BMP085 Data sheet

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order code</td>
<td>0 273 300 144</td>
</tr>
<tr>
<td>Package type</td>
<td>LCC8</td>
</tr>
<tr>
<td>Data sheet revision</td>
<td>1.0</td>
</tr>
<tr>
<td>Release date</td>
<td>01 July 2008</td>
</tr>
<tr>
<td>Document number</td>
<td>BST-BMP085-DS000-03</td>
</tr>
</tbody>
</table>

**Notes**
The BMP085 digital pressure sensor is functionally compatible to the existing Bosch Sensortec SMD500 digital pressure sensor. Product photos and pictures are for illustration purposes only and may differ from the real product's appearance. Specifications are subject to change without notice.
BMP085 Digital pressure sensor

Key features
Pressure range: 300 ... 1100hPa (+9000m ... -500m above sea level)
Supply voltage: 1.8 ... 3.6V ($V_{DDA}$)
1.62V ... 3.6V ($V_{DDD}$)
LCC8 package: Robust, ceramic lead-less chip carrier (LCC) package
Small footprint: 5.0mm x 5.0mm
Super-flat: 1.2mm height
Low power: 5µA at 1 sample / sec. in standard mode
Low noise: 0.06hPa (0.5m) in ultra low power mode
0.03hPa (0.25m) ultra high resolution mode
< 0.1m possible with software averaging algorithm
- Temperature measurement included
- I²C interface
- Fully calibrated
- Pb-free, halogen-free and RoHS compliant,
- MSL 1

New features comparison

<table>
<thead>
<tr>
<th>feature</th>
<th>BMP085</th>
<th>SMD500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smaller package height</td>
<td>1.2mm</td>
<td>1.55mm</td>
</tr>
<tr>
<td>Faster conversion time (standard mode each)</td>
<td>7.5ms (max.)</td>
<td>34ms</td>
</tr>
<tr>
<td>Faster I²C data transfer</td>
<td>max. 3.4MHz</td>
<td>max. 400kHz</td>
</tr>
<tr>
<td>Extended min. supply voltage</td>
<td>min. 1.8V</td>
<td>min. 2.2V</td>
</tr>
<tr>
<td>Lower stand-by current (typ.)</td>
<td>0.1µA</td>
<td>0.7µA</td>
</tr>
<tr>
<td>External clock</td>
<td>not necessary</td>
<td>necessary</td>
</tr>
</tbody>
</table>

Typical applications
- Enhancement of GPS navigation (dead-reckoning, slope detection, etc.)
- In- and out-door navigation
- Leisure and sports
- Weather forecast
- Vertical velocity indication (rise/sink speed)
BMB085 general description

The BMP085 is the fully pin- and function compatible successor of the SMD500, a new generation of high precision digital pressure sensors for consumer applications. The universal C-code SMD500/BMP085 ("BMP085_SMD500_API") is fully upward compatible to SMD500 and recognizes automatically the device ID. Customers already working with the SMD500 pressure sensor are invited to contact Bosch Sensortec as soon as they intend to switch-over to the BMP085 sensor for getting first-hand support.

The ultra-low power, low voltage electronics of the BMP085 is optimized for use in mobile phones, PDAs, GPS navigation devices and outdoor equipment. With a low altitude noise of merely 0.25m at fast conversion time, the BMP085 offers superior performance. The I2C interface allows for easy system integration with a microcontroller.

The BMP085 is based on piezo-resistive technology for EMC robustness, high accuracy and linearity as well as long term stability.

