Pressure sensors

Differential pressure transmitter (SENT)

Series/Type:	**F+E ALD 0.500 K D7 Z16E L ST B743**
Ordering code:	**B58622X3273B743**
Date:	2021-11-15
Version:	0.4

Preliminary data

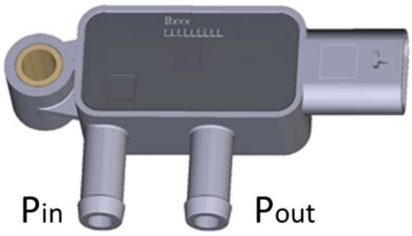
Applications

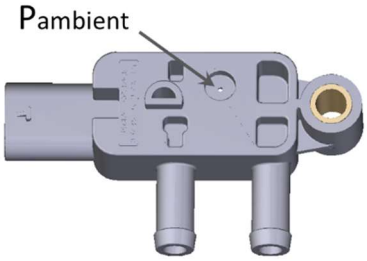
- Differential and relative pressure sensor transmitter based on two piezo-resistive pressure sensor elements with SENT output.
- The transmitter electronic compensates non-linearity and temperature effects and supplies a precise calibrated output signal.
- TDK pressure transmitters are based on our in-house designed and produced piezo-resistive pressure sensor elements (MEMS Technology).

Features

- Differential and relative pressure measurement
- High measuring accuracy
- SENT output signal acc. SAE J2716
- Overvoltage and reverse voltage protection
- High media resistance
- RoHS-compatible

