

# KP276D1201

## Digital Absolute Pressure Sensor

### dTurboTMAP with SENT Output and Temperature Sensor Interface



## Features

- Increased media robustness for current automotive requirements
- High accuracy pressure sensing ( $\pm 0.77\%$  FSS)
- Integrated signal processing for external temperature sensor
- SENT protocol interface
- Real 12-bit pressure resolution
- Real 12-bit temperature resolution
- Self diagnosis features
- “Green” 8 pin SMD housing
- Automotive qualified



## Potential applications

- Automotive applications, Industrial control
- Consumer applications, Medical applications

## Product validation

Qualified for automotive applications.  
Product validation according to AEC-Q100.

## Description

The KP276D1201 is a miniaturized Digital Absolute Pressure Sensor IC based on a capacitive principle. It is surface micromachined with a monolithic integrated signal conditioning circuit implemented in BiCMOS technology.

The sensor converts a pressure into a 12-bit digital value and sends the information via the SENT protocol (SAE J2716 revised April 2016). In addition, an interface for an external negative temperature coefficient (NTC) temperature sensor is provided. The temperature information given by the NTC is also digitized into a 12-bit value and transmitted with the SENT protocol.

A special safety feature is the integrated diagnostic mode, which allows testing of the sensor cells as well as the signal path. This diagnosis is triggered by powering the device.

The chip is packaged in a “green” media robust SMD housing. The sensor has been primarily developed for measuring manifold air pressure, but can also be used in other application fields. The high accuracy, high sensitivity and safety features of the device makes it a perfect fit for advanced automotive applications as well as in industrial and consumer applications.

Type	Package	Ordering Code	Marking
KP276D1201	PG-DSOF-8-162	SP005420999	KP276D1201

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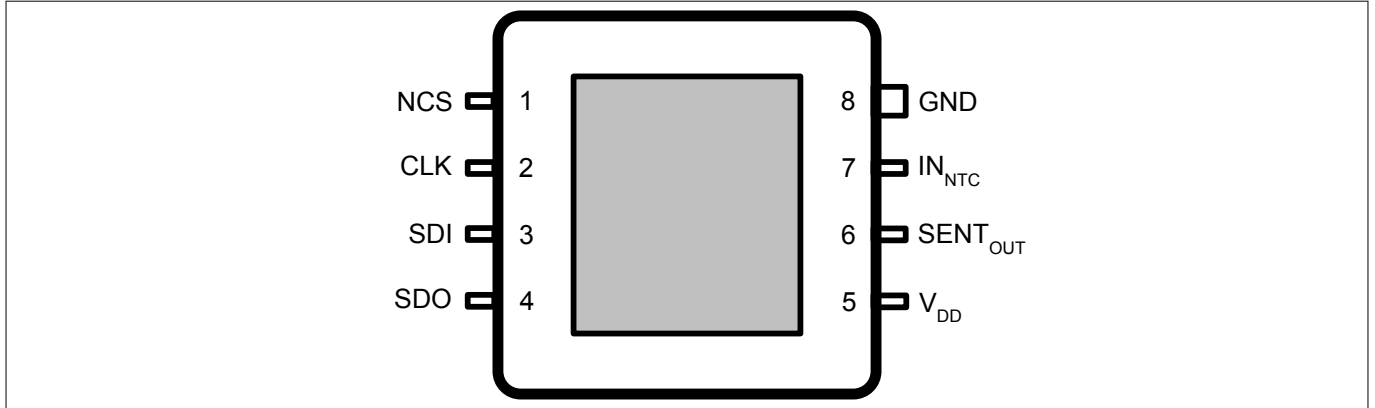
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**Functional description**

**1 Functional description**

**1.1 Pin configuration**

Figure 1 shows the pin configuration.



**Figure 1 Pin configuration (top view, figure not to scale)**

**1.2 Pin description**

Table 1 shows the pin description.

**Table 1 Pin description**

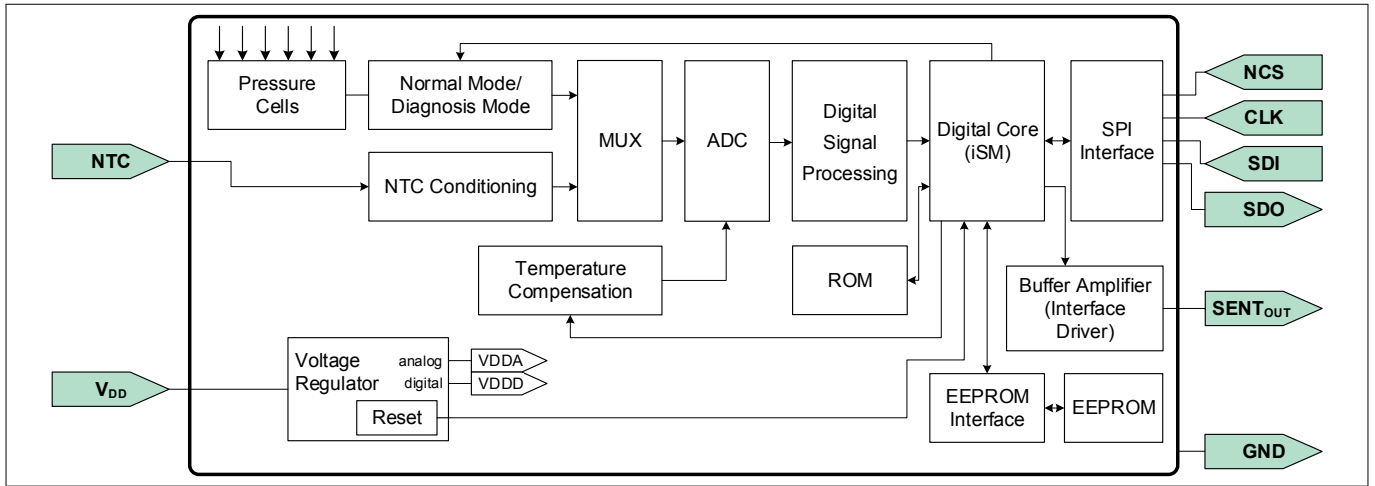
Pin No.	Name	Function	Comment
1	NCS	Not-Chip-Select (active-low)	Communication is enabled when NCS is low <sup>1)</sup>
2	CLK	Serial Clock	External clock for serial communication <sup>1)</sup>
3	SDI	Serial Data In	Serial data input (e.g. from a controller) <sup>1)</sup>
4	SDO	Serial Data Out	Tri-state serial data output <sup>1)</sup>
5	VDD	Supply voltage	–
6	SENT <sub>OUT</sub>	SENT output	Digital Output of the SENT Interface
7	NTC <sub>IN</sub>	NTC Input	Input pin for an external NTC
8	GND	Ground	–

<sup>1)</sup> SPI pins (Pin No. 1 - Pin No. 4) are used only during calibration and test. It is recommended to leave these pins floating in the application.

**Functional description**

**1.3 Block Diagram**

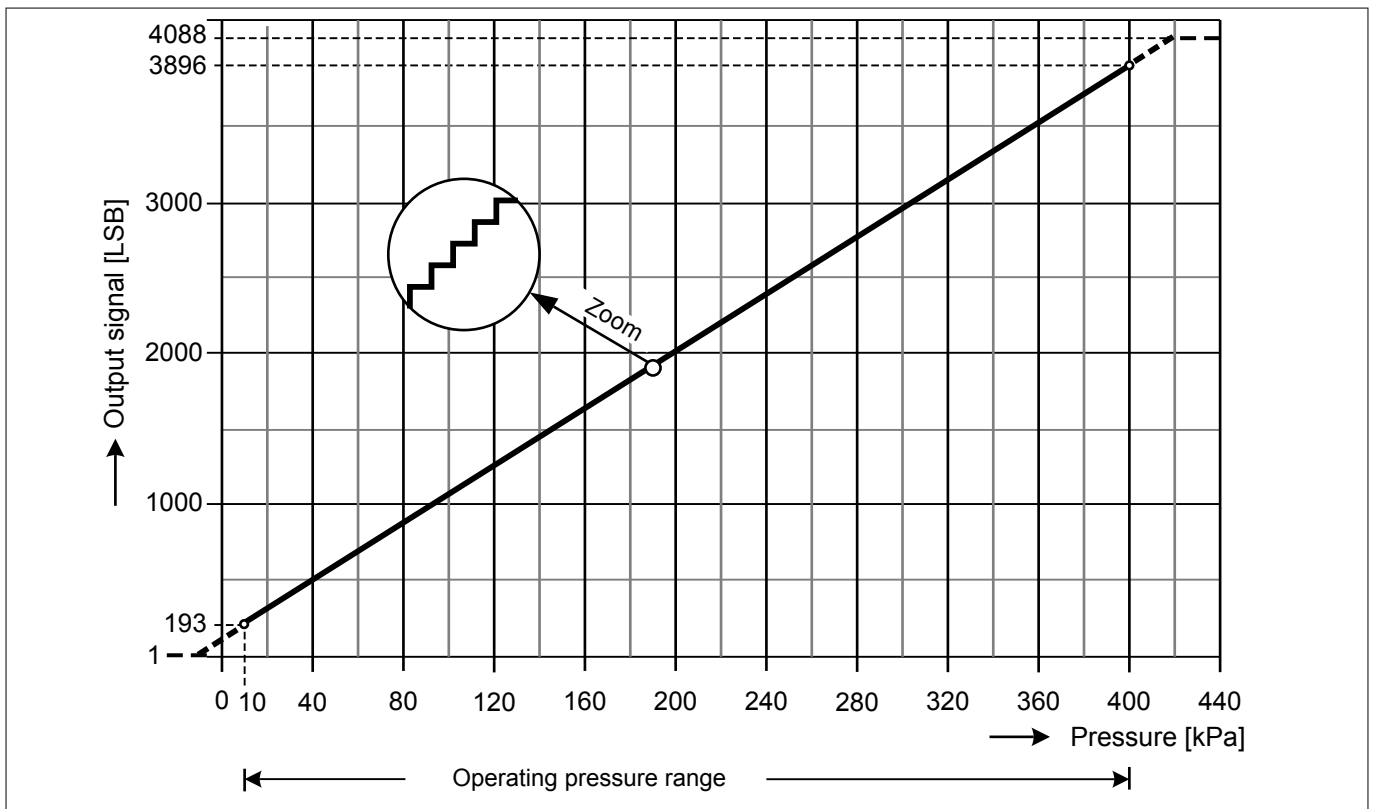
Figure 2 shows the functional block diagram.



