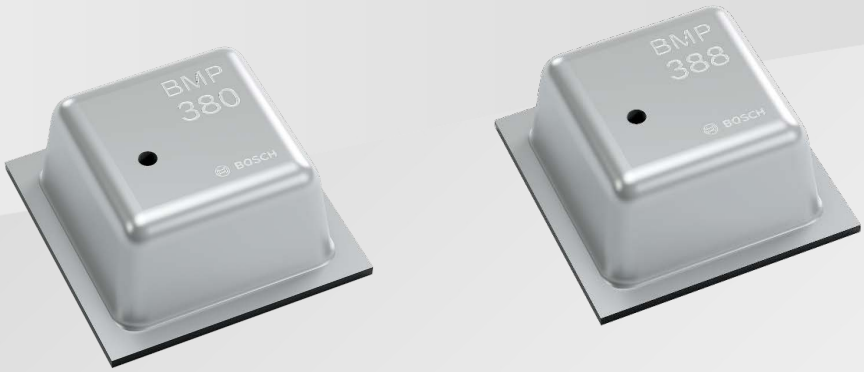
BMP38x
Self-test application note



Application Note

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Notes	Data and descriptions in this document are subject to change without notice. Product photos and pictures are for illustration purposes only and may differ from the real product appearance.

BMP38x
Digital pressure sensor

The BMP38x is a digital sensor with pressure and temperature measurement based on proven sensing principles. The sensor module is housed in an extremely compact 10-pin metal-lid LGA package with a footprint of only 2.0 × 2.0 mm^2 and max 0.8 mm package height. Its small dimensions and its low power consumption of 3.4 µA @1Hz allow the implementation in battery driven devices such as mobile phones, GPS modules or watches.

Typical applications

- Vertical velocity indication (e.g. rise/sink speed)
- Internet of things
- Enhancement of GPS navigation
  (e.g. time-to-first-fix improvement, dead-reckoning, slope detection)
- Indoor navigation & localization (floor detection, elevator detection)
- Outdoor navigation, leisure and sports applications
- Weather forecast
- Health care applications (e.g. spirometry)
- Fitness applications like enhancement of calorie detection
- AR & VR applications
- Context awareness

Target Devices

- Flying toys
- Drones
- Handsets such as mobile phones, tablet PCs, GPS devices
- Navigation systems
- Portable health care devices
- Home weather stations
- Watches
- White goods

Key features

- Package — 2.0 mm x 2.0 mm x 0.8 mm metal lid LGA
- Digital interface — I²C (up to 3.4 MHz) and SPI (3 and 4 wire, up to 10 MHz)
- Supply voltage — V_{DD} main supply voltage range: 1.71 V to 3.6 V; V_{DDIO} interface voltage range: 1.2 V to 3.6 V
- Relative accuracy — typ. ± 8 Pa, equiv. to ± 0.66 m (700 ... 900 hPa, 25 . . . 40 °C)
- Absolute accuracy — typ. ± 50 Pa (300 ...1100 hPa, 0 ...+65 °C)
- Temperature coefficient offset — typ. ± 0.75 Pa/K (-20 ... 65°C @700 -1100 hPa)
- Current consumption — 3.4 µA at 1 Hz pressure and temperature; 2.0 µA in sleep mode
- Operating range — -40 – +85 °C, 300–1250 hPa
- The product is RoHS compliant, halogen-free, MSL1

BMP38x enables accurate altitude tracking and is specifically suited for drone applications. The best-in-class TCO between 0-65°C for accurate altitude measurement over a wide temperature range of the BMP38x greatly enhance the drone flying experience by making accurate steering easier. It is compatible for use with other Bosch sensors, including the new BMI088 for better performance, robustness and stability. The new BMP38x sensor offers outstanding design flexibility, providing a single package solution that can also be easily integrated into other existing and upcoming devices such as smart homes, industrial products and wearables.

