<table>
<thead>
<tr>
<th>Product Name:</th>
<th>TMAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number:</td>
<td>CPF00002</td>
</tr>
<tr>
<td>Drawing Number:</td>
<td>CPFJ0002</td>
</tr>
</tbody>
</table>
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1. GENERAL DATA

1.1. Description
This document outlines a production verification plan for the TMAP (Temperature + Manifold Absolute Pressure) sensor.
The TMAP sensor provides Intake manifold absolute pressure output and Intake manifold air temperature output. The intake manifold absolute pressure output is derived from a sensing element, while a NTC thermistor provides the intake manifold air temperature output.

1.2 Installation Guide
The following notes provide preliminary installation recommendations for the TMAP (Temperature + Manifold Absolute Pressure) sensor.

Mounting Orientation
The TMAP port must point down. Deviation of the sensor port from vertical should not exceed 30 degrees.

Mounting Location
The TMAP should be mounted on top of the manifold, away from fuel injectors, away from exhaust gas recirculation and away from points where condensation will collect.

Mounting Surface
The TMAP should mate to a nominally planar surface to avoid bending the sensor body upon fastening. Material for the mating surface should be sufficiently strong to retain fastener pre-load over the life of the product.

Fasteners
The inner diameter of the mounting through hole is nominally 6.6mm and is intended to accommodate an M6 fastener. Assuming an ISO5.8 fastener is used, the recommended tightening torque is 8Nm.

Temperature
The operating temperature range of the sensor is -40°C to 130°C

Clearances
Sufficient room should be provided in the neighboring space to all access to drive the fasteners during installation, and to engage the mating connector. Other than the mating manifold, neighboring system components should not be in contact with the sensor housing during operation.
### 1.3 Maximum ratings of pressure sensor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Values</th>
<th>Unit</th>
<th>Note / Test Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>$V_{DD _max}$</td>
<td>-0.3</td>
<td>–</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>–6.5</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Output voltage</td>
<td>$V_{OUT}$</td>
<td>–0.3</td>
<td>–</td>
<td>$V_{DD} + 0.3$</td>
</tr>
<tr>
<td>Voltage on CLOCK / $V_{PROG}$ pin</td>
<td>$V_{CLK}$</td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Voltage on DATA IN &amp; DATA_OUT pins</td>
<td>$V_{DATA}$</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_s$</td>
<td>–60</td>
<td>–</td>
<td>150</td>
</tr>
<tr>
<td>Thermal resistance</td>
<td>$R_{thJA}$</td>
<td></td>
<td></td>
<td>180</td>
</tr>
<tr>
<td>Maximum input pressure</td>
<td>$P_{amb _max}$</td>
<td>10</td>
<td>–</td>
<td>350</td>
</tr>
<tr>
<td>ESD robustness (HBM: 1.5 kΩ, 100 pF)</td>
<td>$V_{ESD}$</td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

1) Reverse polarity, $I_{DD} < 300$ mA

#### Table 1: Absolute maximum ratings

Attention: Stresses above the max. values listed in Table 1 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.

### 1.4 Operating characteristics of pressure sensor

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.
1.5 Transfer function of pressure sensor

The sensor has a linear transfer function between the applied pressure and the output signal:

\[ V_{\text{OUT}} = V_{\text{DD}} \times (a \times P + b) \]

The output signal is ratiometric. Gain \( a \) and offset \( b \) are determined during calibration in order to generate the required transfer function.

Calibrated Transfer Function

The following calibration is adjusted with the parameters \( a \) and \( b \):

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Values</th>
<th>Unit</th>
<th>Symbol</th>
<th>Values</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P_{\text{in},1} )</td>
<td>50</td>
<td>kPa</td>
<td>( V_{\text{OUT},1} )</td>
<td>0.50</td>
<td>V</td>
</tr>
<tr>
<td>( P_{\text{in},2} )</td>
<td>400</td>
<td>kPa</td>
<td>( V_{\text{OUT},2} )</td>
<td>4.50</td>
<td>V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a )</td>
<td>0.00229</td>
<td>1/kPa</td>
</tr>
<tr>
<td>( b )</td>
<td>-0.01429</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 3: Transfer Function
1.6 Accuracy of Pressure Sensor

The basic output tolerance is shown in Figure 2. The output tolerance includes error due to temperature, hysteresis, repeatability, linearity and life.