Robert Bosch is the world market leader for pressure sensors in automotive applications. Based on the experience of over 150 million pressure sensors in the field, the BMP085 continues a new generation of micro-machined pressure sensors.
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1 Electrical characteristics

If not stated otherwise, the given values are maximum values over temperature/voltage range in the given operation mode.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>$T_A$</td>
<td>operational</td>
<td>-40</td>
<td>+85</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>full accuracy</td>
<td>0</td>
<td>+65</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>$V_{DD}$</td>
<td>ripple max. 50mVpp</td>
<td>1.8</td>
<td>2.5</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$V_{DDIO}$</td>
<td></td>
<td>1.62</td>
<td>2.5</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Supply current</td>
<td>$I_{DDLOW}$</td>
<td>ultra low power mode</td>
<td>3</td>
<td></td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>@ 1 sample / sec. 25°C</td>
<td>$I_{DDSTD}$</td>
<td>standard mode</td>
<td>5</td>
<td></td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_{DDHR}$</td>
<td>high resolution mode</td>
<td>7</td>
<td></td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_{DDUHR}$</td>
<td>ultra high res. mode</td>
<td>12</td>
<td></td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>Peak current</td>
<td>$I_{peak}$</td>
<td>during conversion</td>
<td>650</td>
<td>1000</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>Standby current</td>
<td>$I_{DDSBM}$</td>
<td>at 25°C</td>
<td>0.1</td>
<td></td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>Serial data clock</td>
<td>$f_{SCL}$</td>
<td></td>
<td>3.4</td>
<td></td>
<td>MHz</td>
<td></td>
</tr>
<tr>
<td>Conversion time temperature</td>
<td>$t_{c_temp}$</td>
<td>standard mode</td>
<td>3</td>
<td>4.5</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>Conversion time pressure</td>
<td>$t_{c_p_low}$</td>
<td>ultra low power mode</td>
<td>3</td>
<td>4.5</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$t_{c_p_std}$</td>
<td>standard mode</td>
<td>5</td>
<td>7.5</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$t_{c_p_hr}$</td>
<td>high resolution mode</td>
<td>9</td>
<td>13.5</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$t_{c_p_luhr}$</td>
<td>ultra high res. mode</td>
<td>17</td>
<td>25.5</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>Absolute accuracy pressure</td>
<td>700 . . . 1100 hPa</td>
<td>0 . . . +65 °C</td>
<td>-2.5</td>
<td>1.0</td>
<td>2.5</td>
<td>hPa</td>
</tr>
<tr>
<td>$V_{DD} = 3.3V$</td>
<td>300 . . . 700 hPa</td>
<td>0 . . . +65 °C</td>
<td>-3.0</td>
<td>1.0</td>
<td>3.0</td>
<td>hPa</td>
</tr>
<tr>
<td></td>
<td>300 . . . 1100 hPa</td>
<td>-20 . . . 0 °C</td>
<td>-4.0</td>
<td>1.5</td>
<td>4.0</td>
<td>hPa</td>
</tr>
<tr>
<td>Resolution of output data</td>
<td>pressure</td>
<td></td>
<td>0.01</td>
<td></td>
<td>hPa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>temperature</td>
<td></td>
<td>0.1</td>
<td></td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Relative accuracy pressure</td>
<td>700 . . . 1100 hPa</td>
<td>@ 25 °C</td>
<td>±0.2</td>
<td></td>
<td>hPa</td>
<td></td>
</tr>
<tr>
<td>$V_{DD} = 3.3V$</td>
<td>0 . . . 65 °C @ p const.</td>
<td></td>
<td>±0.5</td>
<td></td>
<td>hPa</td>
<td></td>
</tr>
<tr>
<td>Noise in pressure</td>
<td>see table on page 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute accuracy temperature</td>
<td>@ 25 °C</td>
<td></td>
<td>-1.5</td>
<td>±0.5</td>
<td>1.5</td>
<td>°C</td>
</tr>
<tr>
<td>$V_{DD} = 3.3V$</td>
<td>0 . . . +65 °C</td>
<td></td>
<td>-2.0</td>
<td>±1.0</td>
<td>2.0</td>
<td>°C</td>
</tr>
</tbody>
</table>
### 2 Absolute maximum ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Min</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage temperature</td>
<td></td>
<td>-40</td>
<td>+85</td>
<td>°C</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>all pins</td>
<td>-0.3</td>
<td>+4.25</td>
<td>V</td>
</tr>
<tr>
<td>ESD rating</td>
<td>HBM, R = 1.5 kΩ, C = 100 pF</td>
<td>±2</td>
<td></td>
<td>kV</td>
</tr>
<tr>
<td>Overpressure</td>
<td></td>
<td>10,000</td>
<td></td>
<td>hPa</td>
</tr>
</tbody>
</table>

The BMP085 has to be handled as Electrostatic Sensitive Device (ESD).
3 Operation

3.1 General description
The BMP085 is designed to be connected directly to a microcontroller of a mobile device via the I²C bus. The pressure and temperature data has to be compensated by the calibration data of the E²PROM of the BMP085.

