# Bluetooth AHRS IMU sensor | BS-IW11-BLE

The Robust Acceleration, Angular velocity, Angle & Magnetic filed Detector

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The BS-IW11-BLE is a Bluetooth 5.0 multi-sensor device, detecting acceleration, angular velocity, angle as well as magnetic filed. The robust housing and the small outline makes it perfectly suitable for industrial applications such as condition monitoring and predictive maintenance. Configuring the device enables the customer to address a broad variety of application by interpreting the sensor data by smart algorithms and Kalman filtering.
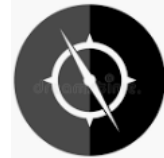
BUILT-IN SENSORS
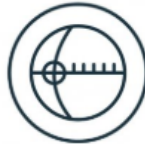
Accelerometer   Gyroscope   Magnetometer

Application

- Unmanned/Assisted Driving

- Large-scale farming automated farming

- Safety monitoring for working at heights

- Unmanned aerial vehicle

- Industrial attitude monitoring

- Human motion tracking/capture

- Robot, Automated Guided Transporter

- Pedestrian Navigation

- Truck-mounted Satellite Antenna Equipment

Contents

1 Overview

BS-IW11-BLE's scientific name is AHRS IMU sensor. A sensor measures 3-axis angle, angular velocity, acceleration, magnetic field. Its strength lies in the algorithm which can calculate three-axis angle accurately.

BS-IW11-BLE is an CE certified accelerometer. It is employed where the highest measurement accuracy is required. BS-IW11-BLE offers several advantages over competing sensor:

• High precision Roll Pitch Yaw (X Y Z axis) Acceleration + Angular Velocity + Angle + Magnetic Field output

2 Features

- The sensor integrates high-precision gyroscope, accelerometer and geomagnetic field sensor, and adopts high-performance microprocessor and advanced dynamic calculation and Kalman dynamic filtering algorithm, which can quickly solve the current real-time motion attitude of the sensor.
- The advanced digital filtering technology can effectively reduce the measurement noise and improve the measurement accuracy.
- The sensor is integrated with the attitude solver and the dynamic Kalman filter algorithm, which can accurately output the current attitude of the sensor in the dynamic environment. The attitude measurement accuracy is 0.2 degree, the stability is extremely high, and the performance is even better than some professional inclination meter.
- The Z-axis heading angle is added to the filter fusion of the geomagnetic sensor, which solves the cumulative error caused by the drift of the gyroscope integral in the 6-axis algorithm, and can output the heading angle data stably for a long time. Note: Due to the magnetic field detection, it needs to be calibrated before use, and it needs to be at least 20cm away from magnetic interference areas, electronic equipment, magnets, speakers and other hard magnetic objects.
- Working current: ≈ 14mA, standby current 14uA-30uA.
- Data interface: baud rate 115200.
- The output content can be selected arbitrarily, data output frequency: 0.2Hz~200Hz, ,default 10HZ.
- Bluetooth 5.0 wireless transmission, transmission stability, the longest distance up to 90 meters.
- Bluetooth 5.0: Support Android /IOS operating system (the actual use depends on the final device)
- battery: working time: 8 hours, charging time: 2 hours, capacity: 130mAh

3 Specification

3.1 Parameter

Parameter	Specification
➤ Voltage	3.3-5V
➤ Current	Working current:14mA Broadcast current:21mA Stand-by current:14uA-30uA
➤ Range	Acceleration: ±16g Angular Velocity: ±2000°/s Magnetic field: ±2Gauss Angle:X/Z±180°,Y±90°
➤ Resolution	Acceleration:0.5mg/LSB(2048LSB/g) Angular Velocity:0.061(°/s)/LSB Magnetic field:0.0667mG/LSB Angle:0.0055 °/LSB
➤ Accuracy	acceleration: 0.01g, angular speed 0.2°/s
➤ Output content	Acceleration, Angular Velocity, Angle (Magnetic is not output by default)
➤ Distance	up to 90 meters (open area)
➤ Battery	working time: 8 hours, charging time: 2 hours, capacity: 130mAh
➤ Duration	8 hours
➤ Size	23.5mm x 32.5mm x 11.4mm
➤ Weight	9g
➤ Data	Angle: X Y Z, 3-axis Acceleration: X Y Z, 3-axis Angular Velocity: X Y Z, 3-axis Magnetic Field : X Y Z, 3-axis Time, Quaternion
➤ Output frequency	0.2Hz--200Hz, default 10HZ
➤ Interface	Bluetooth5.0/Type-C
➤ Bluetooth	Bluetooth Coverage range: ≤90m Built-in Chip: nRF52832