**Figure 2 Functional block diagram**

**1.4 Transfer function pressure**

The KP276D1201 device is fully calibrated on delivery. The sensor has a linear transfer function between the applied pressure and the digital output signal.



**Figure 3 Pressure transfer function**

**Clamping**

The output signal for pressure is limited internally to clamping level low (output code 1) and clamping level high (output code 4088).

**Functional description**

**1.4.1 Pressure transfer function characteristics**

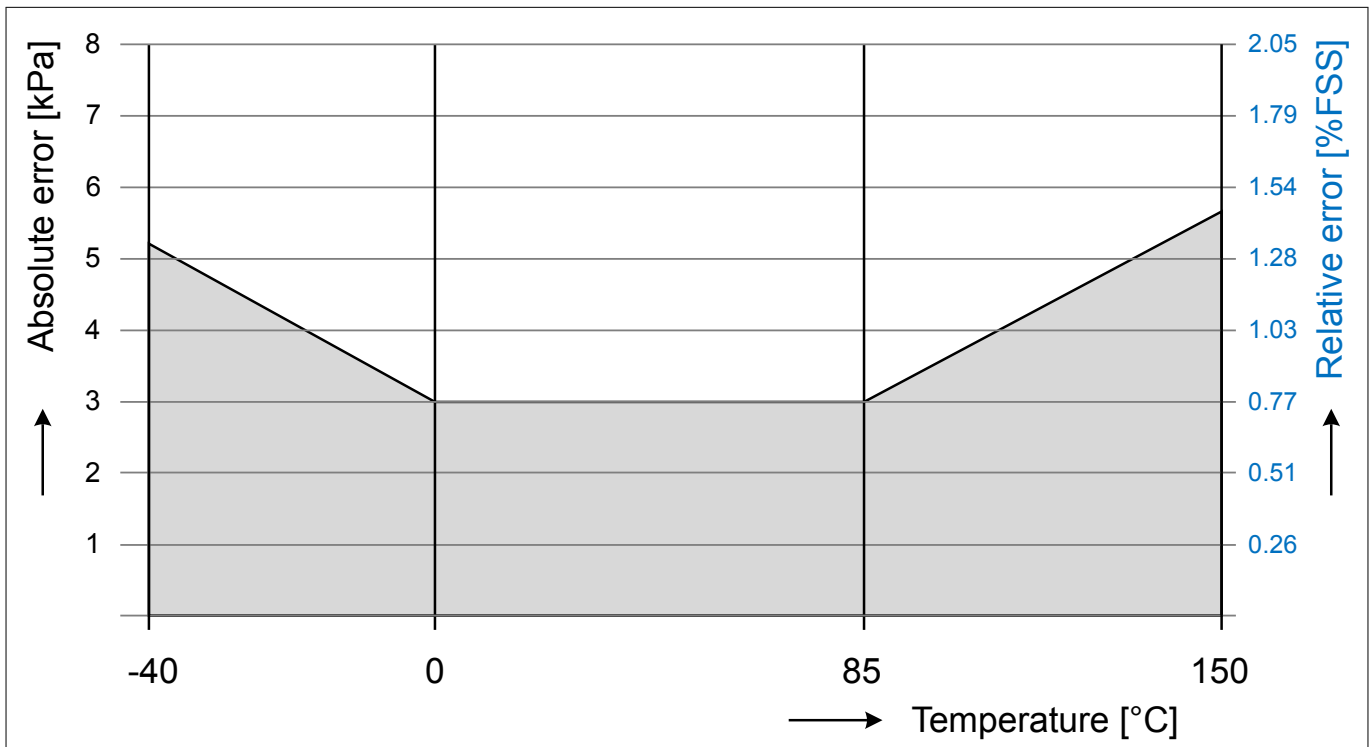
The following calibration is adjusted with the parameters  $S_p$  and  $offs_p$ :

$$p_{amb} = \frac{out_p - ofs_p}{S_p}$$

**Table 2 Pressure transfer function characteristics**

Output Code			Pressure			Gain and Offset		
Symbol	Values	Unit	Symbol	Values	Unit	Symbol	Value	Unit
$p_{IN,1}$	10	kPa	$LSB_{OUT,1}$	193	LSB	$S_p$	9.495	LSB/kPa
$p_{IN,2}$	400	kPa	$LSB_{OUT,2}$	3896	LSB	$offs_p$	98.05	LSB

**1.4.2 Pressure accuracy**



**Figure 4 Accuracy for pressure acquisition**

Functional description

1.5 Transfer function temperature

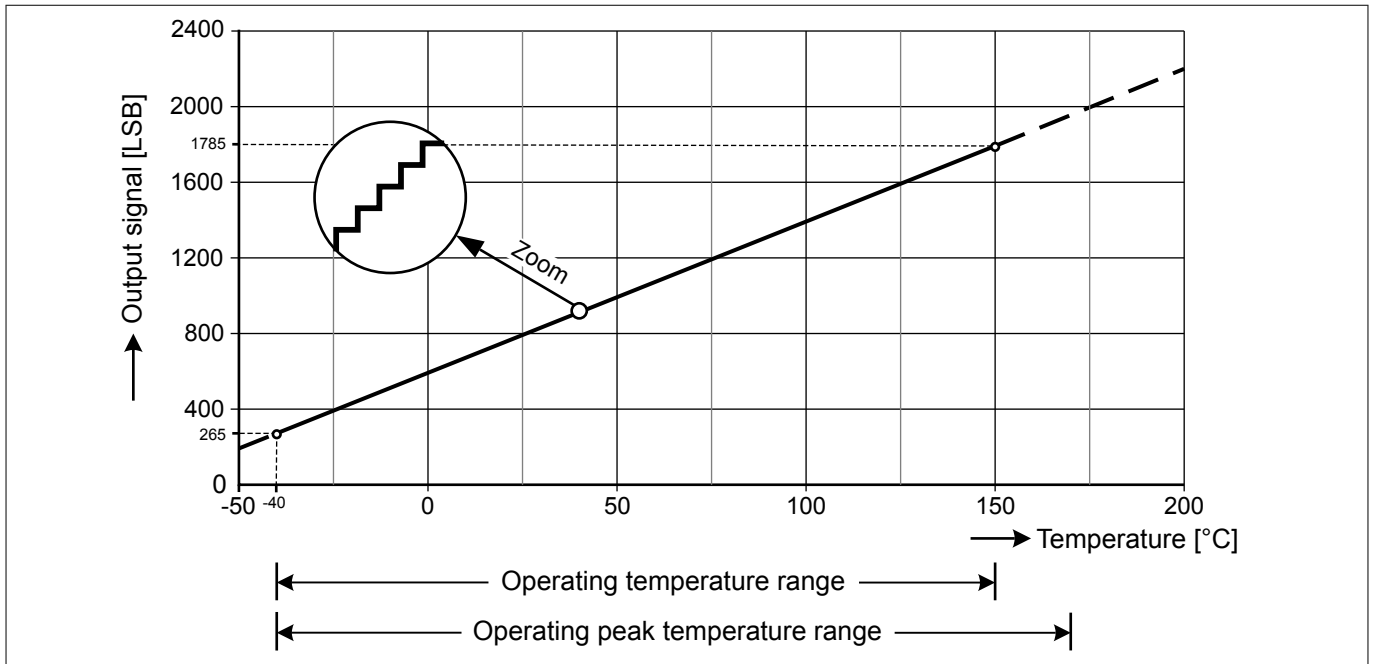


Figure 5 Temperature transfer function

1.5.1 Temperature transfer function characteristics

The following calibration is adjusted with the parameters  $S_T$  and  $offs_T$ :

$$T_{amb} = \frac{out_T - offs_T}{S_T}$$

Table 3 Temperature transfer function characteristics

Temperature			Output Code			Gain and Offset		
Symbol	Values	Unit	Symbol	Values	Unit	Symbol	Value	Unit
$T_{IN,1}$	-40	°C	$LSB_{OUT,1}$	265	LSB	$S_T$	8.0	LSB/°C
$T_{IN,2}$	170	°C	$LSB_{OUT,2}$	1945	LSB	$offs_T$	585.2	LSB

**Functional description**

**1.6 SENT interface**

The SENT interface enables communication according to the SENT (Single Edge Nibble Transmission) specification. The SENT protocol specifies the transmission of information in a series of pulses with data encoded as falling edge to falling edge periods. Each following pulse is called a nibble. The SENT interface transmits messages organized in frames. Each frame consists of several pulses which are delimited by falling edges. Each falling edge marks the start of a new nibble.

