanical strength. The sensor must not break or leak under these loads. The signal does not have to be within the specified tolerances after the test.

4.6.5 High-temperature storage

The testing is carried out according toDIN EN 60068-2-2 (1994-08).The test items are operated electrically using the provided mating connector. Storage at 140°C for 1000h.

4.6.6 Low-temperature storage

The testing is carried out according toDIN EN 60068-2-1 (2008-01).The test items are provided with the intended mating connector, without electrical operation. Storage at -40°C for 200h.

4.6.7 Temperature cycling test

The testing is carried out according toDIN EN 60068-2-14 (2000-08).The test specimens are subjected to 500 temperature shock cycles - 40 °C...140 °C with the provided mating connector. Remain at corner temperatures for 30 minutes, without electrical operation.

4.6.8 Water protection test

The testing is carried out according toISO 20653 (2006-08-15).The test items are tested with the intended mating connector. Water protection tests IPX6K and IPX9K, without electrical operation.

4.6.9 Humidity cycling test

The testing is carried out according to DIN EN 60068-2-38. The test items are tested with the intended mating connector.

Climate change 23°C / 95%rel.Lf. to 40°C / 95%rel.Lf Duration:

6 cycles of 24h each, without electrical operation

4.6.10 Chemical resistance

The test items are tested with the intended mating connector. Resistance to diesel fuel, RME, engine oil, cold cleaners, engine coolant and brake fluid.

4.6.11 Industrial climate test

The testing is carried out according toDIN EN 60068-2-42 (Apr. 2004).Test object with intended mating connector. Test duration 144h, without electrical operation.

4.6.12 Salt spray test

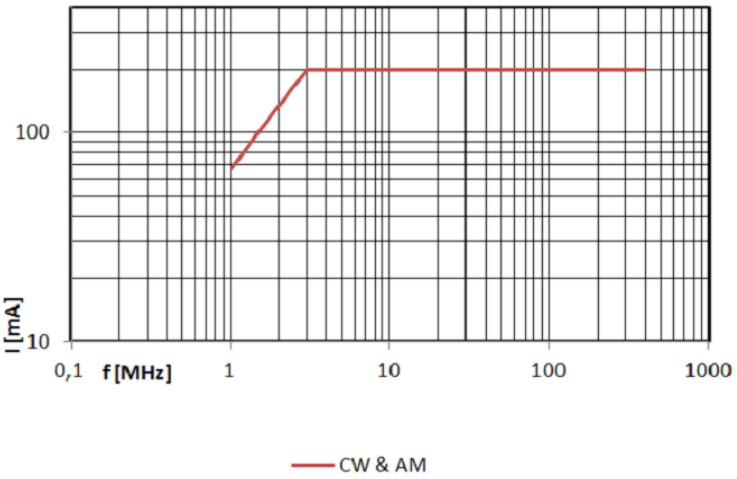
The testing is carried out according toDIN EN 60068-2-11 (Feb. 2000).Test object with designated mating connector. Test duration 240 hours, without electrical operation.

4.6.13 Electromagnetic compatibility

4.6.13.1 BCI test

Maximum deviation of the output signal: -18 LSB (0.5%FS)

Closed Loop according to DIN/ISO 11452-4, current profile:



Open Loop according to DIN/ISO 11452-4, current profile:

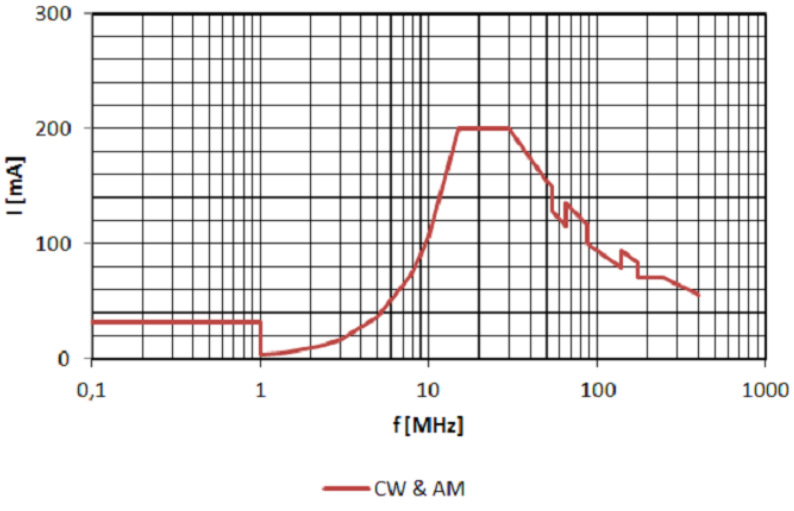


Fig. 17: Current profiles for closed loop (upper graphic) and open loop (lower graphic) as well as tabular