3.2 General function and application schematics
The BMP085 consists of a piezo-resistive sensor, an analog to digital convertor and a control unit with E²PROM and a serial I²C interface. The BMP085 delivers the uncompensated value of pressure and temperature. The E²PROM has stored 176 bit of individual calibration data. This is used to compensate offset, temperature dependence and other parameters of the sensor.

- UP = pressure data (16 to 19 bit)
- UT = temperature data (16 bit)
Typical application circuit:

Note:
(1) Pull-up resistors for $\text{i}^2\text{C}$ bus, $R_p = 2.2\,\Omega \ldots 10\,\Omega$, typ. $4.7\,\Omega$

Note:
The BMP085 can be supplied independently with different levels of $V_{\text{DDA}}$ and $V_{\text{DDD}}$, which is not possible with the SMD500. In case of different voltage levels, $V_{\text{DDA}}$ and $V_{\text{DDD}}$ shall have a 100nF decoupling capacitor each.
3.3 Measurement of pressure and temperature

For all calculations presented here an ANSI C code is available from Bosch Sensortec ("BMP085_SMD500_API").

The microcontroller sends a start sequence to start a pressure or temperature measurement. After converting time, the result value (UP or UT, respectively) can be read via the I^2C interface. For calculating temperature in °C and pressure in hPa, the calibration data has to be used. These constants can be read out from the BMP085 E²PROM via the I^2C interface at software initialization.

The sampling rate can be increased up to 128 samples per second (standard mode) for dynamic measurement. In this case, it is sufficient to measure the temperature only once per second and to use this value for all pressure measurements during the same period.

By using different modes the optimum compromise between power consumption, speed and resolution can be selected, see below table.

Overview of BMP085 modes, selected by driver software via the variable `oversampling_setting`:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Parameter</th>
<th>Internal number of samples</th>
<th>Conversion time pressure max. [ms]</th>
<th>Avg. current @ 1 sample/s typ. [µA]</th>
<th>RMS noise typ. [hPa]</th>
<th>RMS noise typ. [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ultra low power</td>
<td>0</td>
<td>1</td>
<td>4.5</td>
<td>3</td>
<td>0.06</td>
<td>0.5</td>
</tr>
<tr>
<td>standard</td>
<td>1</td>
<td>2</td>
<td>7.5</td>
<td>5</td>
<td>0.05</td>
<td>0.4</td>
</tr>
<tr>
<td>high resolution</td>
<td>2</td>
<td>4</td>
<td>13.5</td>
<td>7</td>
<td>0.04</td>
<td>0.3</td>
</tr>
<tr>
<td>ultra high resolution</td>
<td>3</td>
<td>8</td>
<td>25.5</td>
<td>12</td>
<td>0.03</td>
<td>0.25</td>
</tr>
</tbody>
</table>

All modes can be performed at higher speeds, e.g. up to 128 times per second for standard mode, with the current consumption increasing proportionally to the sample rate. This way the noise can be decreased further by software averaging.
3.4 Calibration coefficients