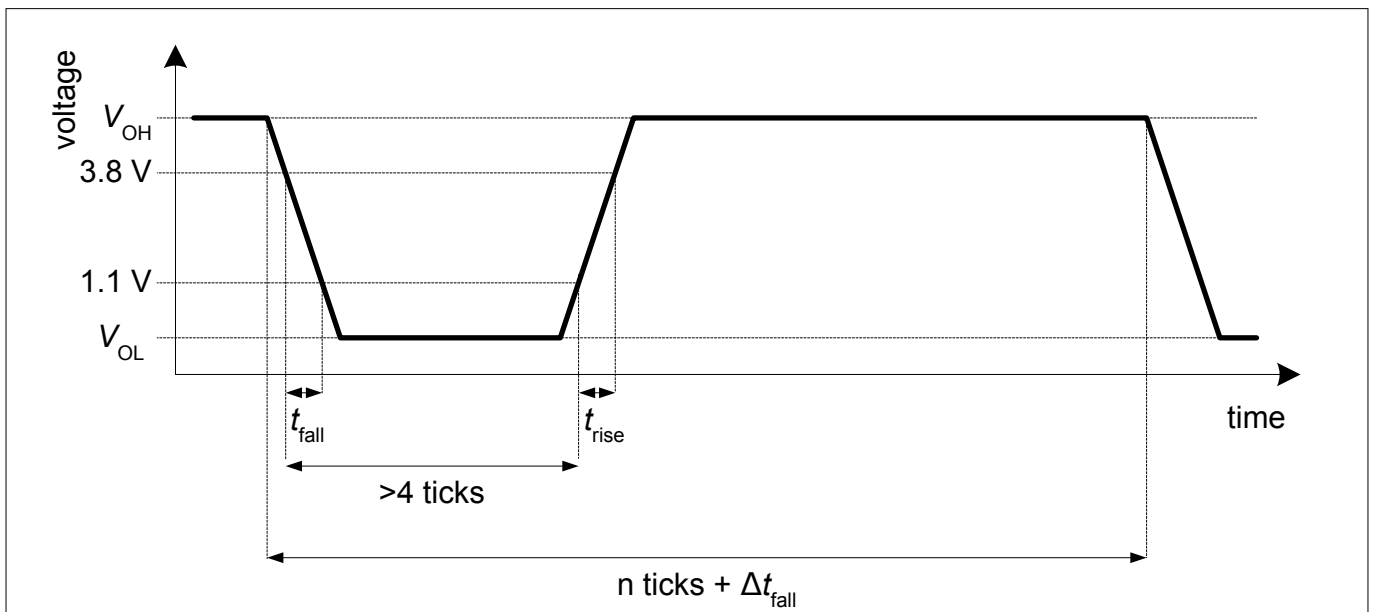
- **KP276D1201 SENT configuration shorthand definition:** SENT2016-03.0us-6dn-ppc(282.0)-esp-A.5

**1.6.1 Physical layer**

The physical layer provides the method of transferring digital data encoded as time between two falling edges of a signal through the communication medium. It consists of power, ground and the signal wire (see [Figure 16](#)).

The basic unit of time for the SENT interface is called a clock tick. The transmission bit rate depends on the data value sent and the sensor clock tolerance. The shortest length of a nibble pulse consists of 12 ticks (nominally 36 μs), the maximum length is 27 ticks (nominally 81 μs).

[Figure 6](#) shows the physical layer specification of a nibble.



**Figure 6 Physical layer specification of a nibble**

**1.6.2 Data link layer**

The SENT interface has two channels for transmitting information:

- Fast channel
- Slow channel

The fast channel represents the information transmitted in the data pulses of the SENT frame. Within a single SENT frame a full pressure code and full NTC code is transmitted.

The slow channel represents the information transmitted within the status and serial communication nibble. On this channel information is transmitted over several SENT frames (4 bits per SENT frame). This information consists of diagnostic codes and serial messages.

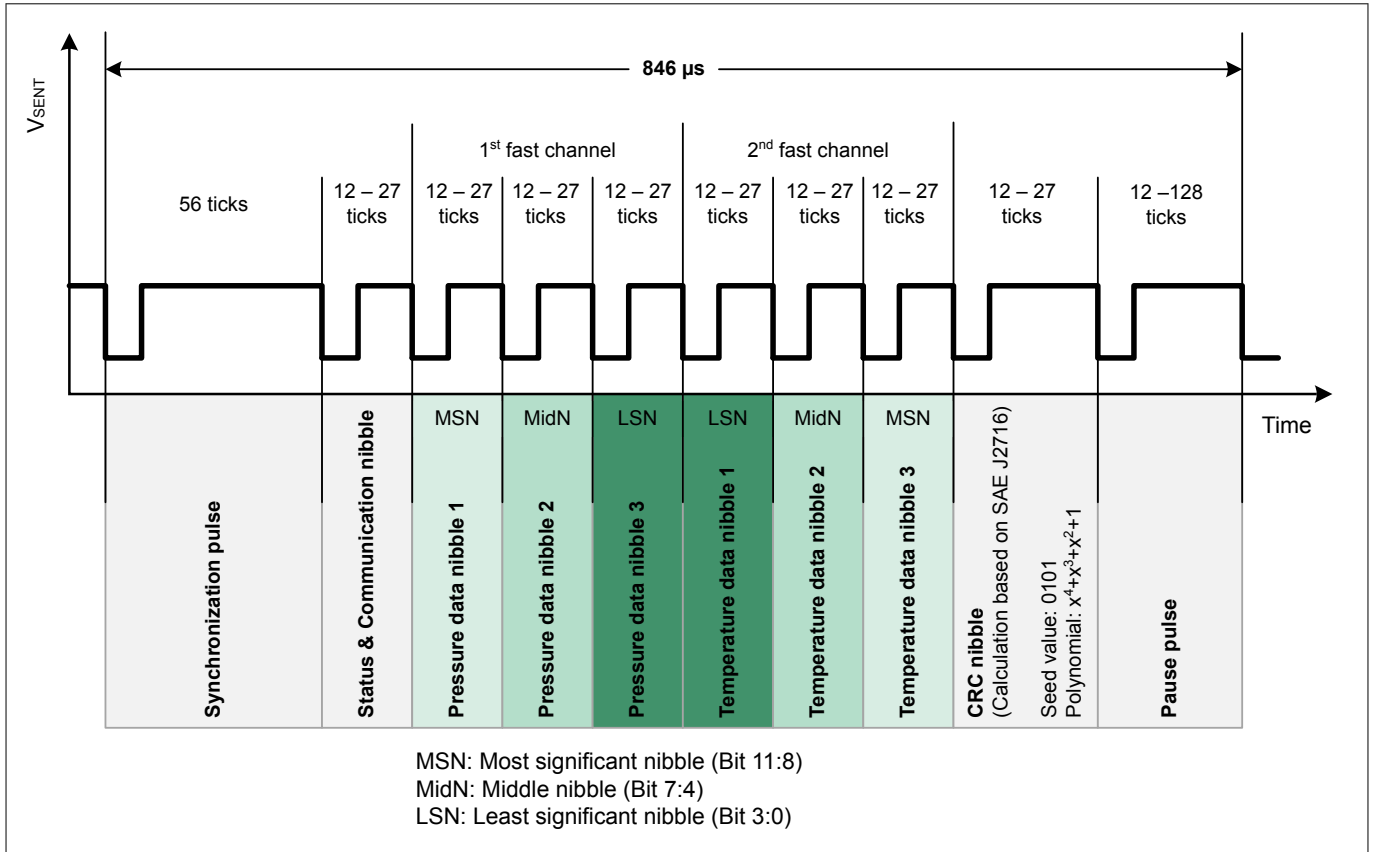
The SENT frame starts with a synchronization and calibration pulse which is used by the receiver to synchronize with the frame and to create a reference for the length measurement of the following nibbles.

The synchronization pulse is followed by a status and serial communication nibble. The value coded in this nibble represents a series of 4 bits. While bit #0 and bit #1 are reserved, bit #2 and bit #3 are used to communicate serial messages.



**Functional description**

The message transmitted by the KP276D1201 contains two fast channels. Each channel is segmented in 3 data nibbles; every nibble includes 4 bits. The 12-bit pressure information is transmitted by the first fast channel, the 12-bit temperature information of the NTC by the second fast channel.



**Figure 7 Message transmission**

The pause pulse is used to create a SENT transmission with a constant frame length of 282 clock ticks (846 μs).

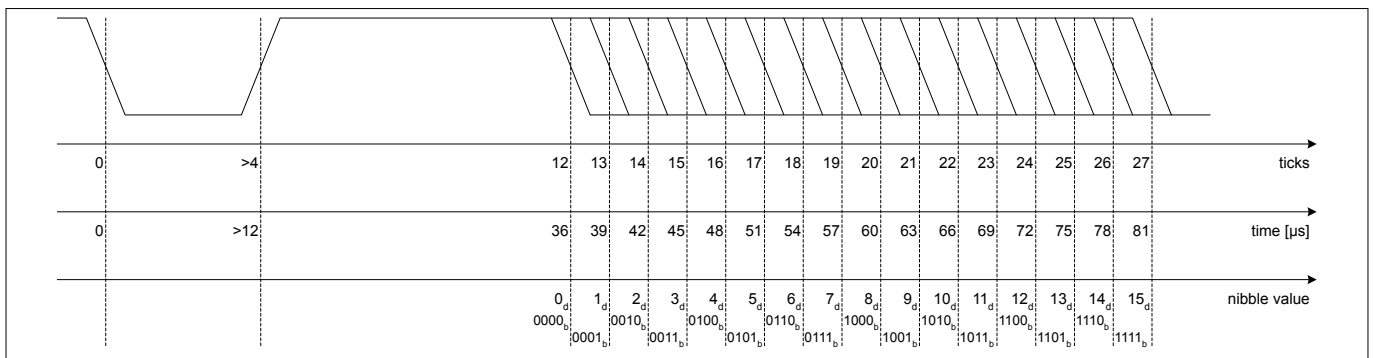
**1.6.2.1 Nibble specification**

A nibble contains 4-bit data content. The length of a nibble defines the content of the 4 bits. The global timing of a nibble is based on ticks. The length of a tick is specified as 3 μs.