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Error [kPa]</th>
<th>Error Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40</td>
<td>±6.0</td>
<td>1.50</td>
</tr>
<tr>
<td>0</td>
<td>±4.0</td>
<td>1.00</td>
</tr>
<tr>
<td>100</td>
<td>±4.0</td>
<td>1.00</td>
</tr>
<tr>
<td>140</td>
<td>±5.0</td>
<td>1.50</td>
</tr>
</tbody>
</table>

Table 4: Accuracy
1.7 Maximum ratings of temperature sensor

Storage temperature: -40/130°C

Power rating at 25°C: 100 mW

1.8 Data of temperature sensor

Temperature range: -40 / 130°C

Rated voltage: Operation by series resistance >1 kΩ at 5V in the control unit, or by constant current ≤ 1 mA for measuring purposes

Nominal resistance at 25 °C: 2kΩ ± 5 %

Temperature response time $\tau_{63}$ in air. $v = 6$ m/s: ≤ 10 s in new condition; in case of contamination by soot and oil deposit it may raise to 25 s.

<table>
<thead>
<tr>
<th>Temperature(°C)</th>
<th>Resistance in R(Ω)</th>
<th>Temperature(°C)</th>
<th>Resistance in R(Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40</td>
<td>44060</td>
<td>50</td>
<td>811</td>
</tr>
<tr>
<td>-35</td>
<td>33332</td>
<td>55</td>
<td>683</td>
</tr>
<tr>
<td>-30</td>
<td>25392</td>
<td>60</td>
<td>579</td>
</tr>
<tr>
<td>-25</td>
<td>19450</td>
<td>65</td>
<td>494</td>
</tr>
<tr>
<td>-20</td>
<td>15034</td>
<td>70</td>
<td>424</td>
</tr>
<tr>
<td>-15</td>
<td>11671</td>
<td>75</td>
<td>364</td>
</tr>
<tr>
<td>-10</td>
<td>9137</td>
<td>80</td>
<td>314</td>
</tr>
<tr>
<td>-5</td>
<td>7210</td>
<td>85</td>
<td>272</td>
</tr>
<tr>
<td>0</td>
<td>5733</td>
<td>90</td>
<td>236</td>
</tr>
<tr>
<td>5</td>
<td>4581</td>
<td>95</td>
<td>207</td>
</tr>
<tr>
<td>10</td>
<td>3688</td>
<td>100</td>
<td>181</td>
</tr>
<tr>
<td>15</td>
<td>2984</td>
<td>105</td>
<td>159</td>
</tr>
<tr>
<td>20</td>
<td>2431</td>
<td>110</td>
<td>140</td>
</tr>
<tr>
<td>25</td>
<td>2000</td>
<td>115</td>
<td>125</td>
</tr>
<tr>
<td>30</td>
<td>1660</td>
<td>120</td>
<td>112</td>
</tr>
<tr>
<td>35</td>
<td>1373</td>
<td>125</td>
<td>100</td>
</tr>
<tr>
<td>40</td>
<td>1142</td>
<td>130</td>
<td>91</td>
</tr>
<tr>
<td>45</td>
<td>960</td>
<td>135</td>
<td>82</td>
</tr>
</tbody>
</table>

*Table 5: Temperature Output*
2 TEST DATA AND TEST METHODS

2.1 Functional requirements of Pressure Sensor

Procedure
1. Each DUT shall be tested in normal mounting position with wiring harness connected.
2. Perform steps a. through c. for the following sequence of temperatures: 25, -40, -130, and 25°C.
   a. Stabilize the sensor at the test temperature.
   b. Measure the pressure sensor output at 8 pressures: 50, 100, 150, 200, 250, 300, 350 and 400KPa A.
   c. Determine the thermistor resistance.

3. TESTS

3.1 General Remarks

For critical requirements the conditions have to be investigated by vehicle measurements. The product functionality in the complete system must be evaluated by the customer through appropriate vehicle tests under realistic operational conditions.
New parts must be used for each test.

3.2 Electromagnetic compatibility of Pressure Sensor

3.2.1 Electrical stability
(a) Supply voltage Ripple: alternating voltage 4.5 to 5.5V; 1kHz to 20kHz; sweep time 2min.
(b) Short circuit protection: short circuit with 5V for 5min; current limited to 0.3A.
(c) Reverse polarity: 6.5V for 5min; current limited to 0.3A.
(d) Over voltage protection: 16.5V for 60min@70°C; current limited to 0.3A.
(e) Insulation resistance: 500V DC for 60sec; Insulation > 10MOhm.
(f) High voltage flash test: 500V AC 130°C for 2sec.
(g) Resistance to feeding over voltage: 35V DC, 10min at RT (1bar).