Measurement Range & Accuracy		
Sensor	Measurement Range	Accuracy/ Remark
➢ Accelerometer	X, Y, Z, 3-axis ±16g	Accuracy: 0.01g Resolution: 16bit Stability: 0.005g
➢ Gyroscope	X, Y, Z, 3-axis ±2000°/s	Resolution: 16bit Stability: 0.05°/s
➢ Magnetometer	X, Y, Z, 3-axis ±4900µT	0.15µT/LSB typ. (16-bit)
➢ Angle/ Inclinometer	X, Y, Z, 3-axis X, Z-axis: ±180° Y ±90° (Y-axis 90° is singular point)	Accuracy:X, Y-axis: 0.05° Z-axis: 1°(after magnetic calibration)

3.2 Size
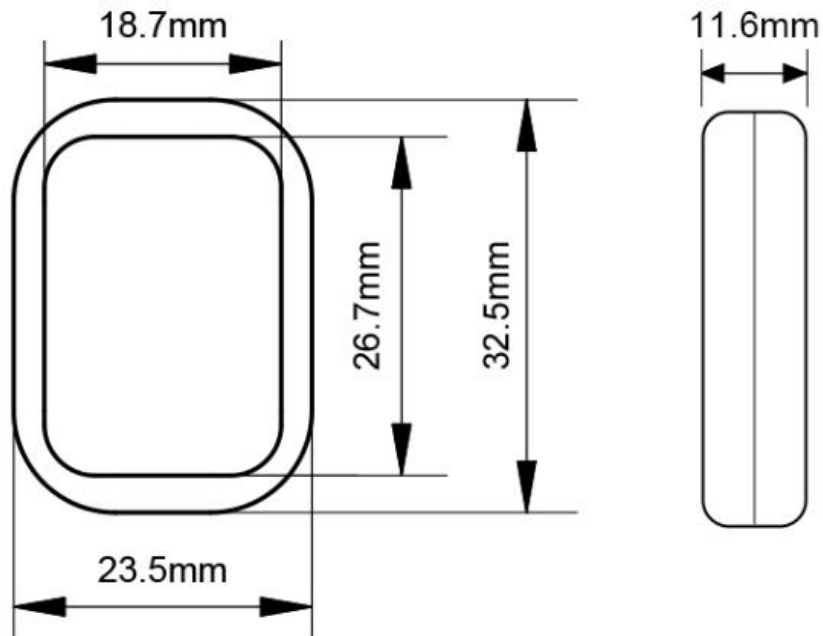
Parameter	Specification	Tolerance	Comment
Length	32.5	±0.2	Unit: millimeter.
Width	23.5	±0.2	
Height	11.6	±0.2	
Weight	9	±0.2	Unit: gram

3.3 Axial Direction

As shown in the product size drawing.The direction of rotation is defined by the rule of the right hand, that is, the thumb of the right hand points to the axis, and the direction of the four fingers bending is the direction of rotation around the axis.
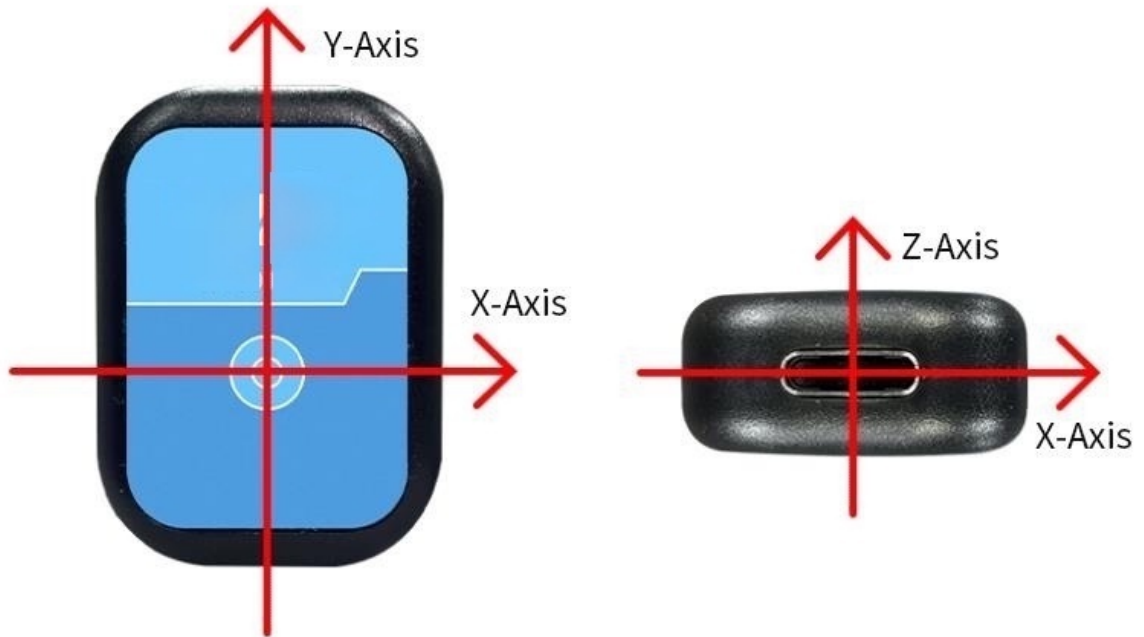
4 Port Definition