The following formula defines the number of ticks ( $n_{ticks}$ ) based on the nibble content ( $data_{nibble}$ ):

$$n_{ticks} = 12 + data_{nibble}$$

Figure 8 shows the nibble timing.



**Figure 8 Nibble timing**

**Functional description**

**1.6.2.2 Status and communication nibble**

This nibble is reserved to enable the sensor to transmit different information such as part numbers or error code information. The nibble is defined in the following table:

**Table 4 Status nibble description**

Status Nibble Bit	Function
0	Fast channel-1 error flag
1	Fast channel-2 error flag
2	Serial message bit: Serial message data bit
3	Serial message bit: Serial message data bit and indicates the start of a serial message

The serial message channel (slow message channel) is implemented as enhanced serial message format.

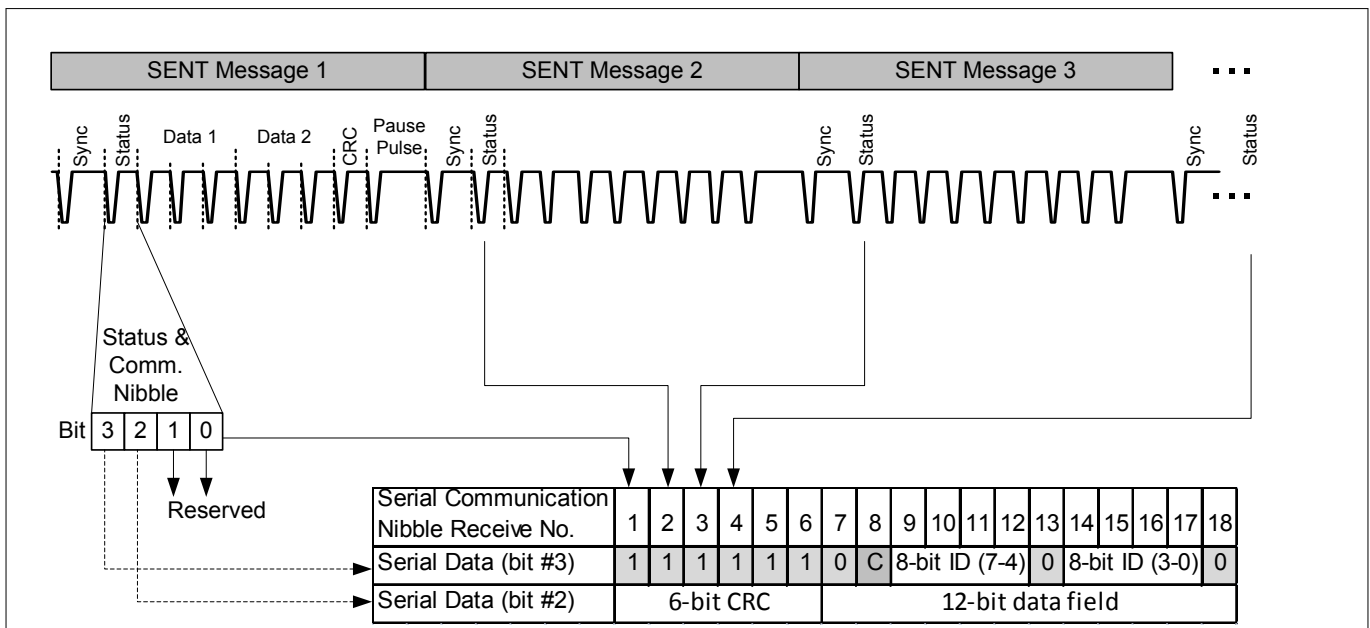
**1.6.2.3 Enhanced serial message format**

Bit #2 and #3 of the status and communication nibble are used for serial data transmission. A serial message stretches over 18 consecutive SENT data messages. All 18 messages must be successfully received for the serial value to be valid.

The frame start of a serial message is indicated by the unique pattern “111110” in bit #3 of the status and communication nibble, **Figure 10**. The first “1” in a series of six “1” (after a “0”) indicates the first nibble of a serial message. Serial data bit #3 of serial communication nibble 1 - nibble 6 are set to “1”, Serial data bit #3 of serial communication nibbles 7, 13 and 18 are set to “0”.

The serial message contains 20 bits of payload data. The communication is defined by the configuration bit (serial data bit #3, serial communication nibble No. 8), configuration bit = 0”:

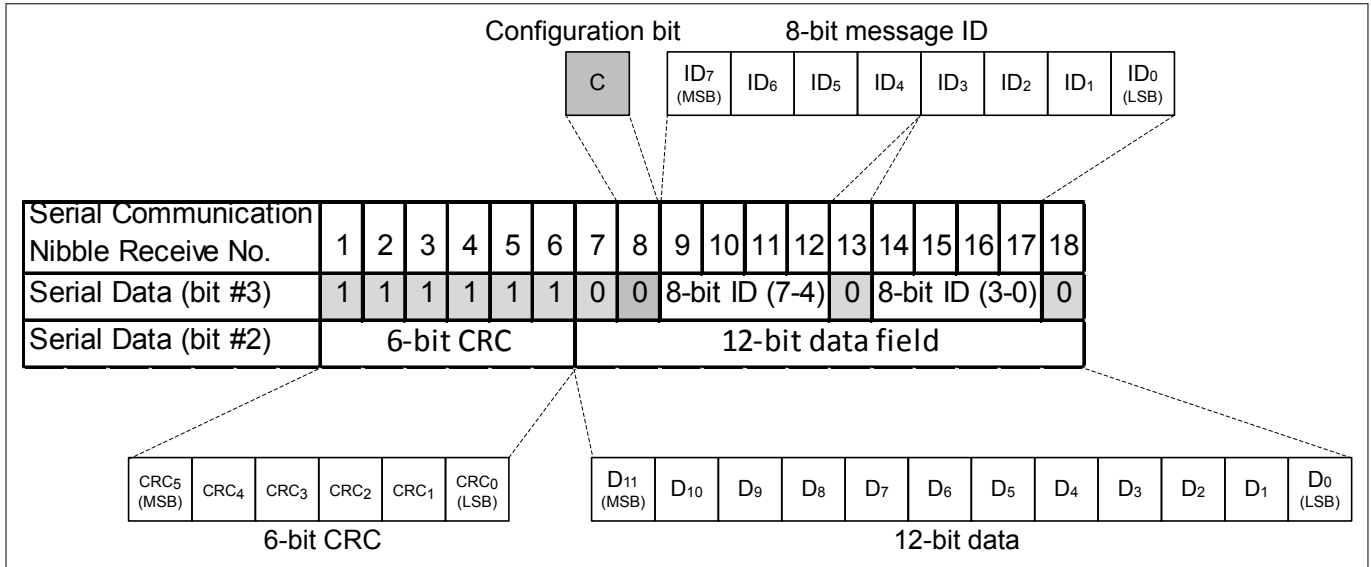
- 12-bit data and 8-bit message ID



**Figure 9 Construction of enhanced serial data message from 18 SENT messages**

All data (data field, message ID and CRC) that is transmitted in the serial message channel is sent in the order MSB to LSB.

**Functional description**



**Figure 10 Enhanced serial message format with 12-bit data field and 8-bit message ID**

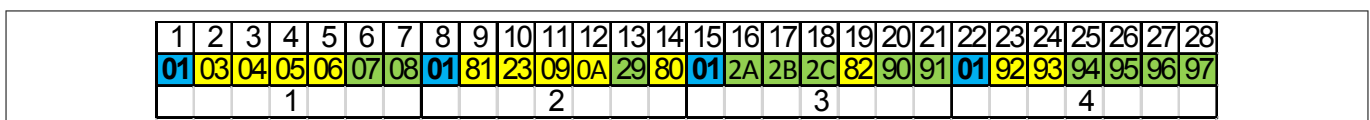
**Functional description**

**1.6.2.4 Enhanced serial message data**

The following 28 serial messages are transmitted over the slow channel and continuously repeated:

**Table 5 Slow message channel data**

Message Number	Message ID	Definition	12-bit data	EEPROM programmable
1	\$01	Diagnostic error codes	–	–
2	\$03	Sensor type Channel 1/2 Pressure/ Temperature	0x007	no
3	\$04	Configuration Code	0x001	no
4	\$05	Manufacturer Code	0x056	no
5	\$06	SENT standard version	0x004	no
6	\$07	Fast channel 1 characteristic $X1$ , ( $X1=p_{IN,1}$ )	0x053	yes
7	\$08	Fast channel 1 characteristic $X2$ , ( $X2=p_{IN,2}$ )	0x144	yes
8	\$01	Diagnostic error codes	–	–
9	\$81	Defined by OEM/Supplier	0x000	no
10	\$23	Supplementary data channel #4,1, reference temperature (NTC temperature)	0x000	no
11	\$09	Fast channel characteristic $Y1$ , default	0x0C1	no
12	\$0A	Fast channel characteristic $Y2$ , default	0xF38	no
13	\$29	Sensor ID #1		yes
14	\$80	Defined by OEM/Supplier	0x000	no
15	\$01	Diagnostic error codes	–	–
16	\$2A	Sensor ID #2		yes
17	\$2B	Sensor ID #3		yes
18	\$2C	Sensor ID #4		yes
19	\$82	OEM/Supplier	0x000	no
20	\$90	OEM part number	0x590	yes
21	\$91	OEM part number	0x66B	yes
22	\$01	Diagnostic error codes	–	–
23	\$92	OEM part number	0x590	no
24	\$93	OEM part number	0x550	no
25	\$94	OEM part number	0x9D1	yes
26	\$95	OEM part number	0x000	yes
27	\$96	OEM part number	0x000	yes
28	\$97	OEM part number	0x000	yes



**Figure 11 ESM cycle**

**Functional description**

**1.6.3 Pressure channel output codes**

*Table 6* gives an overview about the pressure channel data content.