The 176 bit E²PROM is partitioned in 11 words of 16 bit each. These contain 11 calibration coefficients. Every sensor module has individual coefficients. Before the first calculation of temperature and pressure, the master reads out the E²PROM data. The data communication can be checked by checking that none of the words has the value 0 or 0xFFFF.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>BMP085 reg adr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MSB</td>
</tr>
<tr>
<td>AC1</td>
<td>0xAA</td>
</tr>
<tr>
<td>AC2</td>
<td>0xAC</td>
</tr>
<tr>
<td>AC3</td>
<td>0xAE</td>
</tr>
<tr>
<td>AC4</td>
<td>0xB0</td>
</tr>
<tr>
<td>AC5</td>
<td>0xB2</td>
</tr>
<tr>
<td>AC6</td>
<td>0xB4</td>
</tr>
<tr>
<td>B1</td>
<td>0xB6</td>
</tr>
<tr>
<td>B2</td>
<td>0xB8</td>
</tr>
<tr>
<td>MB</td>
<td>0xBA</td>
</tr>
<tr>
<td>MC</td>
<td>0xBC</td>
</tr>
<tr>
<td>MD</td>
<td>0xBE</td>
</tr>
</tbody>
</table>

3.5 Calculating pressure and temperature

The mode (ultra low power, standard, high, ultra high resolution) can be selected by the variable oversampling_setting (0, 1, 2, 3) in the C code.

The universal code SMD500/BMP085 is fully upward compatible to SMD500 and recognizes automatically the device ID. Thus, the SMD500 can be replaced "on the fly" by the BMP085 without changing hardware or software.

Calculation of true temperature and pressure in steps of 1Pa (= 0.01hPa = 0.01mbar) and temperature in steps of 0.1°C.
The following figure shows the detailed algorithm for pressure and temperature measurement. The algorithm is available as C source code ("BMP085_SMD500_API") from Bosch Sensortec.

**Calculation of pressure and temperature for BMP085**

- **Read calibration data from the E2PROM of the BMP085**
  - read out E2PROM registers, 16 bit, MSB first
  - AC1 (0xAA, 0xAB) (16 bit)
  - AC2 (0xAC, 0xAD) (16 bit)
  - AC3 (0xAE, 0xAF) (16 bit)
  - AC4 (0xB0, 0xB1) (16 bit)
  - AC5 (0xB2, 0xB3) (16 bit)
  - AC6 (0xB4, 0xB5) (16 bit)
  - B1 (0xB6, 0xB7) (16 bit)
  - B2 (0xB8, 0xB9) (16 bit)
  - MB (0xBa, 0xBB) (16 bit)
  - MC (0xBC, 0xBD) (16 bit)
  - MD (0xBE, 0xBF) (16 bit)

- **Calculate true temperature**
  - X1 = (UT - AC6) * AC5 / 215
  - X1 = 4743 long
  - X2 = MC * 211 / (X1 + MD)
  - X2 = -2344 long
  - B5 = X1 + X2
  - B5 = 2399 long
  - T = (B5 + 8) / 2
  - T = 150 temp in 0.1°C

- **Calculate true pressure**
  - B6 = B5 - 4000
  - X1 = (B2 * (B6 * B6 / 212)) / 211
  - X2 = AC2 * B6 / 211
  - X3 = X1 + X2
  - B3 = ((AC1*4+X3) << oss + 2) / 4
  - X1 = AC3 * B6 / 216
  - X2 = (B1 * (B6 * B6 / 212)) / 216
  - X3 = (((X1 + X2) ^ 2) / 2)
  - B4 = AC4 * (unsigned long)(X3 + 32768) / 215
  - B7 = (unsigned long)UP - B3) * (50000 >> oss)
  - if (B7 < 0x80000000) { p = (B7 * 2) / B4 }
  - else { p = (B7 / B4) * 2 }
  - X1 = (p / 2) ^ (p / 2)
  - X2 = (-7357 * p) / 216
  - p = p + (X1 + X2 + 3791) / 2
- **Display temperature and pressure value**

- **Example:**
  - C code function: bmp085_get_cal_param
  - type: short
  - AC1 = 408
  - AC2 = -72
  - AC3 = -14383
  - AC4 = 32741
  - AC5 = 32757
  - AC6 = 23153
  - B1 = 6190
  - B2 = 4
  - B3 = -32767
  - MC = -8711
  - MD = 2868

- **Calculate true pressure**
  - B6 = -1601
  - X1 = 1
  - X2 = 56
  - X3 = 57
  - B3 = 422
  - X1 = 2810
  - X2 = 59
  - X3 = 717
  - B4 = 33457
  - B7 = 1171050000
  - if (B7 < 0x80000000) { p = (B7 * 2) / B4 }
  - else { p = (B7 / B4) * 2 }
  - X1 = 74774
  - X2 = -7859
  - p = 69965 press. in Pa