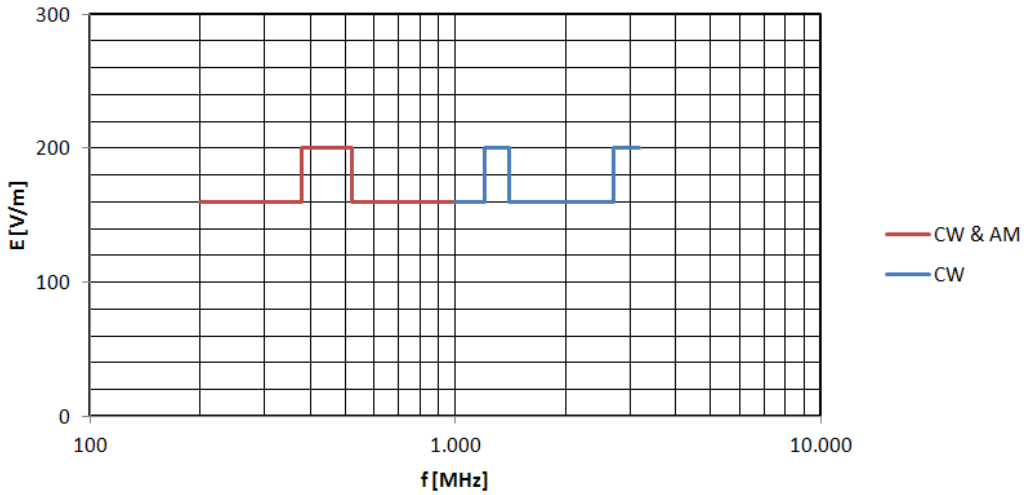
frequency [MHz]	level [mA]	modulation
0.1 – 1	32	CW, AM
1 – 1.3	3 - 5	
1.3 – 1.5	5 - 6	
1.5 – 1.8	6 - 8	
1.8 – 2	8 - 9	
2.2 – 2.38	11 - 12	
2.38 – 3	12 - 17	
3 – 3.5	17 - 22	
3.5 – 5	22 - 37	
5 – 7.82	37 - 73	
7.82 – 9	73 - 91	
9 – 10	91 - 107	
10 – 15	107 - 200	
15 – 30	200	
30 – 50	200 - 155	
50 – 54	155 - 150	
54 – 65	128 - 116	
65 – 88	136 - 117	
88 – 100	100 - 94	
100 – 140	94	
140 – 150	94 - 91	
150 – 174	91 - 84	
174 – 250	71	
250 – 300	71 - 65	
300 – 380	65 - 58	
380 – 400	-	

4.6.13.2 Antenna

200MHz-3.2GHz according to DIN/ISO 11452-2

Maximum deviation of the output signal: -18 LSB (0.5%FS)

Field strength of the radiated interference see Fig. 18 below:



frequency	level	
[MHz]	[V/m]	modulation
200 – 380	160	CW, AM
380 – 460	200	
460 – 520		
520 – 800	160	CW, AM
800 – 915		
915 – 1 000		
1 000 – 1 200		CW
1,200 – 1,400	200	CW
1 400 – 1 710	160	CW
1 710 – 1 980		
1 980 – 2 700		
2,700 – 3,200	200	CW

Fig. 18: Radiated field strength graphically (top) and in tabular form (bottom).

4.6.13.3 ESD tests

ESD handlingaccording to ISO/TR 10605

Network:	150pF/ 330 -
Contact discharge on pins/housing metal:	-8kV
Air discharge on housing plastic:	-15kV

ESD operating,direct FCP according to ISO/TR 10605

Network:	330pF/ 330 -
Contact discharge on housing metal:	-8kV
Air discharge on housing plastic:	-15kV

ESD operating,indirect FCP according to ISO/TR 10605

Network:	330pF/ 330 -
Contact discharge on discharge islands:	-15kV

4.6.13.4 Test pulses on sensor lines

according to ISO 7637-3

CCC method

Pulse fast a:	- 200 V
Pulse fast b:	+ 200 V
Test duration:	10 minutes

ICC method

Pulse slow -:	- 6 V
Pulse slow +:	+ 6 V
Test duration:	10 minutes

5th series-accompanying tests

The following tests are carried out during series production to monitor and ensure product quality. It is permissible to shorten the test period by increasing the load.

1. Sinusoidal shaking test (DIN EN 60068-2-6)
2. High pressure pulsation, 10 million load cycles:
   Pressure amplitude:
   140...200bar Variants: 270bar
   200...280bar Variants: 390bar
   280...420bar Variants: 550bar
3. High temperature storage (DIN EN 60068-2-2)
4. Temperature cycling test (DIN EN 60068-2-14)
5. Water protection test IPX6K and IPX9K (DIN EN 60068-2-18)

The sample size and frequency are determined by the factory's quality department. The test requirements may differ from those specified in Chapter 4.6.

6th evaluation of field parts

6.1 0-km parts evaluation

0 km parts are tested for their mechanical and electrical functionality. The test limits for the characteristic curve are the same as for new parts in accordance with Section 3.2.

6.2 field part evaluation

Field parts are checked for their mechanical and electrical functionality. If there are complaints about the products, they are considered to be free of defects if the characteristics are achieved and the tolerances in accordance with section 4.1.1 (“Service life”) are achieved.

7th references and attachments

[1] SAE International, “SENT—Single Edge Nibble Transmission for Automotive Applications,” J2716 JAN2010, January 2010.

[2] Appendix SENT parameters for TKU

Legally binding signatures:

Robert Bosch GmbH	. . . . . [Customer]
. . . . .	. . . . .
Location	Location . . . . .
Date	Date . . . . .
Signature	Signature . . . . .