Description

Scope

This document describes the function and electrical characteristics of the absolute pressure sensor SMD288 in the range of 50 to 115 kPa.

General information

The pressure sensor SMD288 serves to measure the atmospheric pressure in the range of 50 to 115 kPa in electronic control units.

Four piezo-resistors connected to a wheatstone bridge are located on a micromechanical silicon diaphragm, which is deflected by the applied pressure. The output voltage is proportional to the applied pressure. The signal is amplified and temperature compensated by an electronic circuit which is integrated on the silicon chip.

A reference vacuum is enclosed between the backside of the diaphragm and the silicon substrate. The active chip surface is protected by a gel-passivation and exposed to atmospheric pressure.

The pressure sensor SMD288 supplies an analog output signal, which is ratiometric to the supply voltage.

The sensor is assembled in a premold housing with standard SO footprint.

Application hints

An external RC low pass filter with e.g. τ = 2 ms may be added in order to reduce ripples on the supply line.

Failure diagnosis

The application of the pressure sensor SMD288 with external pull-up/pull down resistors at the sensor output permits the detection of open circuit V_{CC}, V_{OUT}, GND.
An output signal above the output upper limit or below the output lower limit indicates then an open circuit V_{CC}, V_{OUT}, GND.
Values for pull-up/pull-down resistors are defined in chapter “Operating conditions”.

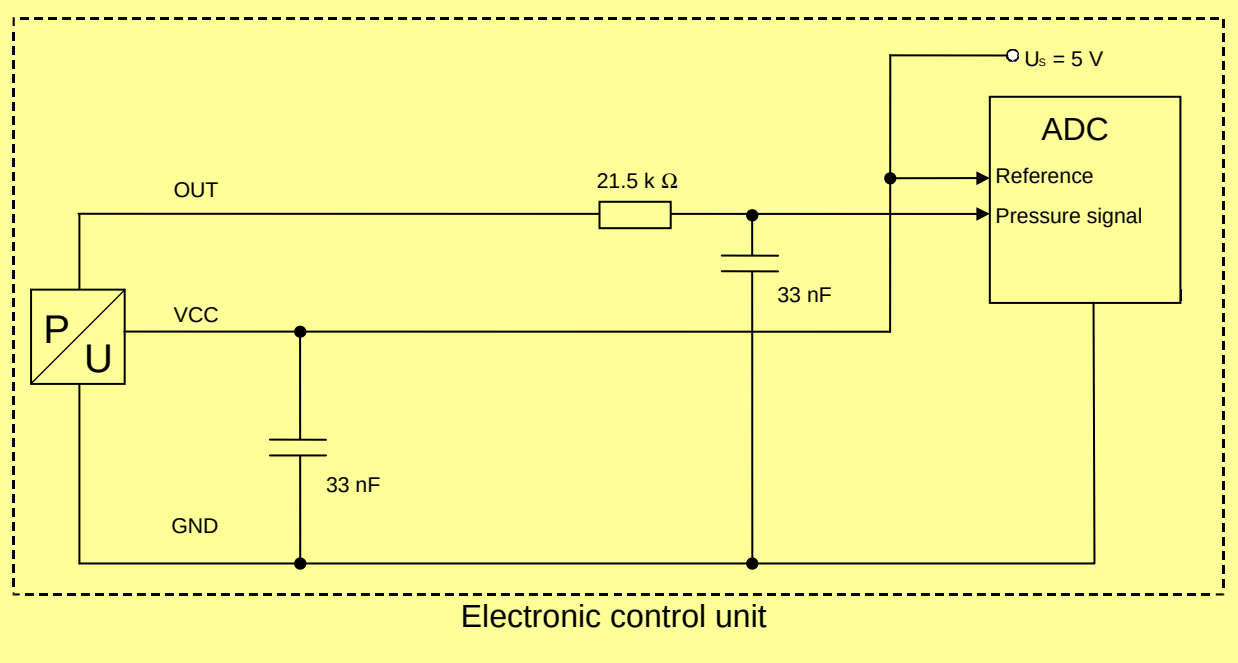

Figure 1. Typical application (without open circuit detection) for SMD288, V_{CC} = 5V.

