
# BW-IMU200 Serials

## Low-cost Inertial Measurement Unit

## Technical Manual

# BW-IMU200

Low-cost inertial measurement unit




## Introduction

As a low-cost inertial measurement sensor, the BW-IMU200 measures the attitude parameters of the motion carrier (roll angle, pitch angle, angular velocity, acceleration).Attitude and angular velocity deviations are estimated by a 6-state Kalman filter with appropriate gain, that is suitable for inertial attitude measurement in motion or vibration.

BW-IMU200 uses highly reliable MEMS accelerometers and gyroscopes, and ensure measurement accuracy through algorithms, meanwhile, the seal design and strict process ensure that the dynamic parameters of the carrier such as the angular velocity、acceleration and attitude can be accurately measured under harsh conditions. Through various compensations such as nonlinear compensation, quadrature compensation, temperature compensation and drift compensation, the error source of BW-IMU200 can be greatly eliminated, and the product accuracy level can be improved. The BW-IMU200 is equipped with digital interface that can be easily integrated into the user's system.

## Features

- Dynamic compensation and quadrature compensation
- Accuracy：1°
- Special offset tracking algorithm eliminates drift
- Gyro drift compensation
- Standard RS232/RS485/TTL output interface
- Operating temperature:: -40℃+85℃，temperature compensation
- High-performance Kalman filter algorithm
- Small size： L60 × W59× H29mm

## Applications

- Ship
- Construction machinery
- Platform stability
- Agricultural machinery
- Special vehicle
- Driverless
- Robot
- Aircraft

# Specifications

## Electrical Specifications

| | |
|---|---|
| Power supply | 9-35V DC |
| Operating current | 40mA （DC 12V） |
| Operating temperature | -40~85℃ |
| Store temperature | -55~100℃ |

## Performance Specifications

| | | |
|---|---|---|
| Pitch angle | Accuracy | 1° |
| | Resolution | 0.01° |
| | measuring range | -90°~90° |
| Roll angle | Accuracy | 1° |
| | Resolution | 0.01° |
| | Range | -180°~180° |
| Gyro | Resolution | 0.02°/sec |
| | Range | ±500°/sec |
| | Zero instability | 50 °/h |
| | ARW | 1.6 °/√h |
| | Noise density | 0.005 °/s/√Hz |
| | Zero absolute error | ±0.2 °/sec |
| Accelerometer | Range： X,Y,Z | ±2 g |
| | Resolution | 1 mg |
| | Bias stability | ±4 mg |
| Maximum output frequency | 100Hz | |
| Start delay | 50ms | |
| Anti-vibration performance | 2000g | |

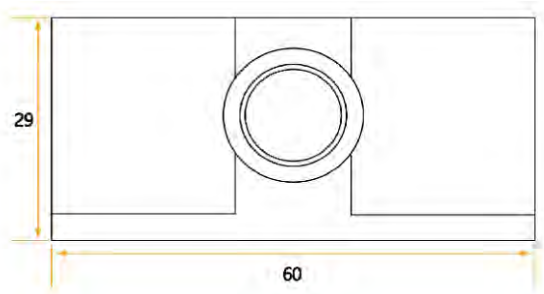
Resolution: The measured minimum change value that the sensor can detect and resolve within the measurement range.
Accuracy: The error between the actual angle and the Root mean square(RMS) of the measured angle of the sensor (≥16 times).

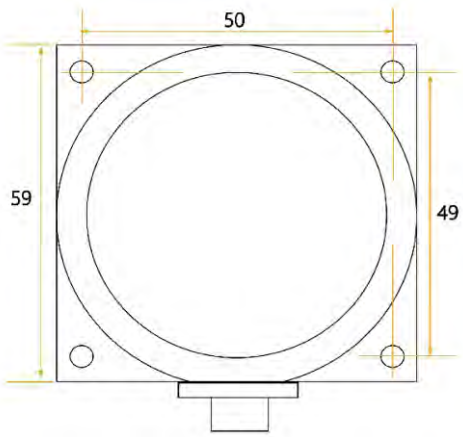
## Mechanical Characteristic

| | |
|---|---|
| Connector | Metal connector ( standard cable is 1.5m ) ) |
| Protection level | IP67 |
| Shell material | Magnesium alloy sanding oxidation |
| Installation | Four M4 screws |