The sensor is more accurate than its predecessor BMP38x, covering a wide measurement range from 300 hPa to 1250 hPa. This new barometric pressure sensor exhibits an attractive price-performance ratio coupled with low power consumption. It is available in a compact 10-in 2.0 x 2.0 x 0.75 mm³ LGA package with metal lid

Due to the built-in hardware synchronization of the pressure sensor data and its ability to synchronize data from external devices such as acceleration sensors, the BMP38x is ideally suited for fitness and navigation applications which require highly accurate, low power and low latency sensor data fusion.
The new interrupt functionality provide simple access to data and storage. Examples of interrupts than can be used in a power efficient manner without using software algorithms include: Data ready interrupt, watermark interrupt (on byte level) or FIFO full interrupt.
BMP38x also includes a new FIFO functionality. This greatly improves ease of use while helping to reduce power consumption of the overall device system during full operation. The integrated 512 byte FIFO buffer supports low power applications and prevents data loss in non-real-time systems.

Table of contents

1 Application note objective

This document provides an explanation to the self-test code for the Bosch Sensortec BMP38x. The code itself refers to the API (Application Programming Interface) of the sensor, which can be obtained from Bosch Sensortec and is also included in this release package.
The included API revision is 1.3. Please ensure that this is the latest version prior to using the self-test files.

2 Self-test flow

The self-test starts by performing a soft reset of the device. After this, Chip-ID and trimming data are read and verified. Then temperature and pressure are measured and compared against customisable plausibility limits. A flow chart is given below.

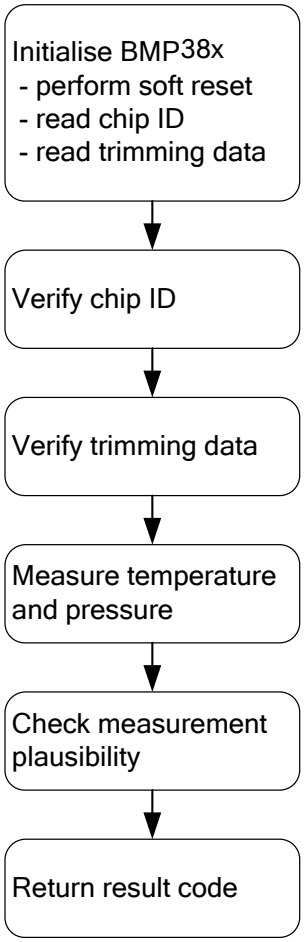

Figure 1: Self-test flow chart

3 Function return codes

A list of the possible function return codes can be found below.

0	Sensor OK
10	Communication error or wrong device found
20	Trimming data out of bound
30	Temperature bond wire failure or MEMS defect
31	Pressure bond wire failure or MEMS defect
40	Implausible temperature (default limits: 0…40°C)
41	Implausible pressure (default limits: 900…1100 hPa)

Error testing is done in ascending error code sequence. This means that if e.g. a trimming data error is detected (code 20), the temperature plausibility (code 40) is not checked anymore. Instead, error code 20 is returned and no others tests are performed.

4 Usage

4.1 File and function pointer integration

- Include BMP38x.c in your programming environment and add the path to the compiler.
- Include BMP38x_selftest.c in your programming environment and add the path to the compiler.
- Modify the lines with read/write function pointer to match your system. Sample functions are given in chapter 6:

```
BMP38x.bus_read   = BMP38x_I2C_bus_read;  // must be defined by customer
BMP38x.bus_write  = BMP38x_I2C_bus_write; // must be defined by customer
BMP38x.delay_msec = BMP38x_delay_msec;    // must be defined by customer
```

- If necessary, adapt the measurement plausibility limits in BMP38x_selftest.h. The default limits are 0…40°C for temperature and 900…1100 hPa for pressure measurement.
- If you are using I²C communication with the address 0x77 (SDO pin high), then change the BMP38x.h line

```
#define BMP38x_I2C_ADDRESS      BMP38x_I2C_ADDRESS1
```

into

```
#define BMP38x_I2C_ADDRESS      BMP38x_I2C_ADDRESS2
```

4.2 Function call

Call the self test function using:

```
unsigned char testresult;
testresult = BMP38x_selftest();
```

A test result of 0 indicates no error. The other return codes are detailed in chapter 3.