**Table 6 Pressure channel data content**

Code [dec]	Code [bin]	Data Nibble 1	Data Nibble 2	Data Nibble 3	Description
0	0000 0000 0000	12 ticks	12 ticks	12 ticks	Invalid value
1	0000 0000 0001	12 ticks	12 ticks	13 ticks	Clamping low
2	0000 0000 0010	12 ticks	12 ticks	14 ticks	Min. pressure output
...	...	...	...	...	...
4087	1111 1111 0111	27 ticks	27 ticks	19 ticks	Max. pressure output
4088	1111 1111 1000	27 ticks	27 ticks	20 ticks	Clamping high
4089	1111 1111 1001	27 ticks	27 ticks	21 ticks	Invalid value
4090	1111 1111 1010	27 ticks	27 ticks	22 ticks	Diagnostic error
4091	1111 1111 1011	27 ticks	27 ticks	23 ticks	Invalid value
4092	1111 1111 1100	27 ticks	27 ticks	24 ticks	Invalid value
4093	1111 1111 1101	27 ticks	27 ticks	25 ticks	Invalid value
4094	1111 1111 1110	27 ticks	27 ticks	26 ticks	Invalid value
4095	1111 1111 1111	27 ticks	27 ticks	27 ticks	Invalid value

**Table 7 Error indication for pressure channel**

Pressure kPa	Fast channel 1 LSB	Slow channel ID\$01	Status Nibble Bit 0	Description
$P < -10$	1	002 <sub>H</sub>	1	Clamping low
$-10 \leq P < 10$	$2 \leq \text{code} \leq 192$	002 <sub>H</sub>	0	Reduced signal accuracy
$10 \leq P \leq 400$	$193 \leq \text{code} \leq 3896$	000 <sub>H</sub>	0	Signal range
$400 < P \leq 420$	$3897 \leq \text{code} \leq 4087$	001 <sub>H</sub>	0	Reduced signal accuracy
$420 < P$	4088	001 <sub>H</sub>	1	Clamping high

*Note:* Status Nibble Bit #0 is calculated at start of every frame. Status value for slow channel is calculated at start of every slow channel status message (ID\$01).

**Functional description**

**1.6.4 Temperature channel output codes**

**Table 8** gives an overview about the temperature channel data content.

**Table 8 Temperature channel data content**

Code [dec]	Code [bin]	Data Nibble 3	Data Nibble 2	Data Nibble 1	Description
0	0000 0000 0000	12 ticks	12 ticks	12 ticks	Initialization
1	0000 0000 0001	12 ticks	12 ticks	13 ticks	Clamping low (-73°C)
...	...	...	...	...	...
185	0000 1011 1001	12 ticks	23 ticks	21 ticks	Min. temperature <sup>2)</sup> (-50°C)
...	...	...	...	...	...
2025	0111 1110 1001	19 ticks	26 ticks	21 ticks	Max. temperature <sup>2)</sup> (180°C)
...	...	...	...	...	...
4088	1111 1111 1000	27 ticks	27 ticks	20 ticks	Clamping high (438°C)
4089	1111 1111 1001	27 ticks	27 ticks	21 ticks	Invalid value
4090	1111 1111 1010	27 ticks	27 ticks	22 ticks	Diagnostic error
4091	1111 1111 1011	27 ticks	27 ticks	23 ticks	Invalid value
4092	1111 1111 1100	27 ticks	27 ticks	24 ticks	Invalid value
4093	1111 1111 1101	27 ticks	27 ticks	25 ticks	Invalid value
4094	1111 1111 1110	27 ticks	27 ticks	26 ticks	Invalid value
4095	1111 1111 1111	27 ticks	27 ticks	27 ticks	Invalid value

**Table 9 Error indication for temperature channel**

Temperature <sup>2)</sup> °C	Fast channel 2 LSB	Slow channel ID\$01	Status Nibble Bit 1	Description
T < -50	code < 185	805 <sub>H</sub>	1	Temperature too low
-50 ≤ T < -40	185 ≤ code ≤ 265	000 <sub>H</sub>	0	Accuracy undefined
-40 ≤ T ≤ 170	266 ≤ code ≤ 1945	000 <sub>H</sub>	0	Temperature range
170 < T ≤ 180	1946 ≤ code ≤ 2025	000 <sub>H</sub>	0	Accuracy undefined
T > 180	code > 2025	804 <sub>H</sub>	1	Temperature too high

Notes:

1. The output code for fast channel 2 is limited by the NTC resistance value.
2. Status Nibble Bit #1 is calculated at start of every frame. Status value for slow channel is calculated at start of every slow channel status message (ID\$01).

<sup>2)</sup> Min/max temperature output depends on external NTC due to limitation of measurement range for NTC resistance, see [Table 18](#)

**Functional description**

**1.6.5 Diagnostic Error Codes**

After power on, a system self check is started. During this initialization phase the following internal sensor checks are performed:

- Pressure out of range
- Signal path check (Diag1)
- Sensor cell check (Diag2)
- EEPROM check

The signal range is continuously monitored and “Signal out of range” is transmitted with every SENT frame. Pressure out of range is transmitted over fast channel1, temperature out of range is transmitted over fast channel2.

If an internal malfunction is detected, the error code 4090 is transmitted over fast channel1 and fast channel2. The error type is transmitted over the slow message channel (Diagnostic Error Code), see [Table 10](#). If more than one error is detected, only the diagnosis code with the highest priority will be sent.

**Table 10 Diagnostic Error Codes**

Description	Priority <sup>3)</sup>	Fast Channel1 Code	Fast Channel2 Code	Diagnostic Error Code
Normal Operation/Initialization		channel1 data	channel2 data	000 <sub>H</sub> no error
Internal Error	5	4090	4090	A05 <sub>H</sub>
Pressure out of range high	4	4088	channel2 data	001 <sub>H</sub>
Pressure out of range low	3	1	channel2 data	002 <sub>H</sub>
Temperature out of range high	2	channel1 data	>2025	804 <sub>H</sub>
Temperature out of range low	1	channel1 data	<185	805 <sub>H</sub>

*Note: Diagnostic error code is updated with start of every new status message ID.*

**1.6.5.1 Signal out of range**

The signal ranges are monitored during normal operation mode. If the pressure value is below the minimum operating pressure range or exceeds the maximum operating pressure range the error code “Pressure out of range low/high” is transmitted. The limits are defined in [Table 7](#).

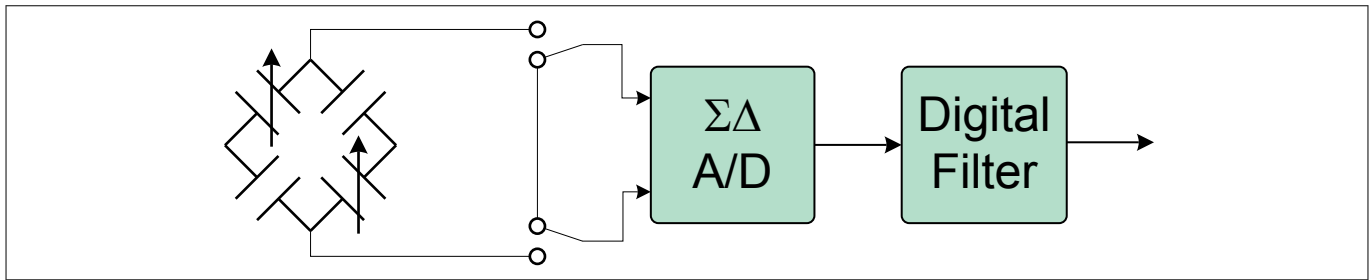
If the NTC temperature is below the minimum operating temperature or NTC resistor exceeds the maximum resistance value of NTC “Temperature out of range low” is transmitted. If the NTC temperature exceeds the maximum operating temperature or NTC resistor is below minimum resistance value the error code “Temperature out of range high” is transmitted. The limits are defined in [Table 9](#), the resistance values of NTC are defined in [Table 18](#).

**1.6.5.2 Diag1**

The Diag1 test checks the functionality of the signal path. Therefore the inputs of the sigma delta ADC are shorted. Afterwards, the system response is compared with the expected range (~ 50% of full scale range). If the system response is out of range, the diagnostic error code “Internal Error” is set.