## Package size

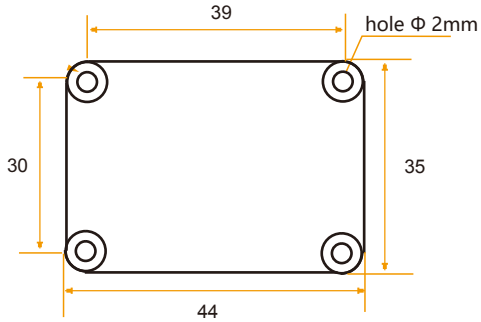
Product Size：L60*W59*H29（mm）




## Bare plate product size

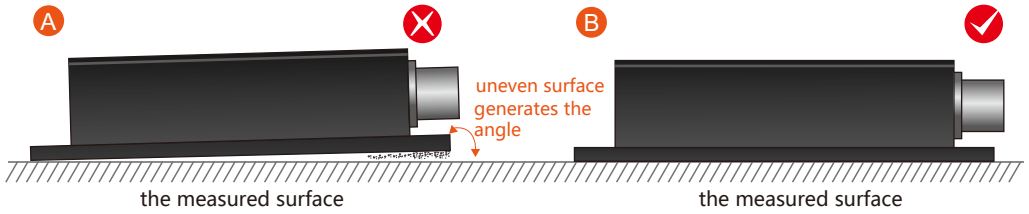
Product size：L44*W35*H11（mm） **Note:** ±1mm error for length and width dimensions, please refer to actual size

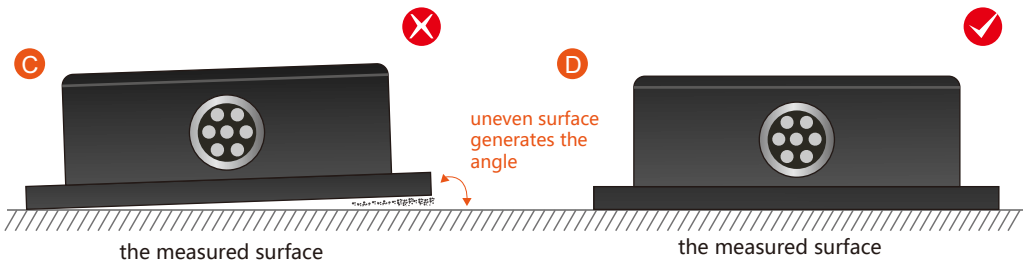


# Installation direction

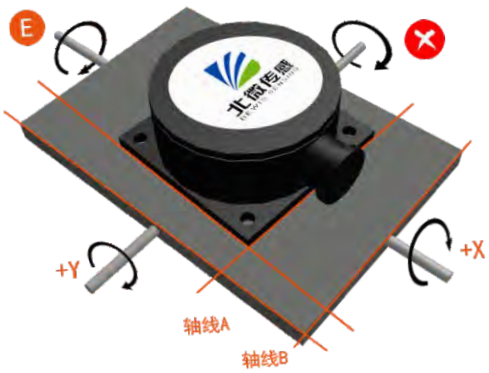
The correct installation method can avoid measurement error. The following points should be made when installing the sensor:

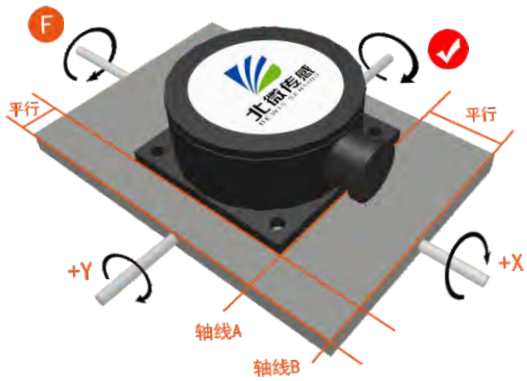
First of all, to ensure that the sensor mounting surface and the measured surface completely close, the measured surface should be as horizontal as possible, can not have the angle shown in Figure A and Figure C, the correct installation is shown in Figure B and Figure D.