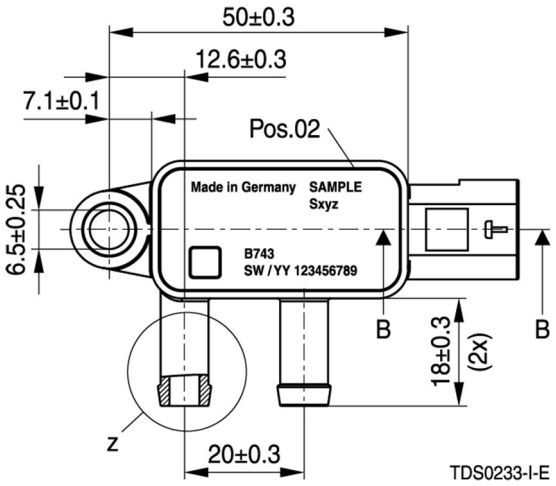
Case configurations

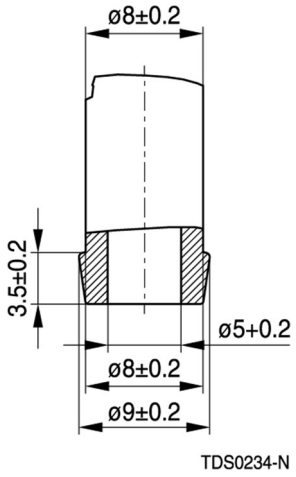


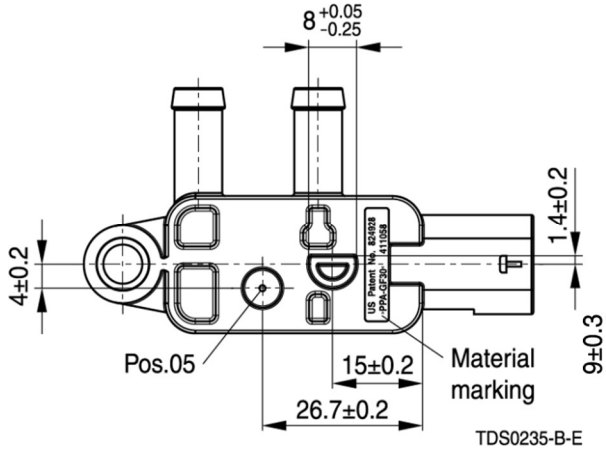


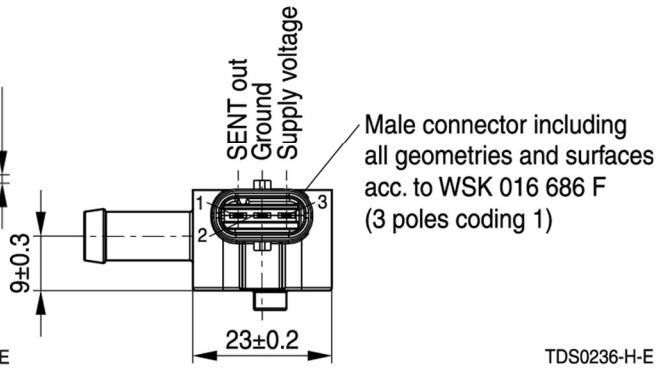
Preliminary data

Dimensional drawings









Dimensions in mm

Preliminary data

Technical data

Absolute maximum ratings

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Temperature ranges						
Operating temperature range	T_a	1)	–40		+140	°C
Short time operating temperature range	$T_{o,short}$	2) in total TBD h short term max. 20 min aim: 1000 h			+150	°C
Differential pressure range $P_{diff} = P_{in} – P_{out}$ (SENT Fast-Channel 1)						
Rated differential pressure range	$p_{diff,r}$	3) differential pressure	-50		1000	mbar
Relative pressure ranges P_{out} (SENT Fast-Channel 2) referred to $P_{ambient}$						
Rated pressure range	$p_{out,r}$	3) Relative pressure	-50		+700	mbar
Overpressure	$p_{out,ov}$	4) Absolute pressure	TBD Aim: 3.5 (10s)			bar
Short time overpressure	$p_{out,ov}$	4) Absolute pressure	TBD Aim: 6			bar
Burst pressure	$p_{out,burst}$	5) Absolute pressure)	TBD			bar
Relative pressure ranges P_{in} (no output signal) referred to $P_{ambient}$						
Rated pressure range	p_r	3) Relative pressure	-50		+1700	mbar
Overpressure	$p_{out,ov}$	4) Absolute pressure	TBD Aim: 3.5 (10s)			bar
Short time overpressure	$p_{out,ov}$	4) Absolute pressure	TBD Aim: 6			bar
Burst pressure	$p_{out,burst}$	5) Absolute pressure)	TBD			bar
Supply voltage /-current						
Supply voltage	V_{supply}	6)	4.75	5.0	5.25	V
Reverse Voltage, Overvoltage	V_{ov}	7)	-18		+18	V
Supply current	I_{supply}	Without load current		10.5	14	mA
Start up and response times						
Startup time Sensor	$t_{StartUpSen}$	8)			10	ms
Startup time measurement	$t_{StartUpMeas}$	9)			TBD	ms
Response time	100% input step	10)			3.5	ms

2. SENT Configuration (acc. to SAE J2716 April 2016 and Renesas ASSP ZSSC4165D)

Parameter	Symbol	Typ.	Unit
Shorthand configuration		SENT2016-3.0us-6dn- ppc(282.0)-esp-D.1000000001010	
SENT revision supported		Rev. April 2016 (→ "SENT2016")	
SENT clock tick length	T_{TICK}	3.0 (-20/+18%)	µs
Message frame length		Constant, 282 ticks	
Number of data nibble		6	nibbles
Pause pulse		Enabled (→ "ppc(282.0)")	
Serial protocol		Enhanced serial protocol (→ "esp")	
Sensor type)		P/P/t Pressure/Pressure sensor / temperature in supplementary channel with sensor specific temp. transfer characteristics (→ "D.1000000001010")	

Parameter	Min.	Typ.	Max.	Unit
Clock tick length	2.4	3.0	3.54	µs
Message rate for fast channel 1 & 2	1477.5	1182.0	1001.7	Samples / s
Message rate for slow channel	82.1	65.7	55.7	Samples / s

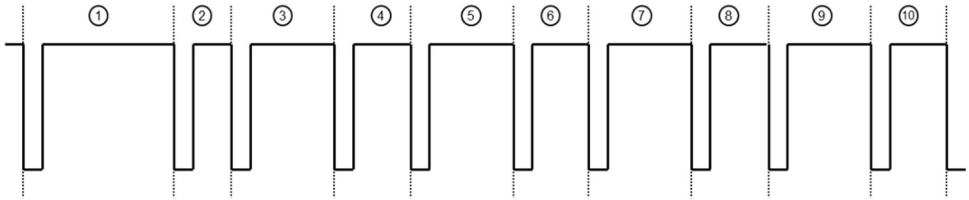
Other SENT ASSP configuration details (for internal use only):

- Internal clock frequency jittering → TBD
- Reset on watchdog → active

Preliminary data

SENT data frame contents

	Status & Communication				Signal / Data																							CRC			
Frame Bit Count	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Signal Bit Count	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4
Signal Bit Number	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	3	2	1	0	3	2	1	0
Nibble Bit Number	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0
	Message Start or Serial Data	Serial Data	Error Flag Channel 2	Error Flag Channel 1	Pressure (Bit 11…0)												Pressure (Bit 11…0)												CRC (Bit 3 …0)			



SENT Message	Index	Description
1	Sync / Calibration pulse	Acc. to SENT SAE J2716 rev. 2016
2	Status incl. slow channel	Acc. to SENT SAE J2716 rev. 2016, table H-2
3	Fast channel 1, data nibble 1 (Pressure, MSN)	Acc. to SENT SAE J2716 rev. 2016
4	Fast channel 1, data nibble 2 (Pressure, MidSN)	Acc. to SENT SAE J2716 rev. 2016
5	Fast channel 1, data nibble 3 (Pressure, LSN)	Acc. to SENT SAE J2716 rev. 2016
6	Fast channel 2, data nibble 4 (Pressure, MSN)	Acc. to SENT SAE J2716 rev. 2016
7	Fast channel 2, data nibble 5 (Pressure, MidSN	Acc. to SENT SAE J2716 rev. 2016
8	Fast channel 2, data nibble 6 (Pressure, LSN)	Acc. to SENT SAE J2716 rev. 2016
9	4 bit CRC	CRC4-Algorithm Acc. to SENT SAE J2716 rev. 2016 (Recommended Implementation)
10	break	Acc. to SENT SAE J2716 rev. 2016

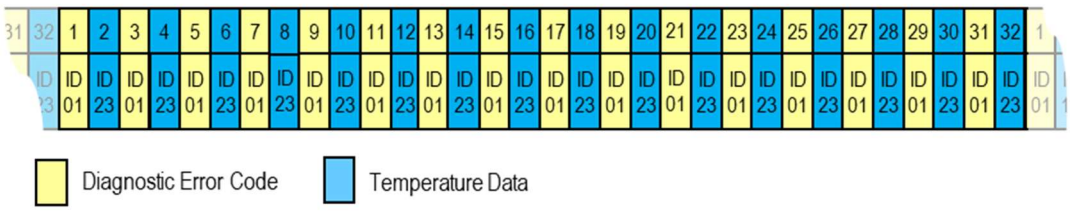
Preliminary data

Enhanced serial data transmission (slow channel)