<sup>3</sup> Priority 5: high, priority 1: low

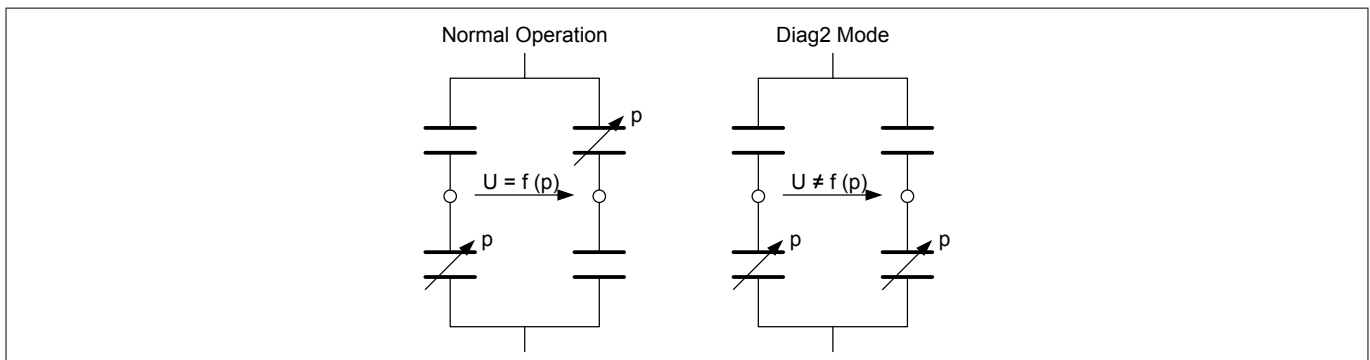
**Functional description**



**Figure 12**      **Diag1 functionality**

**1.6.5.3**      **Diag2**

The Diag2 test checks the functionality of the pressure sensor cells. Therefore a malfunction (e.g. broken membrane) can be detected. The KP276D1201 pressure sensing element is made of 2 measuring cells and 2 reference cells. In the normal mode these four cells are connected in a Wheatstone bridge configuration. In the Diag2 mode, the connection of the cells is modified as shown in **Figure 13**. If Diag2 value is out of range, the diagnostic error code “Internal Error” is set.

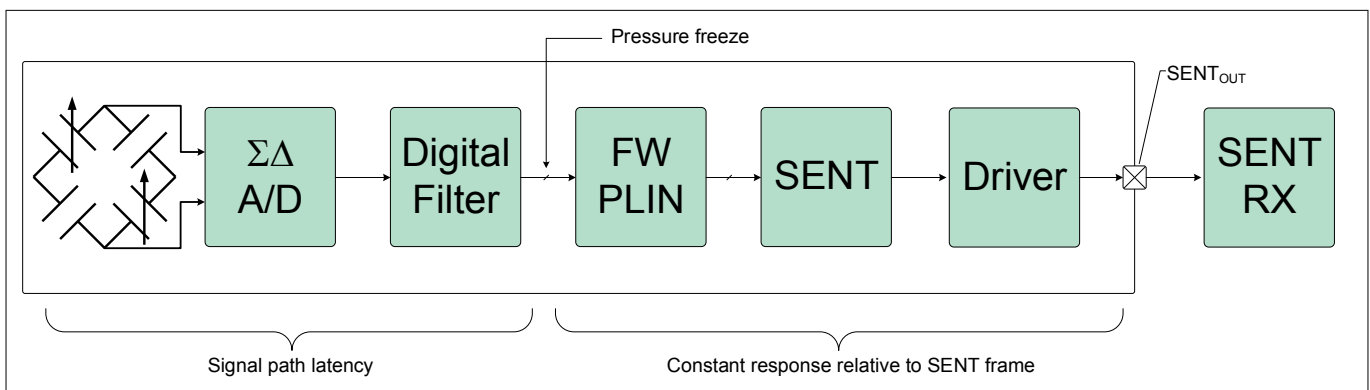


**Figure 13**      **Diag2 functionality**

**1.6.5.4**      **EEPROM Check**

During the initialization phase the content of the EEPROM cells is copied into the corresponding EEPROM registers. Thereby, a parity check is done based on the parity row and column. A one bit error is corrected by the forward error correction. Any additional bit error results in an “Internal Error”.

**1.6.6**      **Definition of Pressure signal path latency**



**Figure 14**      **Pressure signal path latency  $t_{path\_pres}$  (pressure settling time)**

The pressure value is calculated at start of the SENT frame and is transmitted once per frame.



**Functional description**

**1.7 External temperature sensor**

The KP276D1201 can be connected to an external temperature sensor at pin  $NTC_{IN}$ . The internal signal processing of the KP276D1201 makes it a perfect fit for using standard NTC temperature sensors. To avoid errors through self heating of the NTC, the power consumption is limited.

**1.7.1 Linearization of the external temperature sensor transfer function**

The resistance of NTC thermistors is a nonlinear function of the temperature. The used method for mathematical modelling of the resistance  $R$  versus temperature  $T$  is the **Steinhart-Hart Equation**:

$$\frac{1}{T} = A + B(\ln(R)) + C(\ln(R))^3$$

The Steinhart-Hart coefficients for a selected NTC are coded in the EEPROM. Evaluation of accuracy is included for the following thermistor:

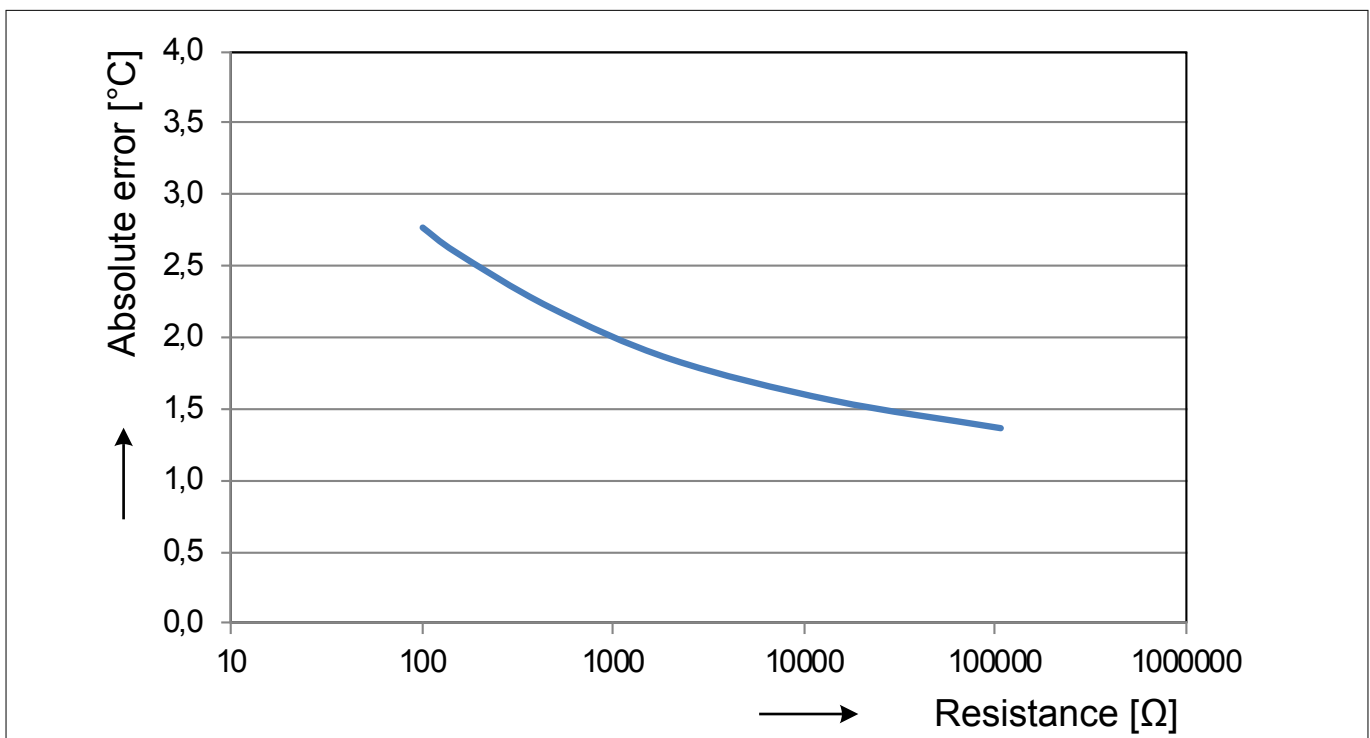
**Table 11 NTC characteristics example**

					Steinhart-Hart coefficients		
	$R_{min} [\Omega]$	$T [^{\circ}C]$	$R_{max} [\Omega]$	$T [^{\circ}C]$	A	B	C
NTC	102	170	107300	-40	1.0211E-03	2.6434E-04	1.3405E-07

Note: The resistance range of the NTC is limited, see [Table 18](#).

**1.7.2 Accuracy for NTC signal processing**

The accuracy of the signal processing for external temperature sensors depends on the resistance value and the nonlinearity of the connected NTC. In [Figure 15](#) the absolute error is displayed graphically, all errors due to the integrated signal processing are considered.