- **Start**

- **Read uncompensated temperature value**
  - read 0x2E into reg 0xF4, wait 4.5ms

- **Read uncompensated pressure value**
  - read 0xF6 (MSB), 0xF7 (LSB)
  - UP = (MSB<<16 + LSB<<8 + XLSB) >> (8-oss)

- **Display temperature and pressure value**

- **Read calibration data from the E2PROM of the BMP085**
  - read 0xF4, 0xF5, 0xF6, 0xF7 into reg 0xF4, wait 4.5ms
  - UT = MSB << 8 + LSB

- **Read reg 0xF6 (MSB), 0xF7 (LSB)**
  - UT = 27898 long

- **Write 0x34+(oss<<6) into reg 0xF4, wait 4.5ms**
  - write 0x2E into reg 0xF4, wait 4.5ms

- **Read reg 0xF6 (MSB), 0xF7 (LSB)**
  - UP = 23843 long

- **Write 0x34+(oss<<6) into reg 0xF4, wait 4.5ms**
  - write 0x2E into reg 0xF4, wait 4.5ms

- **Read reg 0xF6 (MSB), 0xF7 (LSB)**
  - UT = 27898 long

- **Write 0x34+(oss<<6) into reg 0xF4, wait 4.5ms**
  - write 0x2E into reg 0xF4, wait 4.5ms

- **Read reg 0xF6 (MSB), 0xF7 (LSB)**
  - UP = 23843 long

- **Write 0x34+(oss<<6) into reg 0xF4, wait 4.5ms**
  - write 0x2E into reg 0xF4, wait 4.5ms

- **Read reg 0xF6 (MSB), 0xF7 (LSB)**
  - UT = 27898 long

- **Write 0x34+(oss<<6) into reg 0xF4, wait 4.5ms**
  - write 0x2E into reg 0xF4, wait 4.5ms

- **Read reg 0xF6 (MSB), 0xF7 (LSB)**
  - UP = 23843 long

- **Write 0x34+(oss<<6) into reg 0xF4, wait 4.5ms**
  - write 0x2E into reg 0xF4, wait 4.5ms

- **Read reg 0xF6 (MSB), 0xF7 (LSB)**
  - UT = 27898 long

- **Write 0x34+(oss<<6) into reg 0xF4, wait 4.5ms**
  - write 0x2E into reg 0xF4, wait 4.5ms

- **Read reg 0xF6 (MSB), 0xF7 (LSB)**
  - UP = 23843 long
3.6 Calculating absolute altitude

With the measured pressure $p$ and the pressure at sea level $p_0$ e.g. 1013.25hPa, the altitude in meters can be calculated with the international barometric formula:

$$\text{altitude} = 44330 \times \left(1 - \frac{p}{p_0}\right)^{\frac{5.255}{25.67}}$$

Thus, a pressure change of $\Delta p = 1$hPa corresponds to 8.43m at sea level.

![Graph showing the relationship between barometric pressure and altitude above sea level.](image)

3.7 Calculating pressure at sea level

With the measured pressure $p$ and the absolute altitude the pressure at sea level can be calculated:

$$p_0 = \frac{p}{\left(1 - \frac{\text{altitude}}{44330}\right)^{\frac{5.255}{25.67}}}$$

Thus, a difference in altitude of $\Delta\text{altitude} = 10$m corresponds to 1.2hPa pressure change at sea level.
4 I²C Interface

- I²C is a digital two wire interface
- Clock frequencies up to 3.4Mbit/sec. (I²C standard, fast and high-speed mode supported)
- SCL and SDA needs a pull-up resistor, typ. 4.7kOhm to $V_{DD}$
  (one resistor each for all the I²C bus)

The I²C bus is used to control the sensor, to read calibration data from the E²PROM and to read the measurement data when A/D conversion is finished. SDA (serial data) and SCL (serial clock) have open-drain outputs.

