Technical Document

How to use BMP581 NVM to store the offset from end-of-line calibration

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1 Introduction

BMP581 is the new absolute barometric pressure sensor that is based on capacitive change technology. It has key features of low power consumption, high performance, high output data rate, easy to use and dedicated total 6 bytes in NVM (non-volatile memory) for users to store data. BMP581 is 2.0 x 2.0 x 0.75mm^3 LGA-10 package. And it is pin-to-pin compatible with the previous BMP388 and BMP390 that are based on resistive change technology. In addition to I^{2}C/SPI digital interface, BMP581 supports I^{3}C interface.

BMP581 has 3-byte data registers for pressure raw measurement and temperature raw measurement respectively. Users can get final pressure result in the unit of Pa and final temperature result in the unit of °C directly from the raw measurements in those data registers, while for BMP388 and BMP390 users need to run the formula to convert raw measurements to final pressure and final temperature results together with the trimming parameters in the NVM.

Each BMP581 has been calibrated, trimmed, and tested in Bosch factory before being delivered to the market. This means that each BMP581 has its own NVM that contains those trimming parameters as well as unique device ID, final test result, CRC result, etc. The CRC is based on CRC-16 CCITT checksum for some NVM addresses. If the calculated CRC from the values stored in some certain NVM addresses matches the CRC result value stored in NVM, then it means that the NVM is good and not corrupted.

BMP581 NVM operation includes reading values from NVM and writing values to NVM. NVM operation must be performed in Standby power mode, and the power supply of VDD and VDDIO should be stable, and there should be no soft-reset during NVM operation. Otherwise, BMP581 may get damaged.

This document presents BMP581 NVM structure, how to read values from NVM and how to write users' own data into NVM with sample code.

2 NVM structure

BMP581 NVM has total 40 addresses from 0x00 to 0x27 and each address corresponds to 2 bytes. This means that NVM has total 80 bytes and each NVM address contains high byte MSB and low byte LSB with 16-bit Word format.

BMP581 NVM provides 3 addresses 0x20, 0x21 and 0x22 with total 6 bytes for users to store their own data, which could be their product serial number, or software revision number, or pressure offset from end-of-line calibration process in their factory production line. Only these 3 addresses of NVM have read / write access. The maximum number of writing values to these 3 NVM addresses is 10000 times. All other NVM addresses are read only. Trying to write values to read only NVM addresses will be ignored.

Figure 1 shows NVM structure and the relationship between register map and NVM.

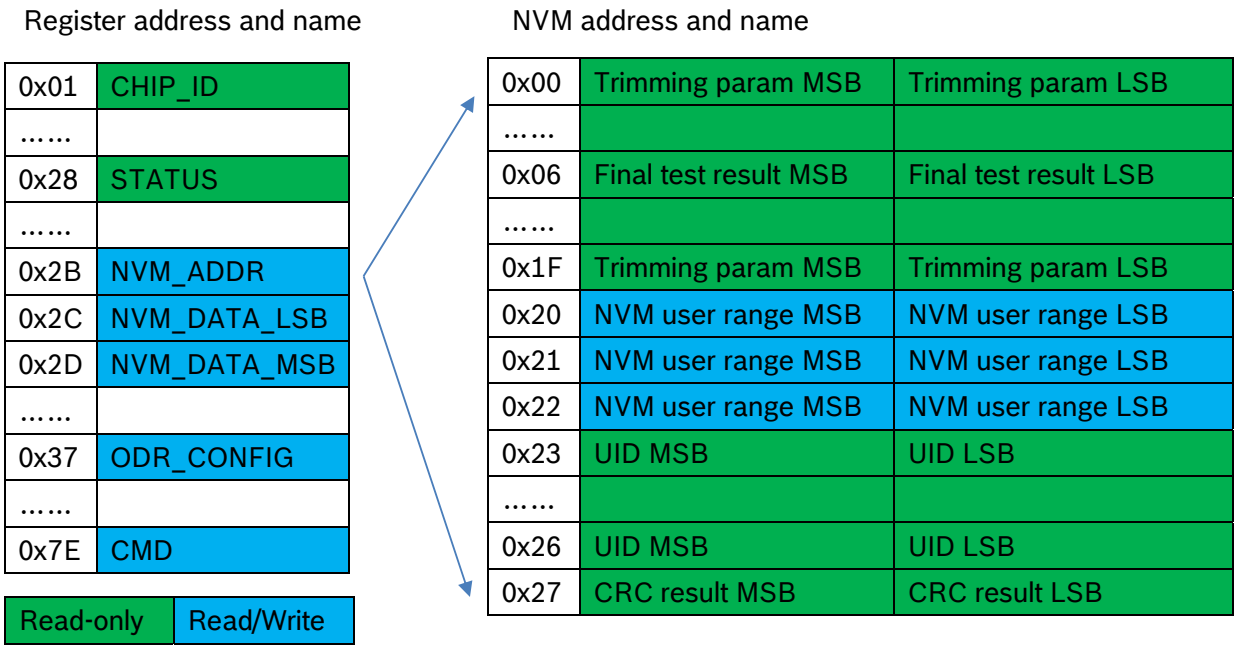

Figure 1 BMP581 register map and NVM structure

- Register 0x28 (STATUS) contains status_nvm_rdy bit. When this bit is “1”, it means NVM is ready for users to perform read or write operation. Otherwise, NVM is not ready.
- Register 0x2B (NVM_ADDR) defines the NVM address users want to read from or write values to. When nvm_prog_en bit is “1”, it means NVM write is enabled. Otherwise, NVM read operation will be performed.
- Register 0x37 (ODR_CONFIG) defines power mode. NVM operation is only possible when BMP581 is in Standby mode.