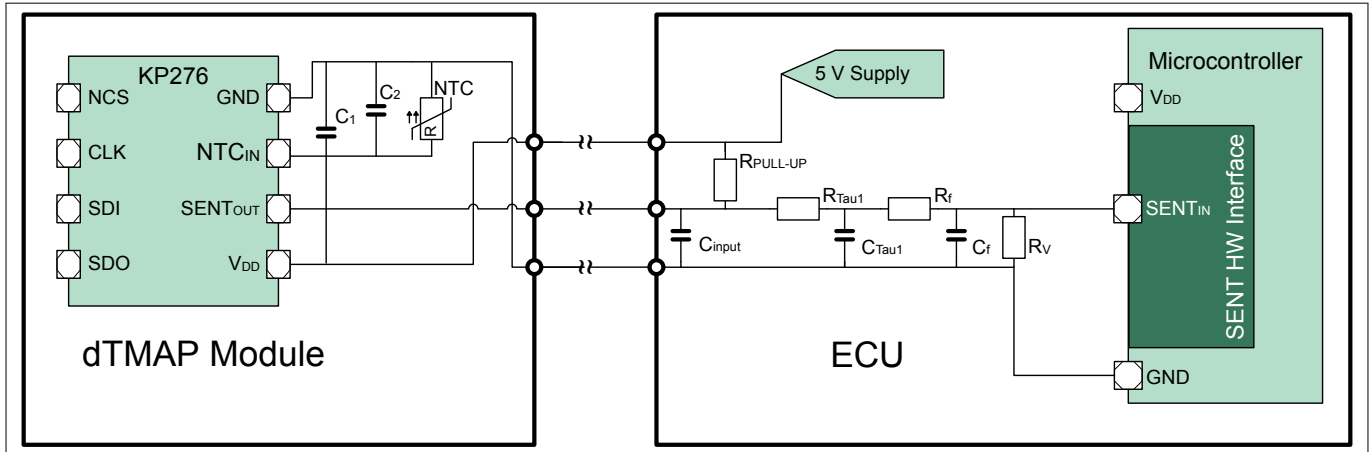


**Figure 15 Accuracy for signal processing of NTC**

**Specification**

**2 Specification**

**2.1 Application circuit example**



**Figure 16 Application circuit example**

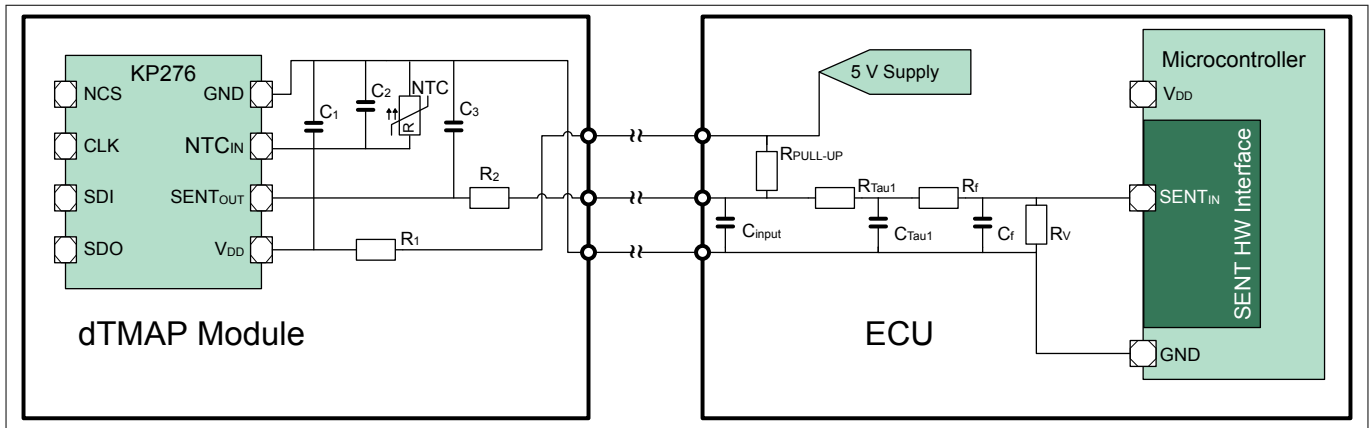
**Table 12 Component values**

Component	Symbol	Values			Unit
		Min.	Typ.	Max.	
Supply Blocking Capacitor	$C_1$	30	100	-	nF
NTC Capacitor	$C_2$	-	330	-	pF
Pull-up Resistor	$R_{PULL-UP}$	10	-	55	k $\Omega$
Parasitic Input Capacitor	$C_{input}$	-	-	0.1	nF
Low Pass Resistor	$R_{Tau1}$	448	560	672	$\Omega$
Low Pass Capacitor	$C_{Tau1}$	1.54	2.2	2.86	nF
Low Pass Resistor - second stage	$R_f$	4	-	-	k $\Omega$
Low Pass Capacitor - second stage	$C_f$	-	47	-	pF
optional resistor	$R_v$	-	100	-	k $\Omega$
Filter Time Constant - first stage, determined by $R_{Tau1}$ and $C_{Tau1}$	$Tau1$	0.74	-	1.73	$\mu s$
Filter Time Constant - second stage, determined by $R_v$ , $R_f$ and $C_f$	$Tau2$	0.6	-	1.4	$\mu s$

**Note:** For the application PCB-layout, it is mandatory to route the NTC GND wire in such a way that the chip current or any other current does not run through any of the NTC input connections. Star ground connection is recommended for the NTC-GND and GND of the supply source. This will reduce the additional external voltage drop that could influence the external NTC accuracy.

**Specification**

**2.2 Application circuit example for EMC**



**Figure 17 Application circuit example for pulse immunity**

**Table 13 Component values**

Component	Symbol	Values			Unit
		Min.	Typ.	Max.	
Supply Blocking Capacitor	$C_1$	-	330	-	nF
NTC Capacitor	$C_2$	-	330	-	pF
SENT Filter Capacitor	$C_3$	-	1	-	nF
Supply Filter Resistor	$R_1$	-	10	-	$\Omega$
SENT Filter Resistor	$R_2$	-	100	-	$\Omega$

For pulse immunity an EMC filter consisting of a capacitor ( $C_3$ ) followed by a resistor in series ( $R_2$ ) with the  $SENT_{OUT}$  pin is recommended to attenuate RF energy coupled on the external signal line. In addition a filter consisting of the adapted supply capacitor ( $C_1$ ) followed by a resistor in series ( $R_1$ ) with the supply pin is recommended to attenuate RF energy coupled on the external supply line.

**Specification**

**2.3 Absolute maximum ratings**

**Table 14 Absolute maximum ratings**

Parameter	Symbol	Values			Unit	Note	Number
		Min.	Typ.	Max.			
Voltage on GND & $SENT_{OUT}$	$V_{max}$	-0.3	-	16	V	-	1.1
Voltage on $V_{DD}$	$V_{max\_VDD}$	-16	-	16	V	Reverse polarity protection against supply	1.2
Storage temperature	$T_S$	-40	-	150	°C	-	1.3
Maximum input pressure	$p_{amb\_max}$	-	-	500	kPa	-	1.4
				600	kPa	Limited time: Max. 300 s	
ESD robustness	$V_{ESD}$	-	-	4	kV	Pins: VDD, GND, $SENT_{OUT}$ , $NTC_{IN}$ (Human Body Model R= 1.5 kΩ, C= 100 pF)	1.5
				2	kV	Pins: NCS, CLK, SDI, SDO (Human Body Model R= 1.5 kΩ, C= 100 pF)	

**Attention:** Stresses above the max. values listed in [Table 14](#) may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

**Note:** The voltage on  $SENT_{OUT}$  must not exceed the voltage on the  $V_{DD}$  pin.

**Specification**

**2.4 Operating range**

The following operating conditions must not be exceeded in order to ensure correct operation of the device. All parameters specified in the following sections refer to these operating conditions, unless noted otherwise.

**Table 15 Operating range**

Parameter	Symbol	Values			Unit	Note	Number
		Min.	Typ.	Max.			
Supply voltage	$V_{DD}$	4.5	5.0	5.5	V	-	2.1
Supply voltage power up/power down gradient	$V_{grad}$	1E-5	-	1E4	V/ms	-	2.2
Input voltage for low level at pins NCS, CLK & SDI	$V_{low\_in}$	-3.0	-	0.8	V	-	2.3
Input voltage for high level at pins NCS, CLK & SDI	$V_{high\_in}$	2.0	-	3	V	-	2.4
Output voltage for low level at pin SDO	$V_{low\_out}$	-	-	0.4	V	Test current at pin SDO is 1.5 mA	2.5
Output voltage for high level at pin SDO	$V_{high\_out}$	$V_{DD} - 0.4$	-	$V_{DD}$	V	Test current at pin SDO is 1.5 mA	2.6
Operating temperature	$T_a$	-40	-	150	°C	-	2.7
Operating peak temperature	$T_{a\_peak}$	-	-	170	°C	Limited time: Max. 20 min.	2.8
Ambient operating pressure range	$p_{amb}$	10	-	400	kPa	-	2.9
Thermal resistance	$R_{thj-amb}$	-	167	-	K/W	Thermal resistance between the die and $T_{amb}$ (measured acc. JESD51-2)	2.10

**Attention:** *The KP27x is sensitive to light incident to the pressure port. The specification “Accuracy pressure” (see [Table 18](#)) is valid for an illuminance of less than 1 lx. At higher illuminance, a higher pressure error may occur.*

**Specification**

**2.5 Characteristics**

Product characteristics involve the spread of values specified within the operating range. Typical characteristics are the median of the production.