For detailed I²C-bus specification please refer to:

The BMP085 has a master clear (XCLR) input that is used to reset the BMP085 and initializes internal registers and counters. The device is automatically reset by power on reset (POR) circuitry. XCLR can be left floating if not used. The pad has an internal pull-up resistor.

4.1 I²C specification

Electrical parameters for the I²C interface:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock input frequency</td>
<td>$f_{SCL}$</td>
<td></td>
<td>3.4</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>Input-low level</td>
<td>$V_{IL}$</td>
<td>0</td>
<td></td>
<td>0.2 * $V_{DD}$</td>
<td>V</td>
</tr>
<tr>
<td>Input-high level</td>
<td>$V_{IH}$</td>
<td>0.8 * $V_{DD}$</td>
<td></td>
<td>$V_{DD}$</td>
<td></td>
</tr>
<tr>
<td>SDA and SCL pull-up resistor</td>
<td>$R_{pull-up}$</td>
<td>2.2</td>
<td></td>
<td>10</td>
<td>kOhm</td>
</tr>
<tr>
<td>SDA sink current @ $V_{DD}$ = 1.62V, $V_{OL}$ = 0.3V</td>
<td>$I_{SDA_sink}$</td>
<td></td>
<td>9</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>EOC sink current @ $V_{DD}$ = 1.62V, $V_{OL}$ = 0.3V</td>
<td>$I_{SDA_sink}$</td>
<td></td>
<td>7.7</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>EOC source current @ $V_{DD}$ = 1.62V, $V_{OH}$ = 1.32V</td>
<td>$I_{SDA_source}$</td>
<td></td>
<td>1.5</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>XCLR pulse length</td>
<td>$t_{XCLR}$</td>
<td>1</td>
<td></td>
<td></td>
<td>µs</td>
</tr>
<tr>
<td>Start-up time after power-up, before first communication</td>
<td>$t_{Start}$</td>
<td>10</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
</tbody>
</table>
4.2 Device and register address

The BMP085 module address is shown below. The LSB of the device address distinguishes between read (1) and write (0) operation, corresponding to address 0xEF (read) and 0xEE (write).

<table>
<thead>
<tr>
<th>A7</th>
<th>A6</th>
<th>A5</th>
<th>A4</th>
<th>A3</th>
<th>A2</th>
<th>A1</th>
<th>W/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
</tr>
</tbody>
</table>

4.3 I2C protocol

The I2C interface protocol has special bus signal conditions. Start (S), stop (P) and binary data conditions are shown below. At start condition, SCL is high and SDA has a falling edge. Then the slave address is sent. After the 7 address bits, the direction control bit R/W selects the read or write operation. When a slave device recognizes that it is being addressed, it should acknowledge by pulling SDA low in the ninth SCL (ACK) cycle. At stop condition, SCL is also high, but SDA has a rising edge. Data must be held stable at SDA when SCL is high. Data can change value at SDA only when SCL is low.
4.4 Start temperature and pressure measurement

The timing diagrams to start the measurement of the temperature value UT and pressure value UP are shown below. After start condition the master sends the device address write, the register address and the control register data. The BMP085 sends an acknowledgement (ACKS) every 8 data bits when data is received. The master sends a stop condition after the last ACKS.

Timing diagram for starting pressure measurement

Abbreviations:
- S   Start
- P   Stop
- ACKS  Acknowledge by Slave
- ACKM  Acknowledge by Master
- NACKM  Not Acknowledge by Master

Control registers values for different internal oversampling setting (osrs):

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Control register value (register address 0xF4)</th>
<th>Max. conversion time [ms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>0x2E</td>
<td>4.5</td>
</tr>
<tr>
<td>Pressure (osrs = 0)</td>
<td>0x34</td>
<td>4.5</td>
</tr>
<tr>
<td>Pressure (osrs = 1)</td>
<td>0x74</td>
<td>7.5</td>
</tr>
<tr>
<td>Pressure (osrs = 2)</td>
<td>0xB4</td>
<td>13.5</td>
</tr>
<tr>
<td>Pressure (osrs = 3)</td>
<td>0xF4</td>
<td>25.5</td>
</tr>
</tbody>
</table>