PIN	Function
➢ Type-C	3.3-5V input supply

5 Casing Specification
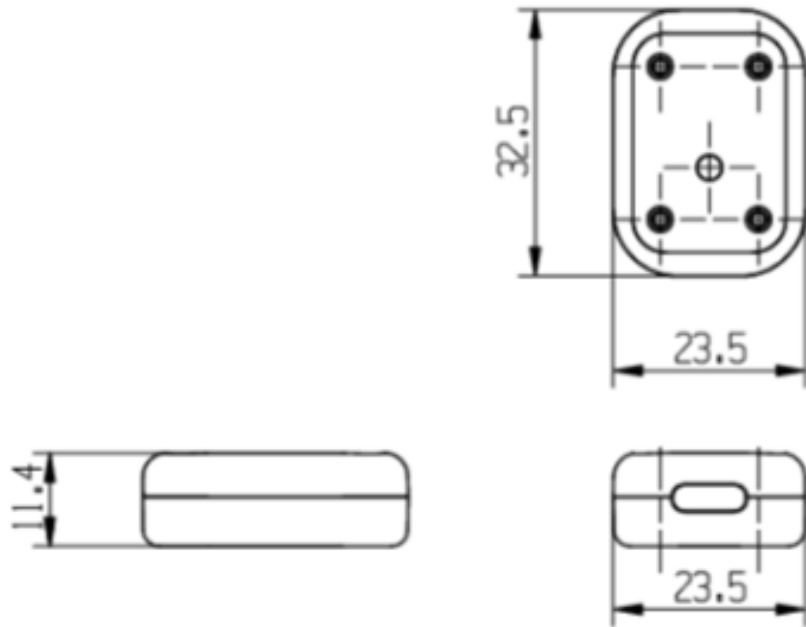
32.5

23.5

11.4

23.5

6 Communication Protocol

6.1 Data Format

Sensor upload Flag=0x61 (Angle, Angular velocity, Acceleration) data default.

Flag=0x71(Magnetic field) need to send the corresponding register instruction.

Upload data format of Bluetooth: uploads up to 20 bytes per data

6.1.1 Data Packet(Default)

Packet heading 1Byte	Flag bit 1Byte	axL	axH	……	YawL	YawH
0x55	Flag	0xNN	0xNN	……	0xNN	0xNN

Note: 0xNN is an accurate value received. Data return sequence: Acceleration X Y Z, Angular velocity X Y Z, Angle X Y Z, low byte first, high byte last.

Flag = 0x61 Data content: 18Byte is Acceleration, Angular velocity, Angle.

0x55		Packet header
0x61		Mark bit
axL		X Acceleration low 8 byte
axH		X Acceleration high 8 byte
ayL		Y Acceleration low 8 byte
ayH		Y Acceleration high 8 byte
azL		Z Acceleration low 8 byte
azH		Z Acceleration high 8 byte
wxL		X Angular velocity low 8 byte
wxH		X Angular velocity high 8 byte
wyL		Y Angular velocity low 8 byte
wyH		Y Angular velocity high 8 byte
wzL		Z Angular velocity low 8 byte
wzH		Z Angular velocity high 8 byte
RollL		X Angle low 8 byte
RollH		X Angle high 8 byte
PitchL		Y Angle low 8 byte
PitchH		Y Angle high 8 byte
YawL		Z Angle low 8 byte
YawH		Z Angle high 8 byte

Acceleration calculation method: Unit: g

$a_x=((axH<<8)|axL)/32768*16g$(g is Gravity acceleration, 9.8m/s^2)
$a_y=((ayH<<8)|ayL)/32768*16g$(g is Gravity acceleration, 9.8m/s^2)
$a_z=((azH<<8)|azL)/32768*16g$(g is Gravity acceleration, 9.8m/s^2)