The SENT status nibble embeds two bits for so called serial data transmission (slow channel). 18 of these pairs that are transmitted in 18 consecutive messages result in one *enhanced serial message*. This is called the slow channel whereas data that is transmitted within the data nibbles belongs to the fast channels. The format of enhanced serial messages is shown below:

SENT message number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Status nibble 3	1	1	1	1	1	1	0	0	ID [7:4]				0	ID [3:0]				0
Status nibble 2	CRC6[5:0]						DATA [11:0]											

The sending of enhanced serial data is looped according to below mentioned scheme. Diagnostic error code (ID 0x01) and temperature data (ID 0x23) are transmitted with every second enhanced serial data.



Parameter	**Min.**	**Typ.**	**Max.**	**Unit**
Clock tick length	2.4	3.0	3.54	µs
Message rate for slow chanel	82.09	65.67	55.65	Samples / s
Message rate for ID0x01/0x23	41.04	32.84	27.83	Samples / s

Enhanced serial message IDs

Message #	**Message ID (8 bit)**	**Definition**	**DATA [11:0] (hex)**	**Description**
1	0x01	Diagnostic error code (DEC)		See below
2	0x23	Temperature data		See below (Temperature)

Other enhanced serial messages IDs acc. SAE J2716 upon request.

Diagnostic error codes

Priority [A] 1 (high) … 9 (low)	Error	Description			Pressure Value	Value of ID0x01	Status bit 0	Status bit 1
1	No error				[B]	0x000	0	0

Following error codes upon request:

- pressure out of range high or low
- temperature out of range
- supply voltage out of range
- pressure sensor die connection check
- electronic failure
- initialization error

[A] Error with higher priority overwrites lower priorities.
[B] Value unchanged.

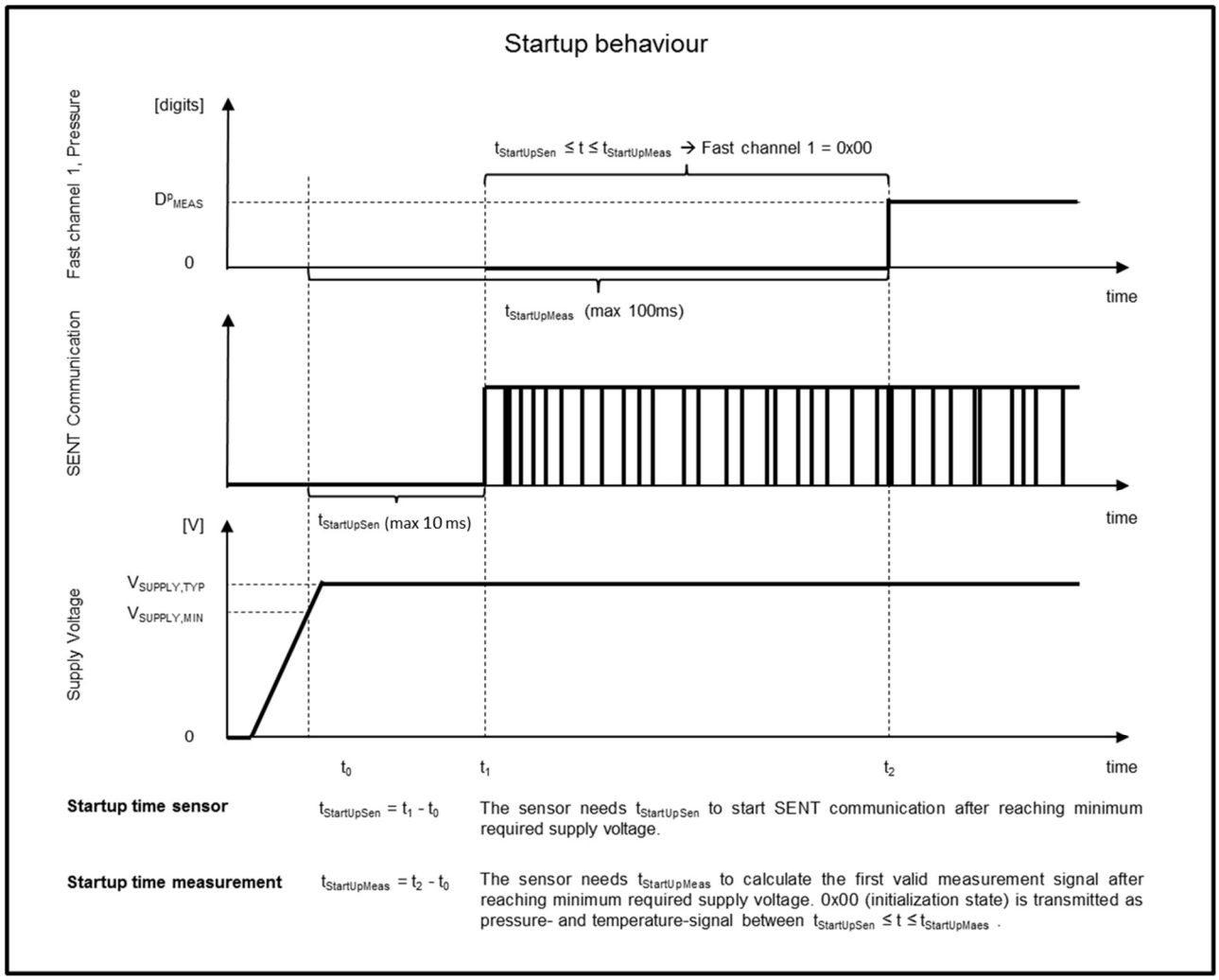
Other error handling

If one or more of below mentioned error occurs, SENT output will be driven to high-resistant state:

- Initialization error (power-on self-test failed)
- EEPROM error
- Memory (incl. EEPROM) signature error
- Short at SENT-pin (current limitation)

Preliminary data

Start-up behavior

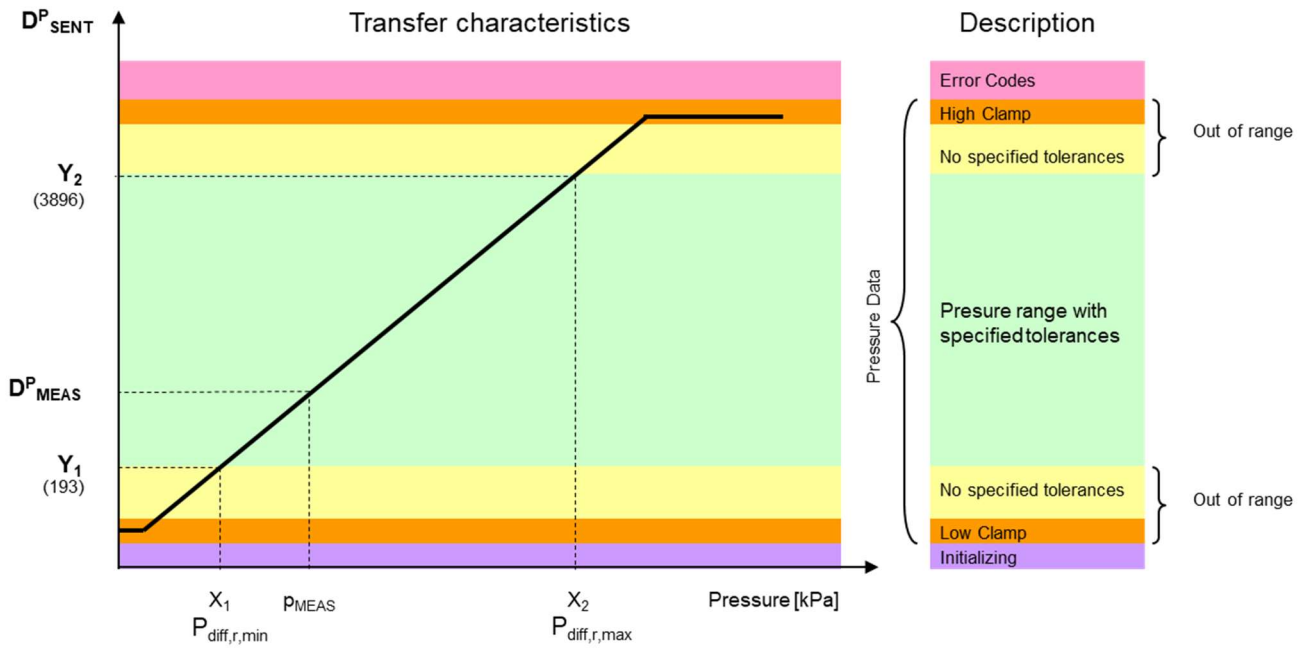


Startup time sensor	$t_{StartUpSen} = t_1 - t_0$	The sensor needs $t_{StartUpSen}$ to start SENT communication after reaching minimum required supply voltage.
Startup time measurement	$t_{StartUpMeas} = t_2 - t_0$	The sensor needs $t_{StartUpMeas}$ to calculate the first valid measurement signal after reaching minimum required supply voltage. 0x00 (initialization state) is transmitted as pressure- and temperature-signal between $t_{StartUpSen} \leq t \leq t_{StartUpMaes}$.