Instead of waiting for the maximum conversion time, the output pin EOC (end of conversion) can be used to check if the conversion is finished (logic 1) or still running (logic 0).
4.5 Read A/D conversion result or E²PROM data

To read out the temperature data word UT (16 bit), the pressure data word UP (16 to 19 bit) and the E²PROM data proceed as follows:

After the start condition the master sends the module address write command and register address. The register address selects the read register:

- E²PROM data registers: 0xAA to 0xBF
- Temperature or pressure value UT or UP: 0xF6 (MSB), 0xF7 (LSB), Optionally 0xF8 (XLSB)

Then the master sends a restart condition followed by the module address read that will be acknowledged by the BMP085 (ACKS). The BMP085 sends first the 8 MSB, acknowledged by the master (ACKM), then the 8 LSB. The master sends a "not acknowledge" (NACKM) and finally a stop condition.

Optionally for ultra high resolution, the XLSB register with address 0xF8 can be read to extend the 16 bit word to up to 19 bits; refer to the application programming interface (API) software rev. 1.1 ("BMP085_SMD500_API", available from Bosch Sensortec).

Timing diagram read 16 bit A/D conversion result:
5 Package

5.1 Pin configuration

Picture shows the device in top view. Device pins are shown here transparently only for orientation purposes.

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Name</th>
<th>Function</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>Ground</td>
<td>Power</td>
</tr>
<tr>
<td>2</td>
<td>EOC</td>
<td>End of conversion</td>
<td>Digital output</td>
</tr>
<tr>
<td>3</td>
<td>$V_{DDA}$</td>
<td>Power supply</td>
<td>Power</td>
</tr>
<tr>
<td>4</td>
<td>$V_{DDD}$</td>
<td>Digital power supply</td>
<td>Power</td>
</tr>
<tr>
<td>5</td>
<td>NC</td>
<td>no internal connection</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>SCL</td>
<td>$I^2C$ serial bus clock input</td>
<td>Digital input</td>
</tr>
<tr>
<td>7</td>
<td>SDA</td>
<td>$I^2C$ serial bus data</td>
<td>Digital bi-directional</td>
</tr>
<tr>
<td>8</td>
<td>XCLR</td>
<td>master clear (low active) input</td>
<td>Digital input</td>
</tr>
</tbody>
</table>
5.2 Outline dimensions

The sensor housing is a standard 8-pin lead-less chip carrier (LCC8) ceramic package. Its dimensions are 5.0mm x 5.0mm (±0.25mm) x 1.2mm (±0.12mm). Package weight is approximately 0.09grams.

Note: All dimensions are in mm.

5.2.1 Top view

Device pins are shown here transparently only for orientation purposes.

5.2.2 Top view with lid
5.2.3 Side view with lid
5.3 Device marking

The device lid shows the following laser-marking:

- Pin 1 identifier
- Date code
- Bosch logo / vent hole / last 3 digits of part ID (TTN)
- Lot ID

The vent hole (diameter 0.5mm) is in the center of the lid, between the Bosch logo and the part ID code (144).

5.4 Tape on reel

Number of parts per reel: 3,000

Orientation of the parts inside the reel is according to EN60286-3.

Carrier tape material: Conductive polystyrene C 100, \(10^3 - 10^6\) Ohm/sq.

Dimensions are in mm:

- \(A_0 = 5.30 \pm 0.10\)
- \(B_0 = 5.30 \pm 0.10\)
- \(K_0 = 2.10 \pm 0.10\)
- \(P = 8.00 \pm 0.10\)
- \(W = 12.00 +0.30 / -0.10\)
- \(t = 0.30 \pm 0.05\)

The bars between the cavities are embossed about 0.2mm into the direction of \(K_0\). All other dimensions and tolerances follow the EIA 481 standard.
5.5 Printed circuit board (PCB) design

Recommended PCB design (top view):

![PCB design diagram]

5.6 Moisture sensitivity level and soldering

The BMP085 is classified MSL 1 (moisture sensitivity level) according to IPC/JEDEC standards J-STD-020C and J-STD-033A.