Angular Calculation method: Unit:°/s

$w_x=((wxH<<8)|wxL)/32768*2000(°/s)$
$wy=((wyH<<8)|wyL)/32768*2000(°/s)$
$wz=((wzH<<8)|wzL)/32768*2000(°/s)$

Angle Calculation method: Unit: °

Roll(X axis)Roll=((RollH<<8)|RollL)/32768*180(°)
Pitch(Y axis)Pitch=((PitchH<<8)|PitchL)/32768*180(°)
Yaw angle(Z axis)Yaw=((YawH<<8)|YawL)/32768*180(°)

Note:

1.   The coordinate system used in the settlement of attitude Angle is the northeast sky coordinate system, and the sensor is placed in the positive direction. As shown in "4 pin Description", the left axis is the X axis, the forward axis is the Y axis, and the upward axis is the Z axis.When Euler Angle represents the attitude, the rotation order of the coordinate system is defined as Z-Y-x, that is, first rotate around the Z axis, then rotate around the Y axis, then rotate around the X axis.

2.   Although the range of the roll Angle is ±180 degrees, in fact, because the coordinate rotation order is Z-Y-X, the range of the pitch Angle (Y-axis) is only ±90 degrees when the attitude is expressed. When it exceeds 90 degrees, it will be changed to less than 90 degrees, and the Angle of the X-axis will be greater than 180 degrees.The detailed principle please Baidu Euler Angle and attitude of the relevant information.

3. Since the three axes are coupled, they only exhibit independent changes when the Angle is small, and the attitude Angle will change coupled when the Angle is large. For example, when the Y-axis is close to 90 degrees, even if the attitude only rotates around the Y-axis, the Angle of the X-axis will also change greatly, which is the inherent characteristic of the attitude represented by Euler Angle.

Description:
1. The data is sent in hexadecimal not ASCII code.
2. Each data is transmitted in order of low byte and high byte, and the two are combined into a signed short type data. For example, the X-axis acceleration data Ax, where AxL is the low byte and AxH is the high byte. The conversion method is as follows:

For example:
Assuming that Data is actual data, DataH is the high byte part, and DataL is the low byte part, then: Data = ((short) DataH << 8) | DataL. It must be noted here that DataH needs to be converted to a signed short data first and then shifted, and the data type of Data is also a signed short type, so that it can represent negative numbers.

6.1.2 Single Return Register Data Packet

Single return data packet needs to send register instruction first:

FF   AA   27   XX   00

--XX is register number. The register number please refer to 7.3. Example as below:

Function	Instruction
Read Magnetic Field	FF AA 27 3A 00
Read Quaternion	FF AA 27 51 00
Read Temperature	FF AA 27 40 00
Read the amount of electricity	FF AA 27 64 00
Read the version number	FF AA 27 2E 00
	FF AA 27 2F 00

After sending the instructions, the sensor will turn back a data packet 0x55 0x71. There are register addresses and 7 registers data (Fixed upload 8 registers). Return data format as below:

Start register(2 byte) + register data(16 byte, 8 registers)

Packet header	Sign	Start register low byte	Start register high byte	Start (No.1) register data low byte	Start (No.1) register data high byte	......	No.8 register data low byte	No.8 register data high byte
0x55	0x71	RegL	RegH	0xNN	0xNN	......	0xNN	0xNN

Note: 0xNN is the specific value received, with the low byte first and the high byte second.

6.1.2.1 Magnetic Field Output

Note: The unit of magnetic field data calculated from raw data is milligauss, which is different from the unit displayed on the computer. If you need to convert the unit to the same as the computer, you need to calculate it

0x55	0x71	0x3A	0x00	HxL	HxH	HyL	HyH	HzL	HzH	……

Calculated formular：Unit: mG

Magnetic field (x axis) Hx=((HxH<<8)| HxL)
Magnetic field (y axis) Hy=((HyH <<8)| HyL)
Magnetic field (z axis) Hz =((HzH<<8)| HzL)

For example: Send instruction to read magnetic field in APP: FF AA 27 3A 00 (Please refer to 6.1.2)
The sensor return data to APP: 55, 71 00 68 01 00 69 3 a 7 a 00 00 00 00 00 00 00 00 00 00 00, a total of 20 bytes.

Calculate the no.5 to no.10 bytes as described above, magnetic field x=360, y=105, z=122

6.1.2.2 Quaternion Output

0x55	0x71	0x51	0x00	Q0L	Q0H	Q1L	Q1H	Q2L	Q2H	Q3L	Q3H

Calculated formular：

Q0=((Q0H<<8)|Q0L)/32768
Q1=((Q1H<<8)|Q1L)/32768
Q2=((Q2H<<8)|Q2L)/32768
Q3=((Q3H<<8)|Q3L)/32768

Checksum：

Sum=0x55+0x59+Q0L+Q0H+Q1L +Q1H +Q2L+Q2H+Q3L+Q3H

6.1.2.3 Temperature Output

0x55	0x71	0x40	0x00	TL	TH	......