Preliminary data

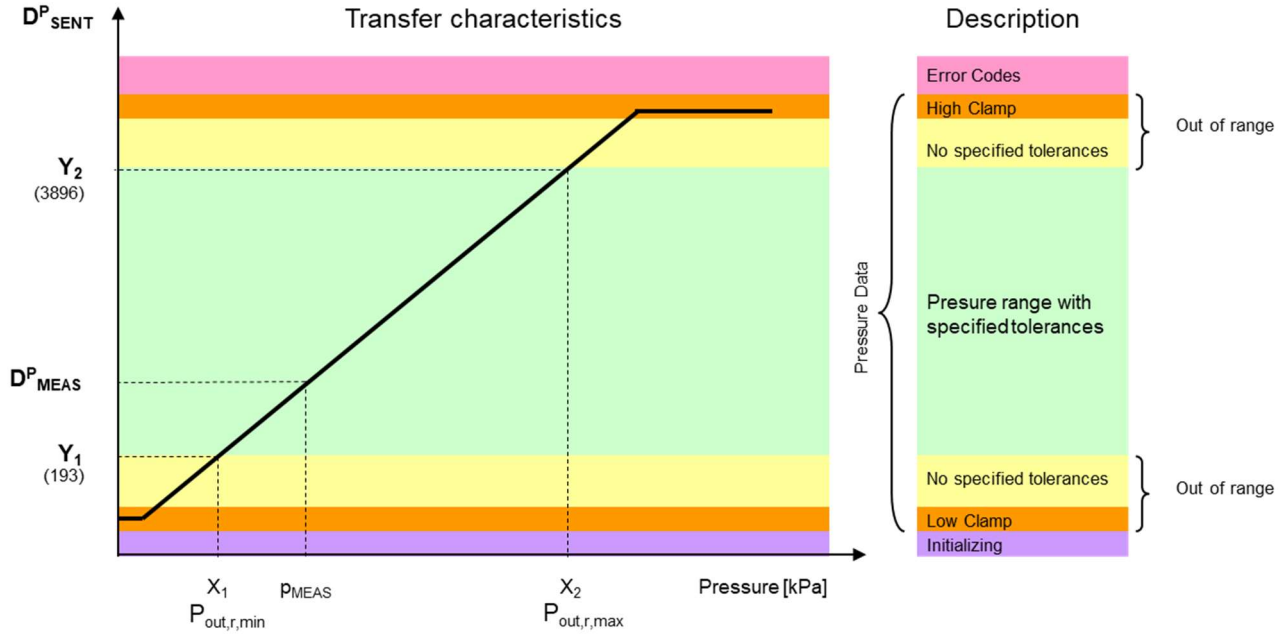
3. Pressure transfer characteristics (acc. to SAE J2716 Apr. 2016)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Digital output pressure signal @ V_{supply} = 5 V						
Initializing				0		digits
Low Clamp				1		digits
Pdiff,r: Output at $pdiff_{,r,min}$ (Chanel 1)	Y_1	Pressure: -5000 Pa ($p_{r,min}$)		193		digits
Pdiff,r: Output at $pdiff_{r,max}$ (Chanel 1)	Y_2	Pressure: 100000 Pa ($p_{r,max}$)		3896		digits
High Clamp				4088		digits
Reserved (not yet assigned)			4089		4095	digits
Signal span (Full Scale)	D^P_{FS}	$D^P_{FS} = Y_2 - Y_1$		3703		digits



Preliminary data

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Digital output pressure signal @ V_{supply} = 5 V						
Initializing				0		digits
Low Clamp				1		digits
Pout,r: Output at $pout_{r,min}$ (Chanel 2)	Y_1	Pressure: -5000 Pa ($p_{r,min}$)		193		digits
Pout,r: Output at $pout_{r,max}$ (Chanel 2)	Y_2	Pressure: 70000 Pa ($p_{r,max}$)		3896		digits
High Clamp				4088		digits
Reserved (not yet assigned)			4089		4095	digits
Signal span (Full Scale)	D^P_{FS}	$D^P_{FS} = Y_2 - Y_1$		3703		digits



Conversation SENT's Pressure Data to physical pressure acc. to conversation formula below.

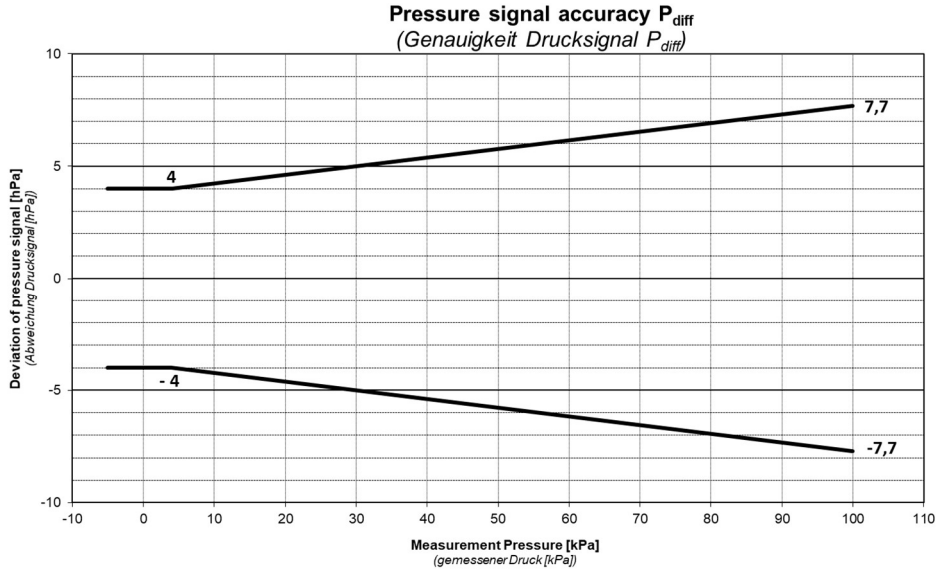
$$p_{meas}[Pa] = X_1 + \frac{X_2 - X_1}{Y_2 - Y_1} \cdot \left(D^p_{meas} - Y_1\right)$$