Secondly, the bottom cable of the sensor and the axis of the measured object shouldn't generate the angle shown in E. When installing, the bottom cable of the sensor should be kept parallel or orthogonal to the rotation axis of the measured object. This product can be installed horizontally or vertically (vertical installation requires customization). The correct installation method is shown in Figure F.



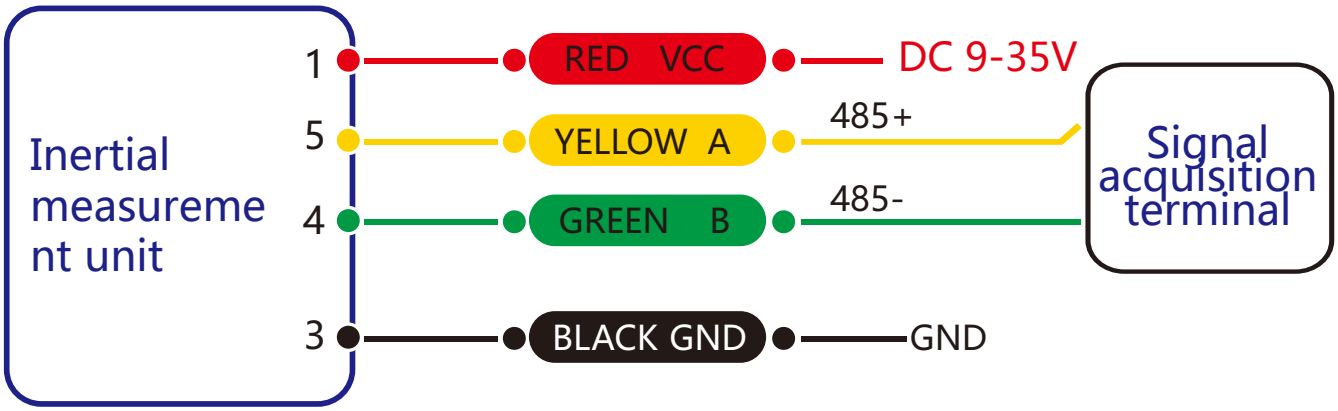




Finally, the installation surface of the sensor must be fixed with the measured surface tightly smoothly, to avoid measurement error that may be caused by the acceleration and vibrati