**Table 16 General characteristics**

Parameter	Symbol	Values			Unit	Note	Number
		Min.	Typ.	Max.			
Supply current into VDD <sup>4)</sup>	$I_{VDD}$	-	9	-	mA	No NTC and no SENT filter connected	3.1
		-	-	15	mA	NTC shorted to GND and SENT filter connected	
Internal pressure update rate	$f_{update}$	-	250	-	kHz	-	3.2
Pressure signal path latency <sup>5)</sup>	$t_{path\_pres}$	-	1	2	ms	-	3.3
Temperature signal path latency	$t_{path\_temp}$	-	153	580	ms	NTC update rate	3.4
Start-up time Pressure <sup>6)</sup>	$t_{start-up\_pres}$	-	10	-	ms	For pressure channel	3.5
Start-up time Temperature	$t_{start-up\_temp}$	-	10	-	ms	For temperature channel	3.6

**Table 17 Physical layer characteristics**

Parameter	Symbol	Values			Unit	Note	Number
		Min.	Typ.	Max.			
Low state voltage level on $SENT_{OUT}$	$V_{OL}$	-	-	0.5	V	0.52 mA DC load current	4.1
High state voltage level on $SENT_{OUT}$	$V_{OH}$	4.1	-	5.5	V	0.10 mA DC load current	4.2
Length of one tick	$t_{tick}$	-	3.0	-	$\mu$ s	-	4.3
Clock tick time variation	$tick_{var}$	-20	-	18	%	-	4.4
Nibble fall time	$t_{fall}$	-	-	6.5	$\mu$ s	From 3.8 V to 1.1 V	4.5
Nibble rise time	$t_{rise}$	-	-	18.0	$\mu$ s	From 1.1 V to 3.8 V	4.6
Jitter	$\Delta t_{fall}$	-	-	0.1	$\mu$ s	Edge to edge with static environment for any pulse period	4.7
Signal stabilization time	$t_{stable}$	6	-	-	$\mu$ s	Signal stabilization time below 1.39 V or above 3.8 V	4.8

<sup>4</sup> Supply current depends on NTC resistor: additional current of approximately 2 mA has to be considered with min  $R_{NTC}$  (40  $\Omega$ ) connected

<sup>5</sup> For more details see, [Definition of Pressure signal path latency](#)

<sup>6</sup> Time from power-up until SENT transmission start

**Specification**

**Table 18**      **Transfer function characteristics**

Parameter	Symbol	Values			Unit	Note	Number
		Min.	Typ.	Max.			
Sensitivity pressure	$S_p$	-	9.495	-	LSB/kPa	-	5.1
Offset pressure	$offs_p$	-	98.05	-	LSB	-	5.2
Sensitivity temperature	$S_T$	-	8.0	-	LSB/°C	-	5.3
Offset temperature	$offs_T$	-	585.2	-	LSB	-	5.4
Accuracy pressure	$acc_p$	-3.0 -5.2 -5.6	-	3.0 5.2 5.6	kPa	$T_a = 0^\circ\text{C} - 85^\circ\text{C}$ $T_a = -40^\circ\text{C} - 0^\circ\text{C}$ $T_a = 85^\circ\text{C} - 150^\circ\text{C}$	5.5
Resistance value of NTC	$R_{NTC}$	0.040	-	127 <sup>7)</sup>	kΩ	-	5.6

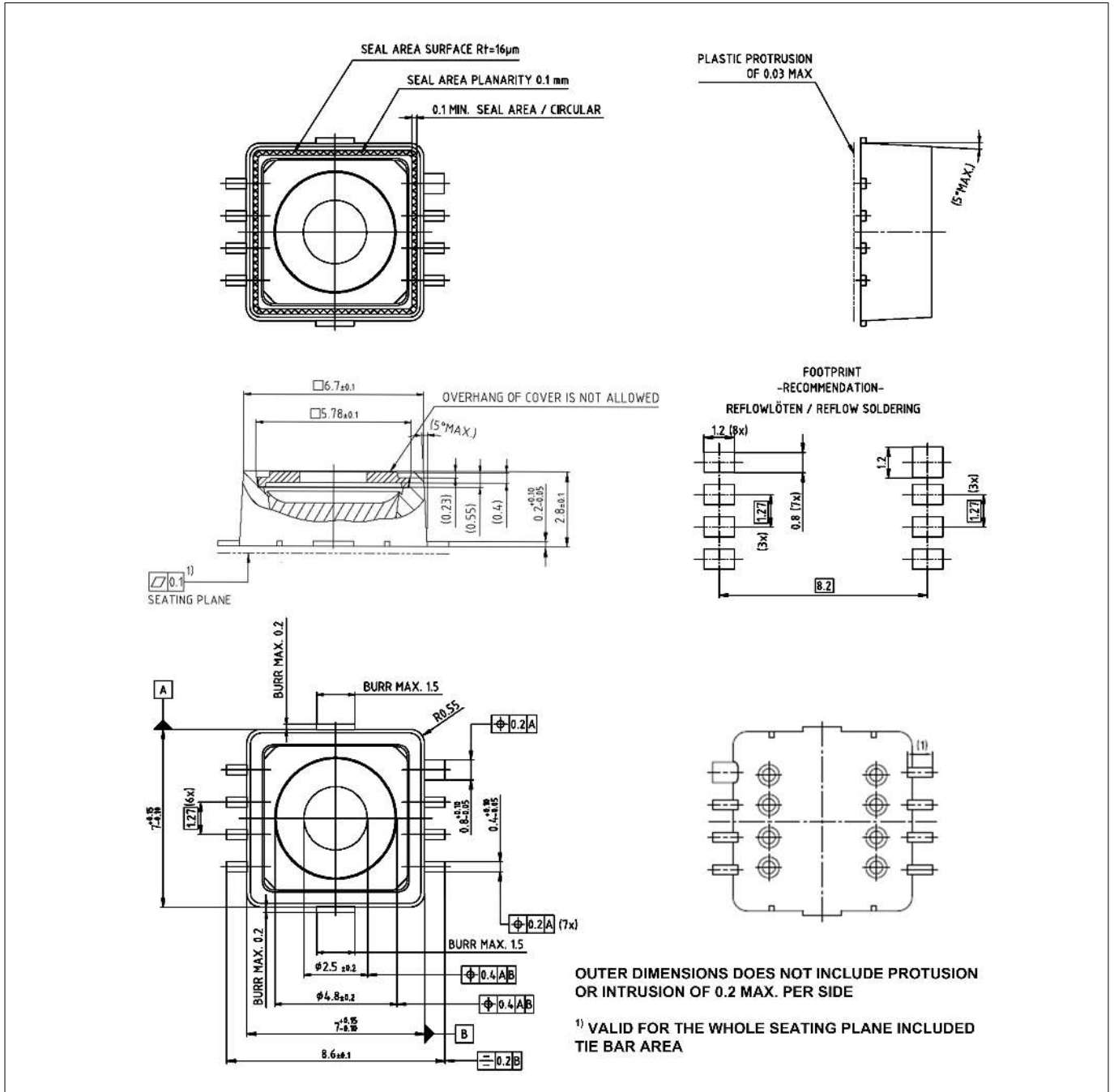
<sup>7</sup> Exceeding this value will not cause damage but the NTC accuracy (see [Figure 15](#)) is not specified. Turning back into the specified  $R_{NTC}$  range the sensor will be within specification again.

**Package information**

**3 Package information**

For passivation the sensor is covered with a transparent gel with gel thickness of 180 µm - 400 µm.

**3.1 PG-DSOF-8-162 Outline**



**Figure 18**

**Green Product (RoHS compliant)**

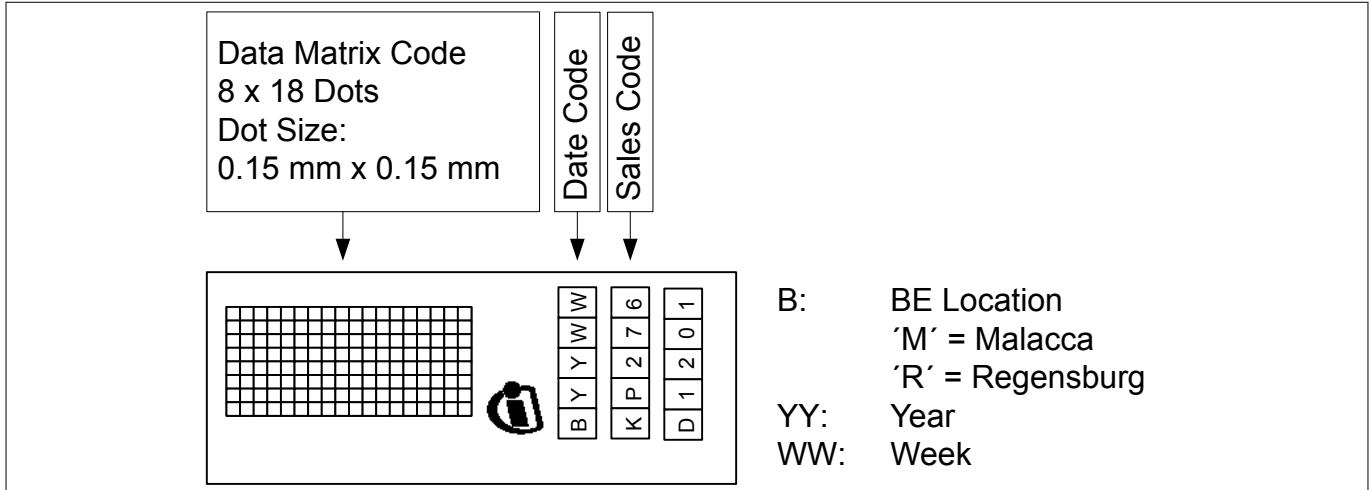
To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).



**Package information**

**3.2 Identification code**

The identification code is provided in a machine readable format. The date and sales code are provided in human readable format.



**Figure 19 Identification code**

The identification code for the KP276D1201 is on the same side of the package as pin 8 (GND).

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Revision history

## Revision history

Document version	Date of release	Description of changes
Revision 1.0	2020-04-15	-

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**Edition 2020-04-15**

**Published by  
Infineon Technologies AG  
81726 Munich, Germany**

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**Document reference  
IFX-fpd1575532135639**

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