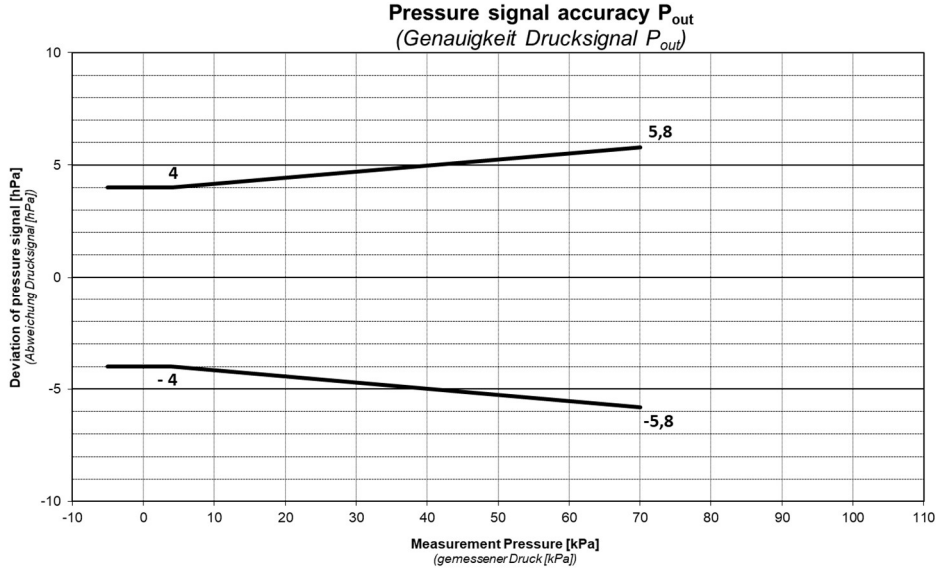
$$\mathbf{P_{diff} = P_{in} - P_{out}}$$

Preliminary data

Pressure signal accuracy

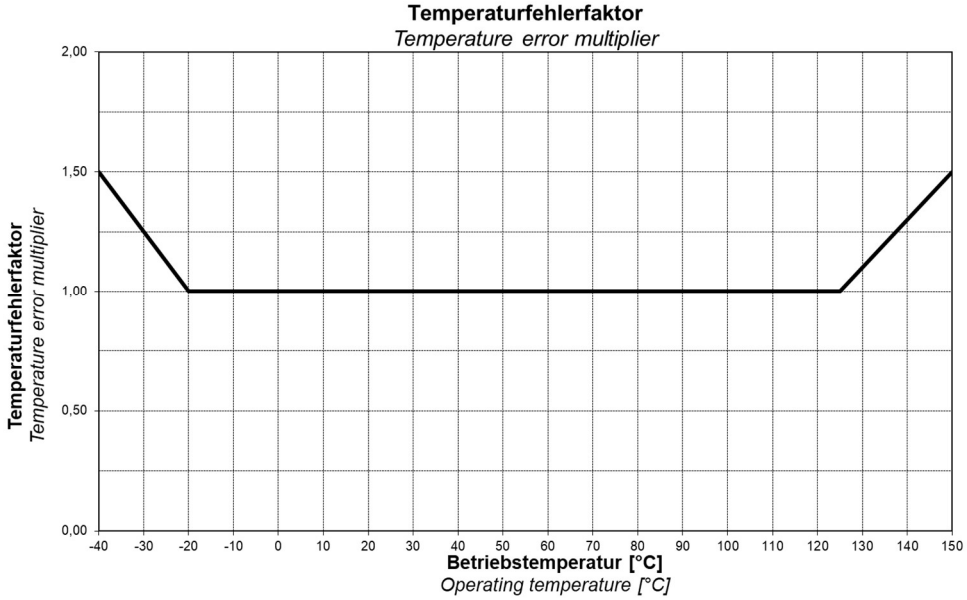
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Digital output pressure signal @ V_{supply} = 5 V						
Total error *(Gesamtfehler)*	E^{P}_{total}	T_{op} = -40 … -20 °C	Refer to charts below other accuracy upon request			mbar
		T_{op} = -20 … +125 °C				mbar
		T_{op} = +125 … +150 °C				mbar





