10 DOF IMU Sensor (B) User Manual

1. Feature

<table>
<tr><td rowspan="2">Driver IC</td><td>MPU9255
(3-axis accelerometer
3-axis gyroscope
3-axisdigital compass)</td><td>Built-in 16-Bit AD convertor
Gyroscope full-scope range: ±250, ±500, ±1000, ±2000°/sec
Accelerometer full-scale range: ±2, ±4, ±8, ±16g
Compass full-scale rage： ±4800uT</td></tr>
<tr><td>BMP180
(Digtal pressure sensor)</td><td>Built-in temperature sensor with temperature measurement compensation
Pressure measuring range: 300~1100hpa (+9000m ~ -500m relating to sea level)
Accuracy: 0.02hPa (0.17m)</td></tr>
<tr><td>Working voltage</td><td colspan="2">3.3V，5V</td></tr>
<tr><td>Supported interface</td><td colspan="2">I2C</td></tr>
<tr><td>Dimensions</td><td colspan="2">31.2mm*17mm</td></tr>
</table>

Table 1: Product features

2. Applications

- Quadcopter;
- Action game controller;
- Indoor inertial navigation;
- Self-balancing Robot;
- Altimeter;
- Industrial measuring instrument.

3. Interface Descriptions

Pin No.	Symbol	Descriptions
1	VCC	3.3V or 5V power supply
2	GND	Supply ground
3	SDA	I2C serial bus data
4	SCL	I2C serial bus clock input
5	INT	MPU9255digital interrupt output
6	FSYNC	MPU9255frame synchronous signal

Table 2: Interface descriptions

4. How to use

We will illustrate the usage of the module with an example of working with a STM32 series' development board.

① Download the relative codes to the development board.

② Connect the development board to a PC via a serial wire, and insert the module into the I2C 2 interface on the development board. Please take attention to the connection between the module and I2C 2 interface, each pin of the module should be connected to its corresponding port on the I2C 2 interface and FSYN pin should be kept suspended respectively.

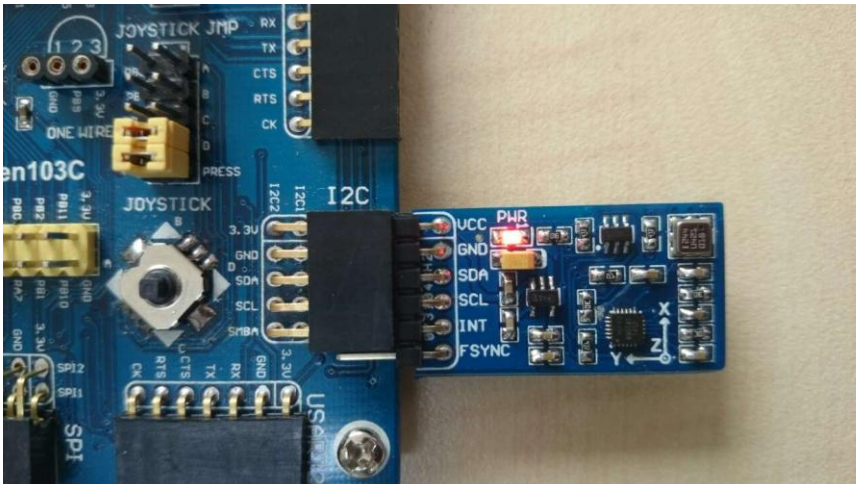

Figure 1: Connection between 10 DOF IMU Sensor (B) module and STM32

③ Here is the configuration of the serial port, as Table 3 shows.