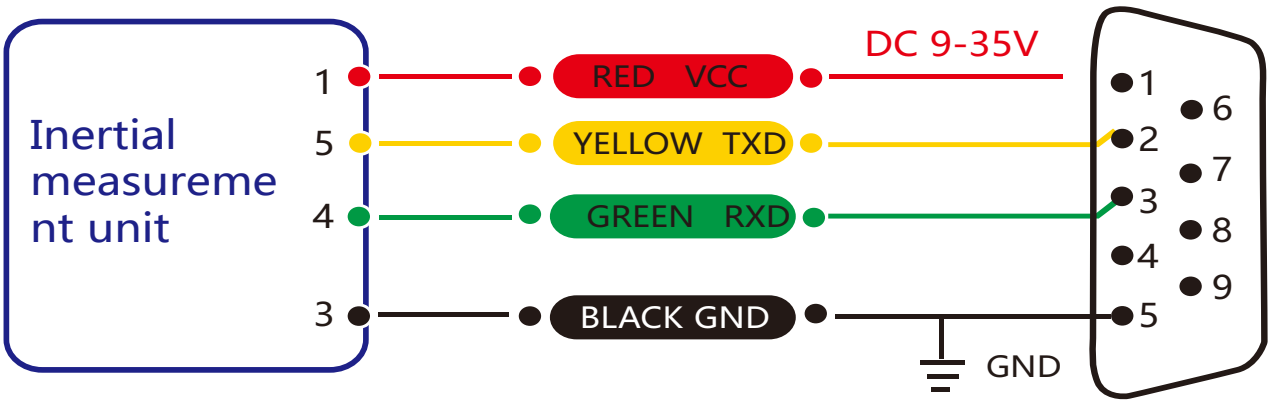
# Electrical connections

## Electrical interfaces

| Cable color & function | RED | BLUE | BLACK | GREEN | YELLOW |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| | VCC DC 9-35V | NC | GND | RXD (B、D-) | TXD (A、D+) |




**RS 485** wiring diagram




**RS 232** wiring diagram

Note: The RS232 interface needs to share the product ground wire with the communication ground wire.

# Debugging software

Users can directly download serial assistant on official website (Supports-Download). You can also use more convenient and intuitive PC software.

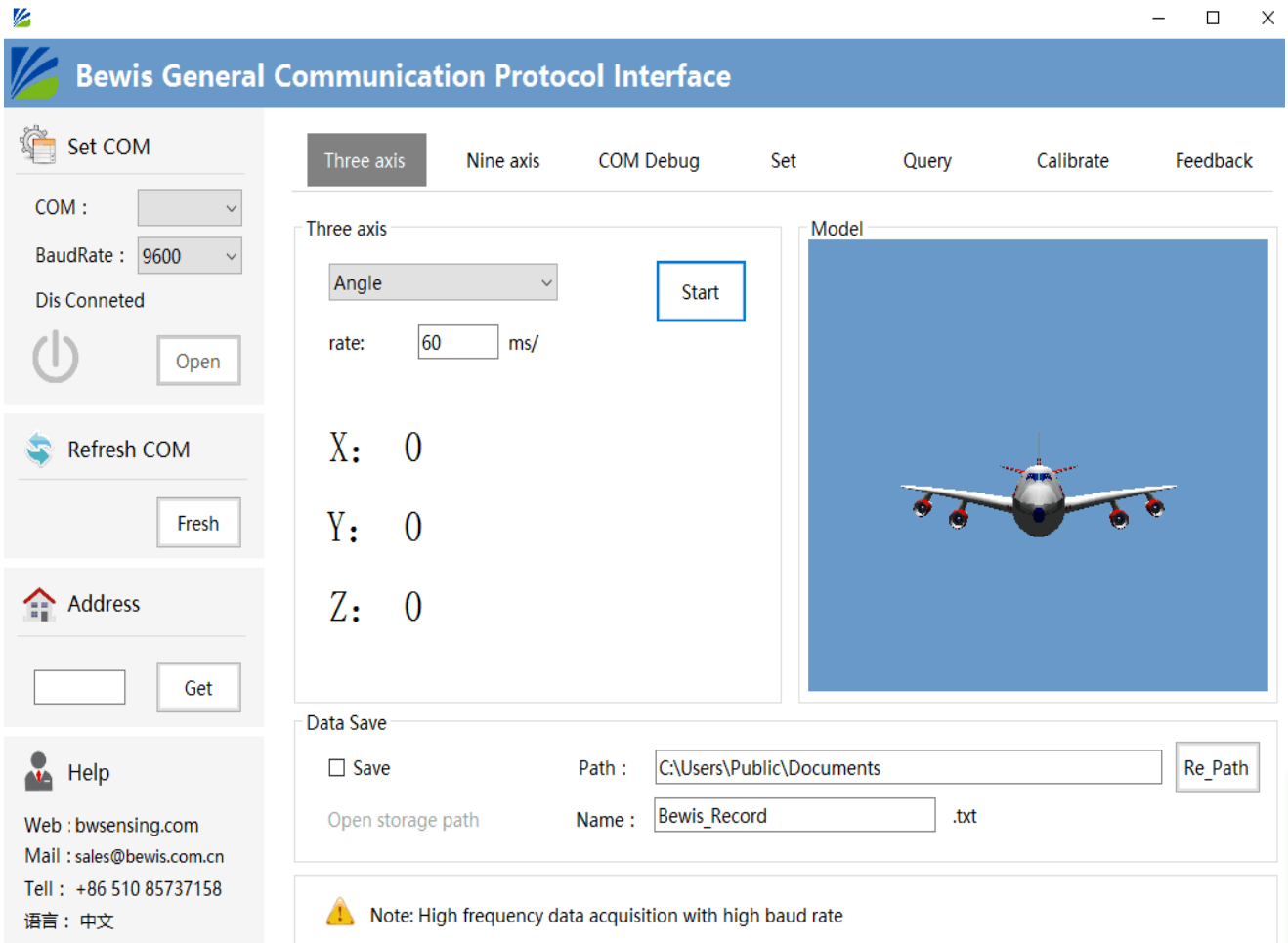
BW-IMU200 supporting serial debugging software can be connected to the inclinometer on the computer for angle display. The software debugging interface is as shown in the figure below. Using the debug software, it can conveniently display the current X-direction tilt angle, and you can also modify and set other parameters by yourself.