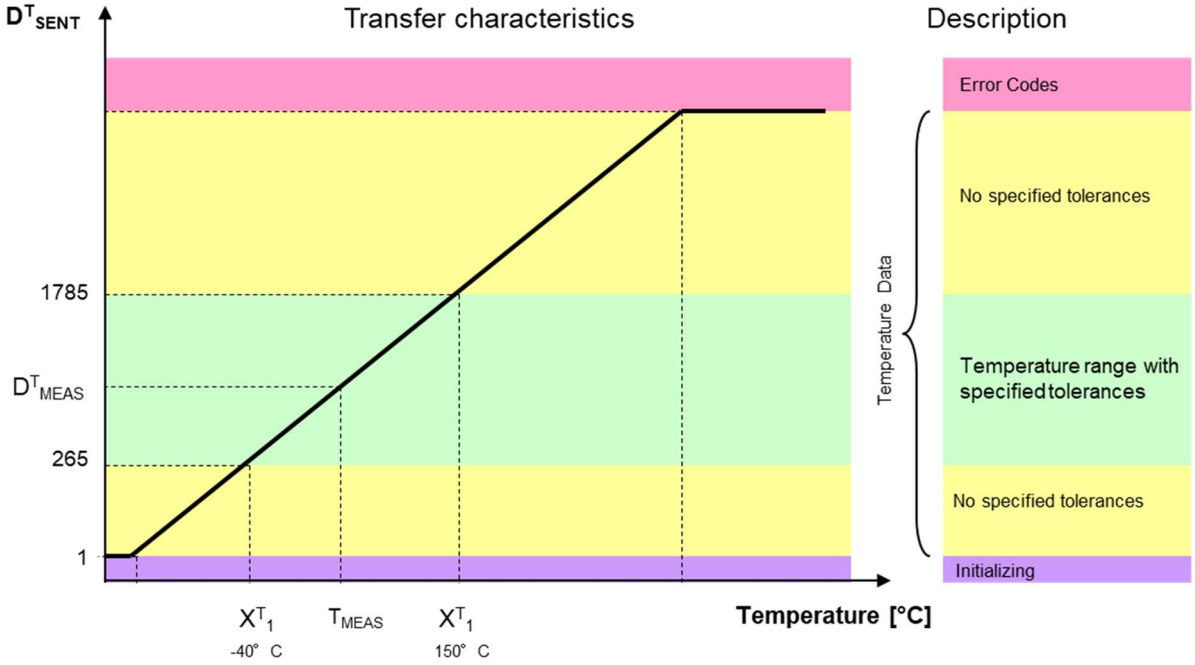
Preliminary data

Temperature dependency factor



4. Temperature transfer characteristics (acc. to SAE J2716 Apr. 2016)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Digital output temperature signal @ p = 1000 mbar, V_{supply} = 5 V						
Initializing				0		digits
Low Clamp		Temp.: ≤ -40°C		265		digits
High Clamp		Temp.: ≥ 150°C		1785		digits
Reserved (not yet assigned)			4089		4095	digits



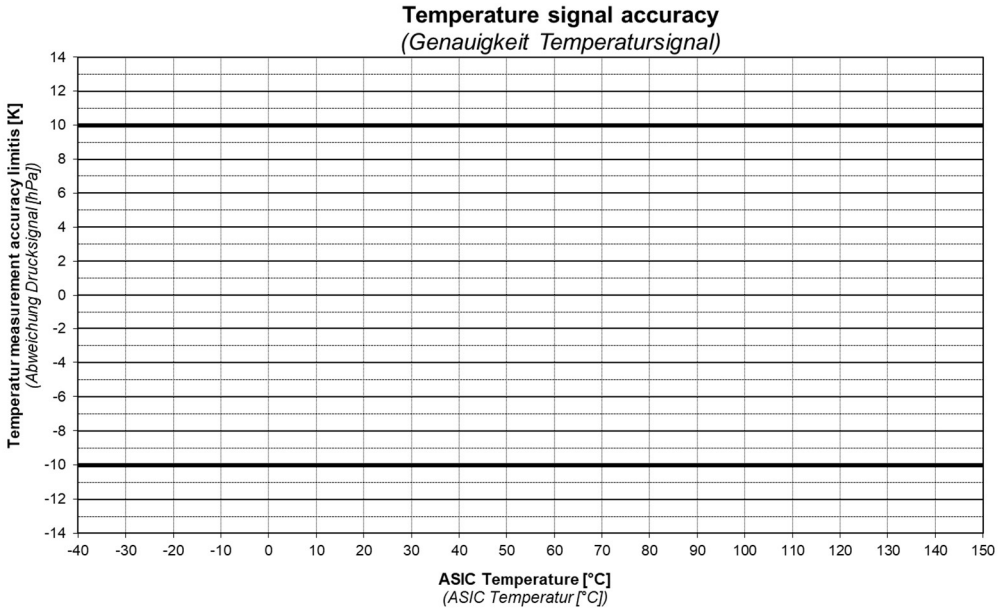
Conversation SENT's Temperature Data to physical Temperature acc. to conversation formula below.

$$T_{meas}[°C] = \frac{\left(X_1^T + \frac{X_2^T - X_1^T}{Y_2^T - Y_1^T} * \left(D_{meas}^T - Y_1^T\right)\right)}{8} - 73{,}15$$

Preliminary data

Temperature signal accuracy

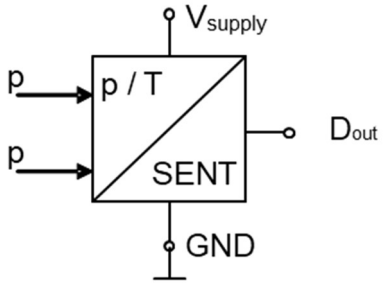
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Digital output pressure signal @ T = 25°C, V_{supply} = 5 V						
Total error	E^{T}_{total}		Refer to chart below other accuracy upon request			



ASIC temperature measurement accuracy: +/- 10 K

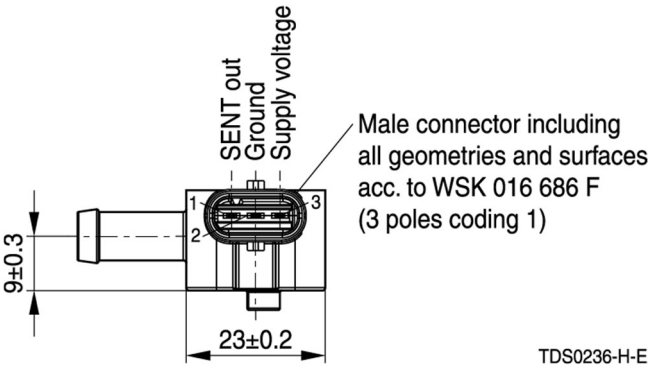
Preliminary data

Connection diagrams



Terminal assignment

Pin	Symbol	Signal
1	D_{out}	*SENT Output signal*
2	GND	*Ground*
3	V_{supply}	*Supply voltage*



Preliminary data

Symbols and terms

1) Operating temperature range T_o

An operation of the pressure sensor within the temperature range $T_{o,min}$ up to $T_{o,max}$ will not affect the performance of the pressure sensor.