The device can be soldered Pb-free with a peak temperature of 260°C for 20 to 40 sec. The minimum height of the solder after reflow shall be at least 50µm. This is required for good mechanical decoupling between the sensor device and the printed circuit board (PCB).

The BMP085 devices have to be soldered within 6 months after shipment (shelf life). To ensure good solder-ability, the devices shall be stored at room temperature (20°C).

The soldering process can lead to an offset shift of typically 1hPa.

5.7 RoHS compliancy

The BMP085 sensor meets the requirements of the EC directive "Restriction of hazardous substances (RoHS)", please refer also to:


The BMP085 sensor is also halogen-free. Please contact your Bosch Sensortec representative for the corresponding analysis report.
5.8 Mounting and assembly recommendations

Please read the following recommendations carefully:

- The clearance above the metal lid shall be 0.1mm at minimum.

- For the device housing appropriate venting needs to be provided in case the ambient pressure shall be measured. If waterproof packaging is needed, venting can be accomplished by a vent element with a membrane like Gore-Tex™.

- Liquids shall not come into direct contact with the device.

- The sensor is sensitive to light, which can influence the accuracy of the measurement. Therefore, the hole in the top lid shall not be exposed to direct light during operation.

- The BMP085 shall not the placed close the fast heating parts. In case of gradients > 3°C/sec. it is recommended to follow Bosch Sensortec application note ANP015, "Correction of errors induced by fast temperature changes". Please contact your Bosch Sensortec representative for details.

- For further details, please refer to the BMP085 handling, soldering & mounting instructions manual that is also available from Bosch Sensortec.
6 Legal disclaimer

6.1 Engineering samples
Engineering Samples are marked with an asterisk (*) or (e). Samples may vary from the valid technical specifications of the product series contained in this data sheet. They are therefore not intended or fit for resale to third parties or for use in end products. Their sole purpose is internal client testing. The testing of an engineering sample may in no way replace the testing of a product series. Bosch Sensortec assumes no liability for the use of engineering samples. The Purchaser shall indemnify Bosch Sensortec from all claims arising from the use of engineering samples.

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The purchaser must monitor the market for the purchased products, particularly with regard to product safety, and inform Bosch Sensortec without delay of all security relevant incidents.

6.3 Application examples and hints
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### 7 Document history and modifications

<table>
<thead>
<tr>
<th>Rev. No</th>
<th>Chapter</th>
<th>Description of modifications/changes</th>
<th>Date</th>
</tr>
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<tbody>
<tr>
<td>0.1</td>
<td></td>
<td>First edition for description of serial production material</td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td></td>
<td>Noise data update, peak current added, several minor changes</td>
<td>19-Feb-2008</td>
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<tr>
<td>0.3</td>
<td>1</td>
<td>Update peak current, typo correction</td>
<td>21-Apr-2008</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Changed $V_{DDA}$ to $V_{DD}$ and $V_{DDD}$ to $V_{DDIO}$</td>
<td>21-Apr-2008</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>Updated flow diagram</td>
<td>21-Apr-2008</td>
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<tr>
<td></td>
<td>4</td>
<td>New comment on floating XCLR</td>
<td>21-Apr-2008</td>
</tr>
<tr>
<td></td>
<td>4.1</td>
<td>Added details on start-up time</td>
<td>21-Apr-2008</td>
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<tr>
<td></td>
<td>5.2</td>
<td>Added package weight</td>
<td>21-Apr-2008</td>
</tr>
<tr>
<td>1.0</td>
<td>1</td>
<td>Absolute accuracy at -20°C added</td>
<td>01-July-2008</td>
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<tr>
<td></td>
<td>2</td>
<td>Updated storage temperature</td>
<td>01-July-2008</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>Added optional EOC to schematic</td>
<td>01-July-2008</td>
</tr>
<tr>
<td></td>
<td>5.7</td>
<td>BMP085 is halogen-free</td>
<td>01-July-2008</td>
</tr>
</tbody>
</table>