## Software usage steps

① Connect the serial port hardware of the inclinometer correctly and connect the power supply.

② Select the computer serial port and baud rate and click to connect to the serial port.

③ Click Start and the tilt angle of the inclinometer in the X and Y directions will be displayed on the screen.



# Protocol

## 1Data Frame Format : ( 8 data bits , 1 stop bit , No parity check , default baud rate 9600 )

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (Xbyte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77H | | | | | |

**Data Format:** Hexadecimal
**Identifier:** Fixed to 77
**Frame Length:** Length from Frame Length to Checksum ( included )
**Address Code:** Address of acquiring module, default 0x00
**Data**: Content and length variable according to Command
**Checksum**: Sum of Frame Length, Address Code, Command and Data. (Please pay attention that when the command or data changes, the checksum will change. )

## 2 Command Format:

### 2.1 Read PITCH angle Command : 77 04 00 01 05

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x01 | | 0x05 |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (3byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x07 | | 0x81 | SXXX.YY | |

Note: Data represents 3 byte angle value in format of compressed BCD code. S is the sign bit (0 means positive, 1 means negative), XXX is the three digit integer part, YY is the fractional part. For example, if the return value is 77 07 00 81 10 34 63 2F, the pitch angle data is “10 34 63”, which means “-34.63 degrees”.”

### 2.2 Read ROLL angle Command : 77 04 00 02 06

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x02 | | 0x06 |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (3byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x07 | | 0x82 | SXXX.YY | |

Note: Data represents 3 byte angle value in format of compressed BCD code. S is the sign bit (0 means positive, 1 means negative), XXX is the three digit integer part, YY is the fractional part.For example, if the return value is 77 82 01 23 57 04, the roll angle data is "01 23 57", which means "123.57 degrees"

### 2.3 Read PITCH, ROLL axis angle  Command：77 04 00 04 08

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x04 | | |

Command response：

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (9byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x0D | | 0x84 | SXXX.YY | |

**PITCH axis: +2.01°, ROLL axis: -0.51°, YAW axis: 0.00°**

**77 0D 00 84 00 02 01 10 00 51 00 00 00 F5**

Identifier; fixed as 77

The length of the data, fixed to 0D means that in addition to 77, there are 13 bytes behind

Address code, default is 00

Command word, fixed at 84

PITCH axis angle:
The first digit of the first byte is the sign bit, 0 is the positive angle, and 1 is the negative angle.
The second and second bytes of the first byte are integer bits of the angle, which are compressed BCD codes.
The third byte is the decimal place of the angle, which is the compressed BCD code.

ROLL axis angle:
The format is the same as the PITCH axis

YAW axis or reserved bit angle: the format is the same as the PITCH axis

The last byte is the sum of all the previous data except the first number (0x77). If there is a carry, the lower data is taken.