Maximum ratings

Parameter	Symbol	Value			Unit
		min	typ	max	
Storage temperature	T	-40		125	°C
Burst pressure	p_{burst}	600			kPa

The output circuit is protected against short circuit to V_{CC} and GND (mode 1 and 2) and battery supply $U_{batt,max}$ = 16V (mode 3 and 4) for 5 min at room temperature.
The sensor is also protected against inverse-polarity up to a supply current of 300 mA for 5 min at room temperature (mode 5).

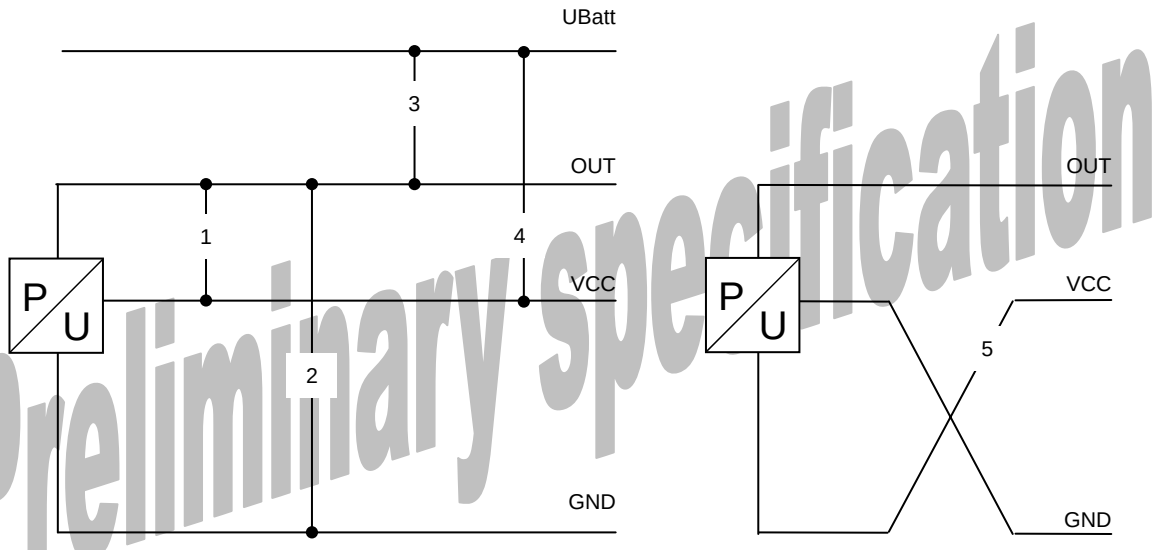

Figure 2. Modes of short circuit and inverse-polarity.

Operating conditions

V_{CC} = 5 V, GND = 0 V, T_A = -40 °C to +125 °C, if not otherwise declared.

Parameter	Symbol	Value			Unit
		min	typ	max	
Operating temperature	T_A	-40		125	°C
Absolute pressure	p_{abs}	50		115	kPa
Supply voltage [1]	V_{CC}	4.75	5.0	5.25	V
Supply current at V_{CC}=5V	I_{IN}			12.0	mA
Load resistance to V_{CC} or to GND	$R_{pull\text{-}up}$ $R_{pull\text{-}down}$	4.6 10.0			kΩ kΩ
Output - lower limit at V_{CC}=5V [2]	$V_{OUT,lo}$	0.25	0.3	0.35	V
Output - upper Limit at V_{CC}=5V [2]	$V_{OUT,hi}$	4.75	4.8	4.85	V
Internal differential resistance for V_{out}	R_I			50	Ω
Load resistance to V_{CC} or to GND for diagnosis	$R_{pull\text{-}up}$ $R_{pull\text{-}down}$	680 470			kΩ kΩ
Load capacitance to GND	C_L			60	nF
Output resistance to GND (V_{CC} open)	R_{lo}	4.5	6.4	8.2	kΩ
Output resistance to V_{CC} (GND open)	R_{hi}	4.5	6.4	8.2	kΩ
Response time [3]	$t_{10/90}$			1.0	ms
Ratiometricity [4]	4.75 – 5.25 V		0.003		
Inverse polarity protection	I_A			300	mA