3 NVM read operation

BMP581 doesn't support NVM burst read and burst write, which means that NVM operation is single byte oriented through I2C/SPI/I3C interface.

The following pseudo code shows how to read value from NVM address of 0x20 as an example. If more NVM addresses need to be read, then the following code can be executed again and again with different NVM addresses to register 0x2B. This is because after each NVM read operation the NVM access will be disabled automatically.

```
Write value of 0xF0 to register 0x37;   // set BMP581 to standby mode with deep standby mode disabled.
Delay 3ms;                              // wait for BMP581 to be in standby mode from any other power mode (max 2.5ms in datasheet from any mode to standby mode)

Write value of 0x20 to register 0x2B;   // set NVM address to 0x20 and nvm_prog_en bit to 0 for read operation
Write value of 0x5D to register 0x7E;   // enable NVM access
Write value of 0xA5 to register 0x7E;   // start NVM read operation
Delay 1ms;                              // wait for NVM read operation to be completed (about 200us in datasheet)

NVM_LSB = Read register 0x2C ;          // get NVM_LSB value
NVM_MSB = Read register 0x2D ;          // get NVM_MSB value
```

For brand new BMP581 the values in NVM user range from address 0x20 to 0x22 are 0x55AA by default. Users can perform burst read at register address 0x2C with 2 bytes to get NVM_LSB and NVM_MSB data in one single I2C/SPI transaction.

Table 1 shows NVM values from a brand new BMP581 as an example.

Table 1: BMP581 example NVM values

NVM address	NVM_MSB	NVM_LSB	Description
0x00	0x0F	0xFE	Trimming parameters
0x01	0x00	0x64	
0x02	0x69	0x11	
0x03	0x8D	0x00	
0x04	0xA0	0x51	
0x05	0x83	0x02	
0x06	0x23	0x09	Final test result. Bit<15:13> = 0b001 ≥ 1, good part
0x07	0x80	0x02	Trimming parameters
0x08	0xB3	0x03	
0x09	0x35	0x30	
0x0A	0x04	0x11	
0x0B	0x32	0x9D	
0x0C	0xF2	0xFA	
0x0D	0xFE	0xD6	
0x0E	0xFD	0xC1	
0x0F	0xFE	0x3E	
0x10	0xF6	0x0C	
0x11	0xFE	0xA2	
0x12	0xFD	0xDA	
0x13	0x00	0x0F	
0x14	0xCC	0x09	
0x15	0x77	0xF9	
0x16	0x18	0x58	
0x17	0x72	0x73	
0x18	0x00	0x1B	
0x19	0xD5	0x74	
0x1A	0x83	0x31	
0x1B	0x12	0x40	
0x1C	0x6C	0xA6	
0x1D	0x00	0x00	
0x1E	0xAA	0x55	
0x1F	0xAA	0x55	
0x20	0x55	0xAA	NVM user range, 0x55AA means this BMP581 is brand new. NVM has not been written before.
0x21	0x55	0xAA	
0x22	0x55	0xAA	
0x23	0x6B	0x00	UID = (0x26 LSB) | 0x25 | 0x24 | (0x23 MSB) = 0x8A44FFB7A96B = 152,028,952,635,755. This is the unique ID for this BMP581 sensor
0x24	0xB7	0xA9	
0x25	0x44	0xFF	
0x26	0xC7	0x8A	
0x27	0x12	0x77	CRC result from the trimming parameters and UID

4 NVM write operation

BMP581 NVM has 3 addresses 0x20, 0x21 and 0x22 with total 6 bytes for users to store their own data, for example the pressure offset from end-of-line calibration process in their factory production line.

In a stable environment such as there is no wind flow nearby and no sudden temperature change, if the pressure reference meter shows 101135 Pa and the BMP581 data registers show 101167 Pa, then the offset is 101135 Pa – 101167 Pa = -32 Pa = 0xFFE6. The user can store this offset in NVM address of 0x20, or 0x21, or 0x22. In the future every time when the system is powered on, the host can read NVM address to get the offset. And then add this offset to every BMP581 pressure measurement to get the final offset compensated pressure value in the unit of Pa.

The following pseudo code shows how to write the value of 0xFFE6 pressure offset to NVM address of 0x20 as an example.

```
Write value of 0xF0 to register 0x37;   // set BMP581 to standby mode with deep standby mode disabled.
Delay 3ms;                              // wait for BMP581 to be in standby mode from any other power mode (max 2.5ms in datasheet from any mode to standby mode)

Write value of 0x60 to register 0x2B;   // set NVM address to 0x20 and nvm_prog_en bit to 1 for write operation
Write value of 0x5D to register 0x7E;   // enable NVM access
Write value of 0xA0 to register 0x7E;   // start NVM write operation
Delay 15ms;                             // wait for NVM write operation to complete (about 10ms in datasheet)

Write value of 0xE6 to register 0x2C;   // write offset LSB value to NVM_DATA_LSB register 0x2C
Write value of 0x5D to register 0x7E;   // enable NVM access
Write value of 0xA0 to register 0x7E;   // start NVM write operation
Delay 15ms;                             // wait for NVM write operation to complete

Write value of 0xFF to register 0x2D;   // write offset MSB value to NVM_DATA_MSB register 0x2D
Write value of 0x5D to register 0x7E;   // enable NVM access
Write value of 0xA0 to register 0x7E;   // start NVM write operation
Delay 15ms;                             // wait for NVM write operation to complete

Write value of 0x20 to register 0x2B;   // set NVM address to 0x20 and nvm_prog_en bit to 0 to disable NVM write operation

Call the above NVM read operation;      // double check if the value of 0xFFE6 has been written to NVM address 0x20 successfully or not
```

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6 Document history and modification

Rev. No	Chapter	Description of modification/changes	Date
1.0		Document creation	July 26th, 2022

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