Calculated formular：

$T=((TH<<8)|TL) /100℃$

6.1.2.4 Temperature Output

0x55	0x71	0x2E	0x00	Version1L	Version1H	......
0x55	0x71	0x2F	0x00	Version2L	Version2H	......

Version number calculation formula:
Version1=((Version1H<<8)|VersionL1)
VERSION=Version1.Version2H.Version2L

6.2 Commands

6.2.1 Read Register Value

FF AA 27 XX 00	Read register value

--XX is register.
For example::
Read magnetic field：FF AA 27 3A 00
Read quaternion：   FF AA 27 51 00
Read temperature：FF AA 27 40 00

After sending this instruction, the sensor will send back a data packet starting with 0x55 0x71, which contains the data of the corresponding start register address, the start register address and the following 7 registers (8 registers are fixed to be uploaded). The format of the return data is referred to 7.1.2.

6.2.2 Calibration

FF AA 01 01 00	Accelerometer Calibration
FF AA 01 07 00	Magnetic Field Calibration
FF AA 01 00 00	Complete Magnetic Field Calibration

For example, to calibrate the magnetic field,
Step 1. Send FF AA 01 07 00

Step 2. Rotate the sensor 360 degree around three axis
(it is recommended to rotate 3 circle, 360 degree *3)

Step 3. Send FF AA 01 00 00 to quit the calibration

6.2.3 Save Settings

FF AA 00 SAVE 00	Save Settings

SAVE：Set
   0：Save current configuration
   1：Restore default configuration and save

6.2.4 Return Rate

FF AA 03 RATE 00	Set return rate

RATE：return rate
   0x01：0.2Hz
   0x02：0.5Hz
   0x03：1Hz
   0x04：2Hz
   0x05：5Hz
   0x06：10Hz(default)
   0x07：20Hz
   0x08：50Hz
   0x09: 100Hz
   0x0B: 200Hz
   0x0C: Single return

6.2.4 Return Rate

FF AA 27 64 00	Reading sensor power

The corresponding relationship between voltage and power percentage is:

Register value	Voltage value	Battery percentage
>396	> 3.96V	100%
393-396	3.93V-3.96V	90%
387-393	3.87V-3.93V	75%
382-387	3.82V-3.87V	60%
379-382	3.79V-3.82V	50%
377-379	3.77V-3.79V	40%
373-377	3.73V-3.77V	30%
370-373	3.70V-3.73V	20%
368-370	3.68V-3.70V	15%
350-368	3.50V-3.68V	10%
340-350	3.40V-3.50V	5%
<340	<3.40V	0%

6.3 Register Address

Address	Symbol	Function
0x00	SAVE	Save the current configuration
0x01	CALSW	The calibration
0x03	RATE	Data return rate
0x05	AXOFFSET	The X-axis acceleration is zero partial
0x06	AYOFFSET	The Y-axis acceleration is zero offset
0x07	AZOFFSET	The z-axis acceleration is zero offset
0x08	GXOFFSET	The X-axis angular velocity is zero offset
0x09	GYOFFSET	The Y-axis angular velocity is zero offset
0x0a	GZOFFSET	The Z axis angular velocity is zero offset

0x0b	HXOFFSET	The X-axis magnetic field is zero offset
0x0c	HYOFFSET	Y-axis magnetic field zero deviation
0x0d	HZOFFSET	Z-axis magnetic field zero deviation
0x30	YYMM	Year and month
0x31	DDHH	Day and hour
0x32	MMSS	Minutes, seconds
0x33	MS	ms
0x34	AX	X axis acceleration
0x35	AY	Y-axis acceleration
0x36	AZ	Z axis acceleration
0x37	GX	X angular velocity
0x38	GY	Y-axis angular velocity
0x39	GZ	Z axis angular velocity
0x3a	HX	X-axis magnetic field
0x3b	HY	Y-axis magnetic field
0x3c	HZ	Z axis magnetic field
0x3d	Roll	X axis Angle
0x3e	Pitch	Y axis Angle
0x3f	Yaw	Z axis Angle
0x51	Q0	Four elements Q0
0x52	Q1	Four elements Q1
0x53	Q2	Four element Q2
0x54	Q3	Four elements Q3
0x04	BAUD	Serial port baud rate
0x2e	VERSION1	version number
0x2f	VERSION2	Firmware version number branch Hardware version number