3.2.2 EMC Test
(a) Radiation in accordance with ISO11452-2, antenna radiation on test specimen.
1. Output signal is measured using an optical signal transmission.
2. Effective field strength in the frequency range 400 to 2000 MHz: 100V/m.
3. Maximum deviation of output signal by the interference pick-up: ± 0.150 V.
(b) Bulk current injection (BCI) in accordance with ISO11452-4.
1. Bulk current injection on cable harness (closed loop, Common-Mode BCI). All wires of the DUT wiring harness shall be routed inside of the injection probe. Use only 450 mm and 750 mm injection probe positions when performing CBCI.
2. Effective current in the frequency range 1 to 400 MHz: 100mA.
3. Use wiring harness length of 1700 +300/-0 mm
4. The DUT shall be placed on an insulated support such that the closest part of the DUT’s circuit board is positioned 50 ± 5 mm above the ground plane during the bench test. The injection probe shall be insulated from the ground plane.
5. All modulation dwell times (i.e. time that RF is applied for per modulation type) shall be at least 2 s.
6. Output signal is measured using an optical signal transmission. Maximum deviation of output signal by the interference pick-up: ± 0.150 V.
(c) Pulses in accordance with ISO7637-3.
1. Pulses of +60V // -40V; Duration: 10min each (Direct Capacitive Coupling Method)
2. Only test pulses 3a and 3b are applied to Sensor Output and Supply line by line.
3. Maximum deviation of output voltage by pulse test after 0.5 ms: ± 0.150 V.

3.2.3 Electrostatic discharge in accordance with ISO TR 10605, level 4, class A.
1. 10 single discharges via 330 pF and 2 kΩ in each case.
Time duration between successive single discharges: 5 s.
2. Contact discharge to open pins: ± 8 kV.
Air discharge to housing surface: ± 15 kV.
3. Performed powered and unpowered.
4. After contact discharge and after air discharge the function must not be affected beyond normal tolerance.

3.3 Environmental Tests
3.3.1 Low Temperature Operation
Expose the sensor to -40 °C for 100h. The sensor powered on during the test.

3.3.2 High Temperature Operation
Expose the sensor to 130 °C for 100h. The sensor powered on during the test.

3.3.3 Temperature Cycle Test
Expose the sensor to the temperature profile below. Number of cycles is 30.

![Temperature Cycle Graph](image)

*Figure 4: Temperature cycle*
3.3.4 Thermal Shock Test

The sensor will be subjected to fast temperature changes with the following characteristics.

- **High temperature**: 130°C
- **Dwell time at high temperature**: 30 min
- **Low temperature**: -40°C
- **Dwell time at low temperature**: 30 min
- **Transition time**: less than 10 sec
- **Number of cycles**: 500

3.3.5 Engine Clean

The sensor will be subjected to a spray of water at elevated temperature while mounted on to a fixture with the same M6 fixing screw and clip as used in the application. Pressure ports will be closed with U-shaped tube.

- **Test procedure**: acc to DIN 40 050 -9
- **Surface protection type**: IPX9K
- **Number of cycles**: 30
- **Pressure**: approx. 80bar

Prior to each cycle cold-cleaning agent shall be applied to the sensor and left on it for approx. 30 min.

3.3.6 Humidity Heat Cyclic

The sensor will be subjected to a humidity cycle as stated in DIN EN 60068-2-30

- **Maximum temperature**: +55°C
- **Number of cycles**: 6

![Figure 5: Temperature cycle](image)
3.3.7 Salt Spray Fog
Test specimens mounted on carrier as in the vehicle. Close off the pressure port. Fit the connector to standard electrical interface.
No electrical operation. Salt spray test at 35°C: 144h in accordance with DIN 50021 - SS
Test solution: 5% saline solution with a pH value of 6.5~7.2.

3.3.8 Immersion Test
The sensors are powered mode with pressure port plugged. (1) The sensors are soaked at 130°C for 1 hour; (2) The sensors are then immersed in cold salt (5% salt by weight) water for 30 minutes; (3) The sensors are finally removed and dried with compressed air for 2 minutes.