4.3 Test time and interface requirements

The self-test uses a total wait time of 9 milliseconds. Of this, 2 milliseconds are used as wait time for soft reset and 7 milliseconds are used as wait time for conversion. The soft reset is performed in order to erase any possible old settings and could be omitted if the sensor is known to be in an untouched state after power on.

In the self-test function, 4 write commands and 6 read commands are issued. In total, 4 bytes are written and 34 bytes are read. Assuming burst read is used, the following time duration can be expected for communication including overhead:

- 6.0 ms for I²C at 100 kHz
- 1.5 ms for I²C at 400 kHz
- 0.5 ms for SPI at 1 MHz

Assuming a 400 kHz I²C interface with burst reads, the total function run time therefore equals 10.5 milliseconds.

5 Function explanation

5.1 Communication test

This function attempts to read the Chip ID. If it is correct, a functioning communication is assumed. Note that the write function functionality is not explicitly tested.

5.2 Trimming data verification

All trimming parameters are tested against their respective bounds. If they exceed these bounds, a memory or programming error has occurred.
For future sensors, the permissible boundaries might change due to process variations. Such a change will be indicated by a marker. The self-test code will recognise this marker and skip the data verification part of the code in order to avoid false error messages.
On change of the permissible boundaries, Bosch Sensortec will release a new self-test code, which will again perform the trimming data verification considering the new boundaries.

5.3 Bond wire test

A pressure and temperature measurement is performed and uncompensated pressure and temperature values are read out. If the measurement results are clipped to the respective minimum or maximum ADC values, this is usually caused by defective bond wires. However, a defective sensing element could also cause this test to fail.
Please note that some combinations of bond wire or sensing element defects do not result in clipping of the measurement value and will therefore not be detected with this test. These cases can be detected by the plausibility test instead.

5.4 Measurement plausibility test

The pressure and temperature values read out previously are compensated using the read out compensation parameters. The compensated temperature and pressure is compared against plausibility limits set in BMP38x_selftest.h, which must be set to match the customer production environment.

6 Sample read, write and delay functions

Below some samples read, write and delay functions are given. These are platform dependant and should only give an idea of how the functions could look.

```
signed char BMP38x_I2C_bus_read(unsigned char device_addr, unsigned char reg_addr,
    unsigned char *reg_data, unsigned char cnt)
{
    int iError=0;
    unsigned char array[I2C_BUFFER_LEN];
    unsigned char stringpos;
    array[0] = reg_addr;
    iError = I2C_write_read_string(I2C0, device_addr, array, array, 1, cnt);
    for(stringpos=0;stringpos<cnt;stringpos++)
    {
       *(reg_data + stringpos) = array[stringpos];
    }
    return (signed char)iError;
}

signed char BMP38x_I2C_bus_write(unsigned char device_addr, unsigned char reg_addr,
    unsigned char *reg_data, unsigned char cnt)
{
    int iError=0;
    unsigned char array[I2C_BUFFER_LEN];
    unsigned char stringpos;
    array[0] = reg_addr;
    for(stringpos=0;stringpos<cnt;stringpos++)
    {
       array[stringpos+1] = *(reg_data + stringpos);
    }
    iError = I2C_write_string(I2C0, device_addr, array, cnt+1);
    return (signed char)iError;
}

void BMP38x_delay_msec(BMP38x_U16_t msec) //delay in milliseconds
{
    BMP38x_U32_t counter;
    for (counter = 0; counter/2000 < msec; counter++); // 2000 counts = 1 msec
}
```

7 Legal disclaimer

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8 Document history and modifications

Rev. No	Chapter	Description of modification/changes	Date
1.1		Added Technical Reference codes	November 2018
1.0		Initial release	April 2018

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