Baud rate	115200
Data bit	8
Stop bit	1
Parity bit	none

Table 3: Serial port configuration

④ After powering 10 DOF IMU Sensor (B) on, firstly, acceleration is calibrated at horizontal state, and magnetic is calibrated later. After done, the qualify data will output from 10 DOF IMU Sensor (B). For detail operations as below:

A. Flatting 10 DOF IMU Sensor (B) on the horizontal position and no motion is allowed,when serial terminal received the stable data from USART1, then press JOYSTICK button down, LED1 is flashing and both of LED2 and LED3 turn off at the mean time.
B. Rotating 10 DOF IMU Sensor (B) 180 degrees around the Z axis on the horizontal position, when serial terminal received the stable data from USART1, then press JOYSTICK button down, LED2 is flashing and both of LED1 and LED3 turn off at the mean time.
C. Inverting 10 DOF IMU Sensor (B) on the horizontal position, means holding the backside of 10 DOF IMU Sensor (B) upward and the positive side downward. Then press JOYSTICK button down, LED3 turn on forever indicating that magnetic calibration is complete, and both of LED1 and LED2 turn off at the mean time.
D. Rotating 10 DOF IMU Sensor (B) 180 degrees around the Z axis on the horizontal position， recording and comparing with the magnetic data from serial terminal before and after rotating, if equaling to each other and behaving at opposite of direction, as a result, magnetic calibrating is successful.

⑤ If succeed to calibrate, serial terminal will received the qualify data as following:

```
//////////////////////////////////////////////////////////////

Roll: -0.46    Pitch: -1.65    Yaw: 38.08

Acceleration: X: -471    Y: -114    Z: 15824

Gyroscope: X: 3    Y: 0    Z: -12

/------------------------------------------------------------/

Magnetic: X: 105    Y: 80    Z: -159

/------------------------------------------------------------/

Pressure: 1003.90    Altitude: 24.95

Temperature: 27.3
```

⑥ The serial output is as followed:

Roll, Pitch, Yaw	Roll angle(°), Pitch angle(°), Yawangle(°)
Acceleration	Acceleration value (LSB, translatable into the unit: g)
Gyroscope	Acceleration value (LSB, translatable into the unit: g)
Magnetic	Digital compass title angle (°)
Pressure	Pressure value (hPa)

Altitude	Altitude value (m)
Temperature	Temperature value (℃)

Table 4: The meanings of the serial output

5. Parameter calibration and calculation

5.1 Altitude calibration

For your first time to use 10 DOF IMU Sensor (B), you may find that there is a large difference between the altitude value outputted by the module and the actual altitude. This is because 10 DOF IMU Sensor (B) calculates the pressure at sea level P0 with the Altitude of its current position and the measured pressure, providing that both module current position and pressure are known. And this P0 will be taken as a benchmark for subsequent calculations.
For more detailed information, please refer to BST-BMP180-DS000-09.pdf：

3.7 Calculating pressure at sea level

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

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

Thus, a difference in altitude of Δaltitude = 10m corresponds to 1.2hPa pressure change at sea level.

Altitude： With the benchmark P0, you can calculate the Altitude of the module current position as well.

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:

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

Therefore, you should firstly set the altitude of the module current position as a benchmark in the sample code 10 DOF IMU Sensor (B)\SRC\HardWare\BMP180\ BMP180.h (normally, it should be the absolute altitude of your position now, unit:

```
#define LOCAL_ADS_ALTITUDE      2500            //mm     altitude of your position now
```

5.2Acceleration calculation

Acceleration measured by the program is in the unit of LSB (Least Significant Bit), however it is usually translated into the unit of gravitational acceleration (g) in practical application. In the sample code of the module, the default setting is AFS_SEL=0, of which the corresponding measurement range is 16384 LSB/g (±2g), so the actual measured acceleration would be:

$$a = \text{Acceleration}/16384\ ,Unit{:}g$$

For more detailed information, please refer to

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5.3Gyroscope angular velocity calculation

Gyroscope angular velocity calculationAngular velocity measured by the program is in the unit of LSB (Least Significant Bit), however it is usually translated into the unit of angular velocity (°/sec) in practical application. In the sample code of the module, the default setting is FS_SEL=2, of which the corresponding measurement range is 32.8 LSB/(°/s) (±1000°/sec), so the actual measured angular velocity would be:

ω=Gyroscope/32.8 ,Unit:°/s

For more detailed information, please refer to

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