Notes:

1) The output of the sensor is ratiometric to the supply voltage V_{CC} within its specified range.
2) Range above upper limit and below lower limit serves as diagnosis range
3) Response time is defined as the time for the change in the output from 10% to 90% signal height after a change in pressure.
4) Formula of ratiometricity: $| (Vout_1/5V) – (Vout_2/V_{CC,\,min}) |$ and $| (Vout_1/5V) – (Vout_2/V_{CC,\,max}) |$ at 25°C

Electrical characteristics

Transfer function

The device is fully calibrated on delivery and has a linear transfer function between the applied pressure and the output signal:

$$V_{OUT} = (c_1 \cdot p_{abs} + c_0) \cdot V_{CC}$$

where

V_{OUT} = signal output voltage in V
V_{CC} = supply voltage in V
p_{abs} = absolute pressure in kPa
c_0 = -0,095
c_1 = 0.009 kPa^{-1}

The output is ratiometric to the supply voltage.

Accuracy at delivery (target)

The accuracy target has to be verified by B-sample/C-sample validation.

	Minimum pressure	Maximum pressure	Accuracy over lifetime
SMD288	50 kPa	115 kPa	1,5 kPa

Figure 3. Accuracy of SMD288

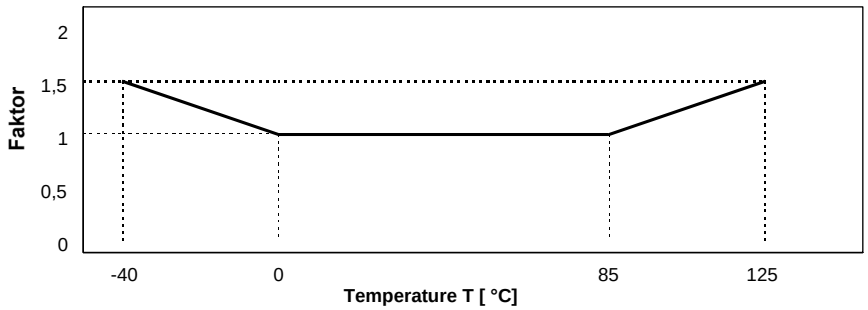

Figure 4. Temperature related accuracy widening factor

Testing and evaluation for product release

The device is tested according to the test flow in Figure 5. Details about the testing parameters are specified in the table below. Applications have to be compliant with ISO16750-3 Test II (gear box mounting).

For information only:

An additional vibration qualification with 3 x 39 parts will be performed. The test will be conducted at constant temperature (RT) according to the following specifications:

Sine:

Frequency: 20 Hz - 1500 Hz

Frequency sweep: 1 oct/min (logarithmic)

Amplitude:

Frequency [Hz]	Peak Amplitude of acc. [m/s²]
20 - 200	250
200 - 500	300
500 - 1500	250

Duration: 3 x 24 hours (24 hours per axis)

Random:

Frequency: 10Hz - 1500Hz

PSD: 0.5 g²/Hz (rectangular profile, 273 m/s² RMS)

Duration: 3 x 8 hours (8 hours per axis)

Measurements of the sensor resonance frequencies will be performed according to a test program, which is to be defined.

The additional vibration test will be integrated in the test flow analogous to REF. 624. In addition to the electrical testing (REF 1534) a final technological investigation will be conducted on 15 parts.

The additional vibration qualification will be integrated in the product specification in case that the test is passed successfully.