### 2.4 Set baud rate  Command: 77 05 00 0B 02 12

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | | 0x0B | XX | |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | | 0x8B | 0x00: success<br>0xFF: failure | |

**Note**: 0x00 means 2400 0x01 means 4800 0x02 means 9600 0x03 means 19200, 0x04 means 115200, default value is 0x02:9600 Each time the communication baud rate is changed successfully, the response command is sent back at the original baud rate, and then the device communication baud rate is changed immediately.
**Note:** If high frequency output is required, set the baud rate to 115200. Modify the baud rate without sending a save command, and it will take effect immediately.

### 2.5 Set module address  Command: 77 05 00 0F 01 15

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | correct address | 0x0F | new address | |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | new address | 0x8F | 0x00: success<br>0xFF: failure | |

**Note:** For example, the following command "77 05 00 0F 0A 1E" means that the address of the product is changed from hexadecimal address 00 to 0A.

### 2.6 Query current address  Command: 77 04 00 1F 23

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | 0x00 | 0x1F | | 0x23 |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | new address | 0x1F | new address | |

**Note:** The query address command is to fix the command.。

### 2.7 Set the output frequency  Command: 77 05 00 0C 00 11

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | | 0x0C | XX | |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | | 0x8C | 0x00: success<br>0xFF: failure | |

The transmitted data field XX is the automatic output frequency option: 00 indicates the answer mode,
01 indicates 5Hz automatic output corresponding data type parameter
02 indicates 10Hz automatic output corresponding data type parameter
03 indicates 20Hz automatic output corresponding data type parameter
04 indicates 25Hz automatic output corresponding data type parameter
05 indicates 50Hz automatic output corresponding data type parameter
06 indicates 100HZ automatic output Corresponding data type parameter

**Note:** 1. When the automatic output frequency setting is high, the baud rate needs to be set to a high baud rate. Under some data types, 100HZ cannot be output due to the baud rate limit.
2. The automatic output data type parameter is determined according to the following data type selection command. The default is the automatic output angle.

### 2.8 Query gravitational acceleration g  Command: 77 04 00 54 58

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x54 | | |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (9byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x0D | | 0x54 | SXYYYY | |

**Note:** The data field part is the value of g value of pitch, roll, Z axis (vertical horizontal plane), which consists of 1 bit sign bit + 1 bit integer bit + 4 decimal places.
If the return value is "77 0D 00 54 00 01 07 00 94 21 10 06 30 64", they are 0.0107g, 0.9421g, -0.0630g respectively.

### 2.9 Query angular velocity  Command: 77 04 00 50 54

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x50 | | |

Command response:

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (9byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x0D | | 0x50 | SXXXYY | |

**Note**: The data field is the pitch, roll, and Z-axis (vertical horizontal) angular velocity. It consists of 1 sign bit + 3 integer bits + 2 decimal places.
For example, the return value is "77 0D 00 50 10 93 76 14 98 87 00 14 03 C0". The data field parts are: pitch axis angular velocity: -93.76°/s, roll axis angular velocity: -498.87°/s Z-axis angular velocity :+14.03°/s

### 2.10 Save settings  Command: 77 04 00 0A 0E

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x0A | | |

Command response:

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x8A | 00:success<br>FF: failure | |

**Note:** It is not necessary to save the settings to set the baud rate. Other settings need to send the save settings.

### 2.11 Quaternion  Command: 77 04 00 57 5B

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x57 | | |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (16byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x14 | | 0x57 | SXYYYYYY | |

**Note:** The data field contains 16 bytes, 4 bytes are a group, respectively quaternary q0, q1, q2, q3, which is a compressed BCD code, the format is SX YY YY YY, S is a sign bit (0 positive, 1 negative), X is a 1-bit integer bit, and YYYYYY is a 6-digit decimal place. For example, the return command
77 14 00 57 00 99 99 96 00 00 02 90 10 00 26 73 10 00 00 01 7F
Then the quaternion data are:
Where q0 is 00 99 99 96, representing 0.999996.
q1 is 00 00 02 90, which means 0.000290
q2 is 10 00 26 73, which means -0.002673
q3 is 10 00 00 01, indicating -0.000001