2) Short time operating temp. range, $T_{o,short}$

An operation of the pressure sensor within the temperature range $T_{o,short,min}$ up to $T_{o,short,max}$ for the explicit mentioned period of time during life-time will not affect the performance of the pressure sensor.

3) Rated pressure p_r

Within the rated pressure range $p_{r,min}$ up to $p_{r,max}$ the signal output characteristic corresponds to this specification.

4) Overpressure p_{ov}

The sensor does not work correctly in the pressure range $p_{r,max}$ up to $p_{ov,min}$ but will return to normal operation after having been subjected to up to 1000 cycles of overpressure within the pressure range $p_{r,min}$ up to $p_{ov,min}$. The sensor cannot be expected to return to normal operation after having been subjected to a pressure above the overpressure $p_{ov,min}$.

5) Burst pressure p_{burst}

The sensor cannot be expected to return to normal operation after having been subjected to a pressure in the range of p_{ov} and p_{burst}. The sensor will not cause leakage of the pressure medium when exposed to pressures up to the burst pressure.

6) Supply voltage V_{supply}

$V_{supply,max}$ is the maximum permissible supply voltage, which has to be applied for normal operation.
$V_{supply,min}$ is the minimum required supply voltage, which has to be applied for normal operation.

7) Reverse voltage, Overvoltage

If supplied with a supply voltage of $V_{ov,min}$ up to $V_{supply,min}$ the sensor does not work correctly (reverse voltage). If supplied with a supply voltage of $V_{supply,max}$ up to $V_{ov,max}$ the sensor does not work correctly (overvoltage). The sensor will return to normal operation after having been subjected to reverse voltage and overvoltage in the range of $V_{ov,min}$ up to $V_{ov,max}$ for 1 hour maximum.

8) Start up time sensor $t_{StartUpSen}$

The sensor needs $t_{StartUpSen}$ to start SENT communication after reaching minimum required supply voltage.

9) Start up time measurement $t_{StartUpMeas}$

The sensor needs $t_{StartUpMeas}$ to calculate the first valid measurement signal after reaching minimum required supply voltage. 0x00 (initialization state) is transmitted as pressure- and temperature-signal between $t_{StartUpSen} \leq t \leq t_{StartUpMaes}$.

10) Response time

The output response time of the ASSP given by the manufacturer for 100% input step of differential bridge measurement.

Please note: Due to the SENT-Frame rate / duration the *transmission of an updated pressure value* via SENT may take longer than the response time itself.

Preliminary data

Cautions and warnings

A-Samples / Prototypes

Storage

The pressure sensors should be stored in their original packaging. They should not be placed in harmful environments such as corrosive gases nor exposed to heat or direct sunlight, which may cause deformations. Similar effects may result from extreme storage temperatures and climatic conditions.

Avoid storing the pressure sensors in an environment where condensation may form or in a location exposed to corrosive gases, which will adversely affect their performance.

Shelf life under these conditions: 24 months.

Operation

Media compatibility with the pressure sensors must be ensured to prevent their failure.
The use of other media can cause damage and malfunction.

Ensure pressure equalization to the environment, if relative pressure sensors are used.
Avoid operating the pressure sensors in an environment where condensation may form or in a location exposed to corrosive gases. These environments adversely affect their performance.

If the operating pressure is not within the rated pressure range, it may change the output characteristics.
Be sure that the applicable pressure does not exceed the overpressure, it may damage the pressure sensor.

Do not exceed the maximum rated supply voltage, it may damage the pressure sensor.

Do not exceed the rated storage temperature range, it may damage the pressure sensor.

Temperature variations in both the ambient conditions and the media (liquid or gas) can affect the accuracy of the output signal from the pressure sensors. Be sure to check the operating temperature range and thermal error specification of the pressure sensors to determine their suitability for the application.

Connections must be wired in accordance with the terminal assignment specified in this publication. Care should be taken as reversed pin connections can damage the pressure sensors or degrade their performance.

Contact between the pressure sensor terminals and metals or other materials may cause errors in the output characteristics.

This listing does not claim to be complete, but merely reflects the experience of TDK Sensors AG & Co. KG.

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2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
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7. **Our manufacturing sites serving the automotive business apply the IATF 16949 standard.** The IATF certifications confirm our compliance with requirements regarding the quality management system in the automotive industry. Referring to customer requirements and customer specific requirements (“CSR”) TDK always has and will continue to have the policy of respecting individual agreements. Even if IATF 16949 may appear to support the acceptance of unilateral requirements, we hereby like to emphasize that **only requirements mutually agreed upon can and will be implemented in our Quality Management System.** For clarification purposes we like to point out that obligations from IATF 16949 shall only become legally binding if individually agreed upon.

Important notes

8. The trade names EPCOS, CarXield, CeraCharge, CeraDiode, CeraLink, CeraPad, CeraPlas, CSMP, CTVS, DeltaCap, DigiSiMic, ExoCore, FilterCap, FormFit, LeaXield, MiniBlue, MiniCell, MKD, MKK, ModCap, MotorCap, PCC, PhaseCap, PhaseCube, PhaseMod, PhiCap, PowerHap, PQSine, PQvar, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SiMic, SIMID, SineFormer, SIOV, ThermoFuse, WindCap, XieldCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.tdk-electronics.tdk.com/trademarks.

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