3.3.9 Resistance to Chemical Agents
The sensor will be wiped with a cotton cloth, soaked with 50ml of the respective agent. Subsequent aging 48h and storage temperate: see table in below

<table>
<thead>
<tr>
<th>Media resistance</th>
<th>Sensor is not electrically operated with closed port. Application: with (30 x 30) cm cotton cloth, soaked with 50 ml of the respective chemical agent. Subsequent aging: 48 h (temperature as specified for each agent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Diesel fuel (acc. to DIN EN 590)</td>
<td>130°C</td>
</tr>
<tr>
<td>b) FAM-B test fuel fluid (acc. to DIN 51604 B)</td>
<td>Room Temperature</td>
</tr>
<tr>
<td>c) Battery acid (37 % sulphuric acid or KOH)</td>
<td>130°C</td>
</tr>
<tr>
<td>d) Brake fluid (DOT 4)</td>
<td>130°C</td>
</tr>
<tr>
<td>e) Coolant additive (TL 774)</td>
<td>130°C</td>
</tr>
<tr>
<td>f) Sealant</td>
<td>130°C</td>
</tr>
<tr>
<td>g) Sealant remover</td>
<td>130°C</td>
</tr>
<tr>
<td>h) Engine oil</td>
<td>130°C</td>
</tr>
<tr>
<td>i) Cold-cleaning agent</td>
<td>130°C</td>
</tr>
<tr>
<td>j) Methylated spirit</td>
<td>Room Temperature</td>
</tr>
<tr>
<td>k) Transmission fluid</td>
<td>130°C</td>
</tr>
<tr>
<td>l) ATF</td>
<td>130°C</td>
</tr>
<tr>
<td>m) Interior cleaner</td>
<td>130°C</td>
</tr>
</tbody>
</table>
### 3.4 Mechanical Test

#### 3.4.1 Vibration Test

Electrical operation at standard electrical interface. Sensor mounted on shaker. Process with provided plug and the defined wiring harness which will be attached 15cm from the sensor.

Sinus vibration, broad band noise and temperature cycling interfere according to Figure 5, Figure 6 and Figure 7. All three profiles are applied simultaneously to the sensors.

Duration of stressing per principle axis: 24 h. Total duration in 3 axis: 72 h

(a) Sinus vibration, rate of frequency change: 1 octave/min; logarithmic
- Amplitude of deflection from 100 Hz : 100m/s^2
- Amplitude of deflection from 200 Hz : 280m/s^2
- Amplitude of deflection from 250 Hz : 250m/s^2
- Amplitude of deflection from 300 Hz : 160m/s^2
- Amplitude of deflection from 500 Hz : 160m/s^2

(b) Broad band noise profile, the r.m.s. acceleration value shall be 181 m/s^2.
- Acceleration density at 10 Hz : 10.00 (m/s^2)^2Hz
- Acceleration density at 100 Hz : 10.00 (m/s^2)^2Hz
- Acceleration density at 300 Hz : 0.51 (m/s^2)^2Hz
- Acceleration density at 500 Hz : 20.00 (m/s^2)^2Hz
- Acceleration density at 2000 Hz : 20.00 (m/s^2)^2Hz

(c) Temperature cycling

<table>
<thead>
<tr>
<th>Chemical agent</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>M15 (Gasoline with 15% methanol)</td>
<td>130°C</td>
</tr>
<tr>
<td>Diesel fuel (PME)</td>
<td>130°C</td>
</tr>
<tr>
<td>Central hydraulic system fluid (TL 52146)</td>
<td>130°C</td>
</tr>
<tr>
<td>Window cleaner</td>
<td>Room Temperature</td>
</tr>
<tr>
<td>Biodiesel (FAME) (acc. to DIN EN 14214)</td>
<td>130°C</td>
</tr>
<tr>
<td>Refreshment containing caffeine and sugar (Cola)</td>
<td>130°C</td>
</tr>
<tr>
<td>E85 fuel (acc. to VW 2.8.1)</td>
<td>Room Temperature</td>
</tr>
</tbody>
</table>

Table 6: Chemical agent list
- Ramp to -40°C within 60min
- Dwell time at -40°C 90min
- Ramp to 20°C within 60min
- Ramp to 130°C within 90min
- Dwell time at 130°C 110min
- Ramp to 20°C within 70min

Figure 5: Sinusoidal vibration profile
3.4.2 Mechanical Shock
(a) Acceleration: 245 m/s²; Nominal shock duration: 15ms; Nominal shock shape: Half sine; Number of shock per axis (+/-): 500; Shocks altogether 3000.
(b) Acceleration: 981 m/s²; Nominal shock duration: 11ms; Nominal shock shape: Half sine; Number of shock per axis (+/-): 3; Shocks altogether 18.

3.4.3 Drop Test
The sensor will be dropped on to a : Concrete floor
Drop height : 1m
Number of orientations : 6
Number of orientations per sensor : 2 (+x,-x), (+y,-y), (+z,-z)