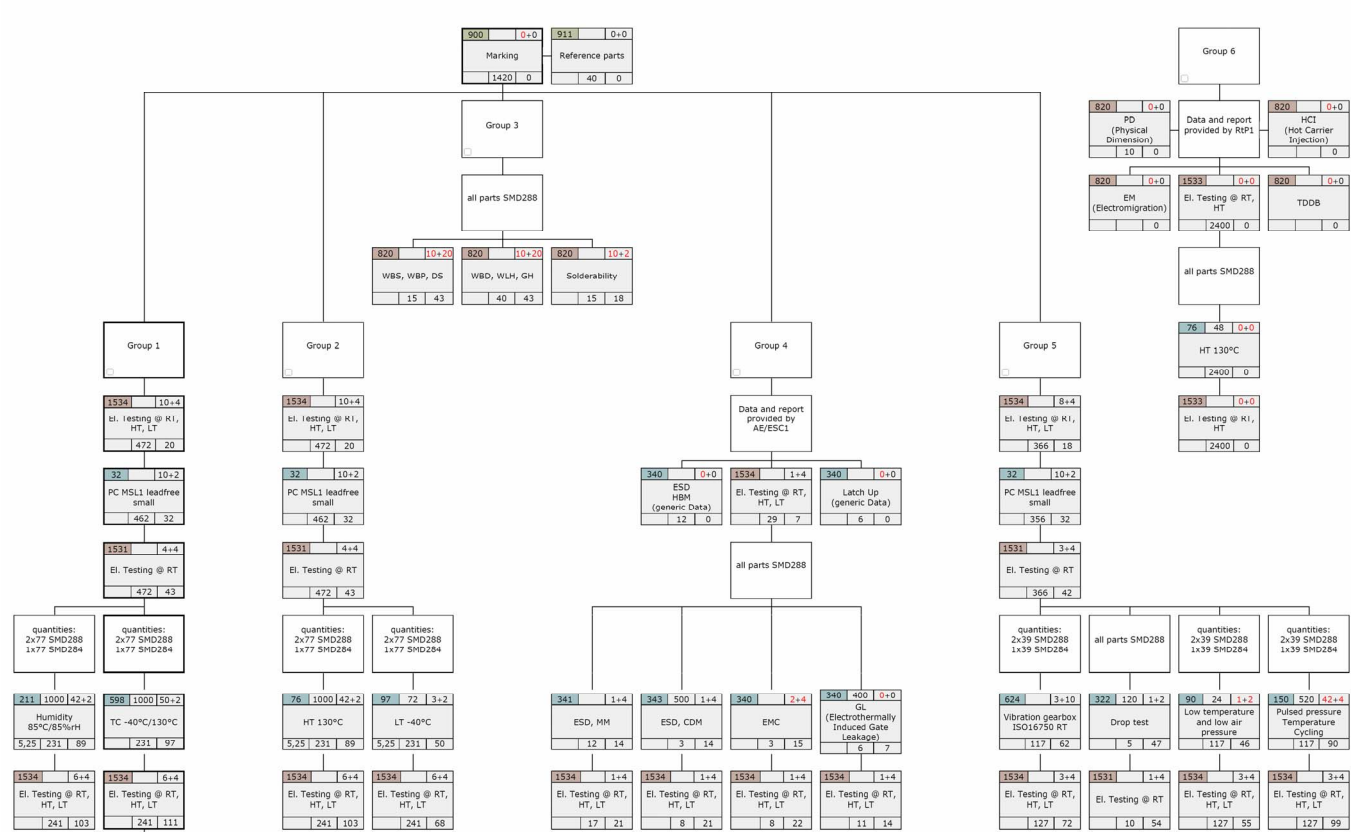

Figure 5. Test flow for SMD288 product release

Testparameters

REF	F1	F2
Short text		
F3	F4	F5

Field identification F1-F5	
F1	**See in list**
F2	**Duration [days]**
F3	**Operation mode in case of a stated number the (e.g. 5.25), the operation mode is power supplied @ 5.25 V**
F4	**No. of parts**
F5	**Not used**