### 2.12 Simultaneous reading angle, accelerometer, gyroscope, quaternion Command: 77 04 00 59 5D

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (0byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x04 | | 0x59 | - | |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (43byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x2F | | 0x59 | Data field | |

**Note:** The data field contains 43 bytes, which are angle, gravitational acceleration g value, angular velocity, quaternion, compressed BCD code, four elements are the last 16 bytes, 4 bytes are a group, a total of 4 groups The rest is a group of 3 bytes, indicating the method to see the corresponding parameter return value.
For example, the return value is:
77 2F 00 59 10 00 60 10 03 06 00 00 00
10 01 07 10 05 43 01 01 54
10 00 13 10 00 04 00 00 09
10 87 06 35 00 01 76 91 00 02 06 94 00 49 11 75 5C
Then: the three axis angles are -0.6 degrees, -3.06 degrees, 0 degrees;
The g values of the three axes were -0.0107 g, -0.0543 g, and 1.0154 g, respectively;
The three angular angular velocities are -0.13 ° / s, -0.04 ° / s, 0.09 ° / s;
The four quaternions are -0.870635, 0.017691, 0.020694, 0.491175

### 2.13 Automatic output data type selection Command: 77 05 00 56 00 5B

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | | 0x56 | XX | |

Command response :

| Identifier (1byte) | Frame Length (1byte) | Address Code (1byte) | Command (1byte) | Data (1byte) | Checksum (1byte) |
|---|---|---|---|---|---|
| 0x77 | 0x05 | | 0x56 | 00 | |

**Note:** Data field XX is the corresponding output data type, which needs to be performed in automatic output mode:
0x00: When outputting automatically, the output parameter is triaxial angle data, and the output format refers to command 2.3;
0x01: When the output is automatic, the output parameter is the triaxial acceleration value, and the output format refers to the command 2.8;
0x02: When outputting automatically, the output parameter is the value of the three-axis gyroscope, and the output format refers to the command 2.9;
0x03: When outputting automatically, the output parameter is triaxial angle data (reserving other data types);
0x04: When outputting automatically, the output parameter is a quaternion value, and the output format refers to the command 2.11.
0x05: When outputting automatically, the output parameters are composed of angle, acceleration, angular velocity and four elements. The output format refers to command 2.12.

## Ordering Information

| Product number | Way of communication | Package condition |
|---|---|---|
| BW-IMU200-485 | RS 485 | IP67 Package/Metal Connector |
| BW-IMU200-232 | RS232 | IP67 Package/Metal Connector |
| BW-IMU200-TTL | TTL | IP67 Package/Metal Connector |

## Executive standard

- Enterprise Quality System Standard: ISO9001:2008 Standard (Certificate No.:10114Q16846ROS)
- CE certification (certificate number: 3854210814)
- ROHS (certificate number: SO81426003)
- GB/T 191 SJ 20873-2003 General specifications for tiltmeters and spirit levels
- GBT 18459-2001 sensor main static performance index calculation method
- JF 1059-1999 Evaluation and Expression of Measurement Uncertainty
- GBT 14412-2005 mechanical vibration and shock mechanical installation of accelerometer
- General requirements for GJB 450A-2004 equipment reliability
- Quality control of key parts and important parts of GJB 909A
- GJB 899 Reliability Qualification and Acceptance Test
- GJB 150-3A high temperature test
- GJB 150-4A low temperature test
- GJB 150-8A rain test
- GJB 150-12A dust test
- GJB 150-16A vibration test
- GJB 150-18A impact test
- GJB 150-23A Tilt and Swing Test
- GB/T 17626-3A RF electromagnetic radiation immunity test
- GB/T 17626-5A surge (hit) impulse immunity test
- GB/T 17626-8A power frequency magnetic field immunity test
- GB/T 17626-11A voltage dips, short interruptions and voltage changes immunity

# BW-IMU200 Serials

## Low-cost inertial measurement unit

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