REF	Testing parameters	Value F1	Field identification F1
32	Preconditioning MSL1, soldering simulation leadfree, class small devices		none
76	High temperature 130°C - Group 2: 1000h active@5,25V / Group 6: 48h passive	1000	duration [h]
90	Low temperature and low air pressure@-55°C/@85mbar	24	duration [h]
97	Low temperature -40°C	72	duration [h]
150	1000h Pulsed pressure Temperature Cycling@50/115kPa@-40/130°C, dwell time 15min, temperature ramp rate 2K, f=0,5Hz	520	cycles
211	Humidity 85°C/85%rH - 2x77BE SMD288@5,25V / 1x77BE SMD284@4,75V	1000	duration [h]
322	Drop test; +-x, +-y, +-z, 9 DUTs; 3 DUTs per axis, 2 Falls per DUT; Impact on concrete	120	height [cm]
340	GL (Electrothermally Induced Gate Leakage) - 4min@155°C@400V	400	Voltage [V]
340	Latch Up (generic data)		Voltage [V]
340	EMC Electromagnetic Compatibility		Voltage [V]
340	ESD HBM (generic data) @500/1000/1500/2000V (3 units per Voltage level)		Voltage [V]
341	ESD, MM (Machine model) - @50/100/150/200V, 3 units per voltage level		Voltage [V]
343	ESD, CDM (Charge device model)	500	Voltage [V]
598	Temperature cycles; -40°C/130°C; dwell time: 30 min; transition time: 10 sec	1000	cycles
624	vibration gearbox ISO16750 3x22h; 96,6m/s² at room temperature Sine: Frequency [Hz] / Amplitude of acc. [m/s²] 100 / 30 200 / 60 440 / 60		Tmax [°C]

<table>
<tr><td></td><td>Random:
<table><tr><th>Frequency [Hz]</th><th>PSD [(m/s²)²/Hz]</th></tr><tr><td>10</td><td>10</td></tr><tr><td>100</td><td>10</td></tr><tr><td>300</td><td>0,51</td></tr><tr><td>500</td><td>5</td></tr><tr><td>2000</td><td>5</td></tr></table></td><td></td><td></td></tr>
<tr><td>820</td><td>HCI (Hot Carrier Injection) - generic data from BCD3sM process</td><td></td><td>none</td></tr>
<tr><td>820</td><td>WBS (Wire Bond Shear), WBP (Wire Bond Pull), DS (Die Shear Strength)</td><td></td><td>none</td></tr>
<tr><td>820</td><td>WBP (Wire Bond Pull)</td><td></td><td>none</td></tr>
<tr><td>820</td><td>PD (Physical Dimension) - generic data (EMPB for PM8 LCP)</td><td></td><td>none</td></tr>
<tr><td>820</td><td>TDDB (Time Dependant Dielectric Breakdown) - generic data for BCD3sM process</td><td></td><td>none</td></tr>
<tr><td>820</td><td>EM (Electromigration) - generic data for BCD3sM process</td><td></td><td>none</td></tr>
<tr><td>820</td><td>Wire Ball Diameter (5BE), Wire Loop Height (5BE), Gel Height (30BE)</td><td></td><td>none</td></tr>
<tr><td>820</td><td>Solderability incl. aging</td><td></td><td>none</td></tr>
<tr><td>900</td><td>Marking
- 970BE SMD288 / ca. 450BE SMD284</td><td></td><td>none</td></tr>
<tr><td>911</td><td>Reference parts (without stress)
- 20 BE SMD288 / 20BE SMD284</td><td></td><td>none</td></tr>
<tr><td>1531</td><td>El. Testing @ RT; SMD</td><td></td><td>none</td></tr>
<tr><td>1533</td><td>El. Testing @ RT, HT; SMD
- HT Group 6: 85°C</td><td></td><td>none</td></tr>
<tr><td>1534</td><td>El. Testing @ RT, HT, LT; SMD</td><td></td><td>none</td></tr>
</table>

Handling instructions

Assembly

The maximum assembly force is 10 N.
For measurement of the atmospheric pressure a sufficient venting of the control unit is necessary. A passivation of the ECU board is only allowed if the pressure sensor is sufficiently protected during this coating step.

Soldering

The SMD288 may be soldered by a reflow process or by hand. Wave soldering is not permitted.