WitMotion Shenzhen Co., Ltd | Datasheet

Bluetooth AHRS IMU sensor | WT901BLECL

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

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The WT901BLECL 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

Tutorial Link

[Google Drive]

Link to instructions DEMO:

WITMOTION Youtube Channel WT901BLECL Playlist *（Android/IOS/PC）*

If you have technical problems or cannot find the information that you need in the provided documents, please contact our support team. Our engineering team is committed to providing the required support necessary to ensure that you are successful with the operation of our AHRS sensors.

Contact

Technical Support Contact Info

Application

- AGV Truck
- Platform Stability
- Auto Safety System
- 3D Virtual Reality
- Industrial Control
- Robot
- Car Navigation
- UAV
- Truck-mounted Satellite Antenna Equipment

Contents

1 Overview

WT901BLECL'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.

WT901BLECL is an CE certified accelerometer. It is employed where the highest measurement accuracy is required. WT901BLECL offers several advantages over competing sensor:

• Heated for best data availability: new WITMOTION patented zero-bias automatic detection calibration algorithm outperforms traditional accelerometer sensor

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

• Low cost of ownership: remote diagnostics and lifetime technical support by WITMOTION service team

• Developed tutorial: providing manual, datasheet, demo video, free software for Windows computer, APP for Android smartphones, iOS APP for iPhone, communication protocol for project development

• WITMOTION sensors have been praised by thousands of engineers as a recommended attitude measurement solution

2 Features

- Built-in WT901BLE module, for detailed parameters, please refer to the instructions.

- The baud rate of this device is 115200 and cannot be changed.

- The module consists of a high precision gyroscope, accelerometer and geomagnetic field sensor. The product can solve the current real-time motion posture of the module quickly by using the high-performance microprocessor, advanced dynamic solutions and Kalman filter algorithm.

- The advanced digital filtering technology of this product can effectively reduce the measurement noise and improve the measurement accuracy.

- Maximum 200Hz data output rate. Output content can be arbitrarily selected,the output speed 0.1Hz~ 200Hz adjustable.

3 Specification

3.1 Parameter

Parameter	Specification
➢ Voltage	3.3V-5V
➢ Current	<40mA
➢ Battery	250mAh, 3.7V
➢ Working hour	A. Play 10h at 1 charge (battery) B. Power source of 5V
➢ Size	51.3mm x36mm X15mm/ 2.02" x 1.41" x 0.59"
➢ 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	0.1Hz--200Hz
➢ Interface	Type-C
➢ Bluetooth	Bluetooth Coverage range: ≤50m Built-in Chip: nRF52832 Version: nRF Bluetooth 5.0
➢ Baud rate	115200(default, can not be changed)

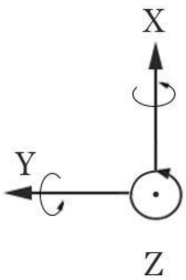
Measurement Range & Accuracy		
Sensor	Measurement Range	Accuracy/ Remark
➢ Accelerometer	X, Y, Z, 3-axis ±16g	Accuracy: 0.01g Resolution: 16bit Stability: 0.005g
➢ Gyroscope	X, Y, Z, 3-axis ±2000°/s	Resolution: 16bit Stability: 0.05°/s
➢ Magnetometer	X, Y, Z, 3-axis ±4900μT	0.15μT/LSB typ. (16-bit)
➢ Angle/ Inclinometer	X, Y, Z, 3-axis X, Z-axis: ±180° Y ±90° (Y-axis 90° is singular point)	Pitch and roll angle accuracy: 0.2° Heading accuracy: 9-axis:1° (without interference from magnetic field) 6-axis algorithm, static: 0.5° (there is an integral cumulative error in dynamic)

3.2 Size

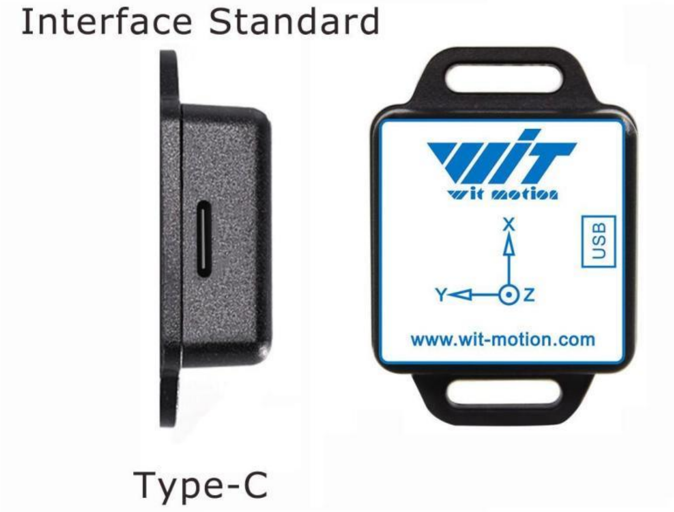
Parameter	Specification	Tolerance	Comment
Length	51.3	±0.2	Unit: millimeter.
Width	36	±0.2	
Height	15	±0.2	
Weight	20	±0.2	Unit: gram

3.3 Axial Direction

The coordinate system used for attitude angle settlement is the northeast sky coordinate system. Place the module in the positive direction, as shown in the figure below, direction forward is the X-axis, the direction left is the Y-axis, and direction upward is the Z-axis. Euler angle represents the rotation order of the coordinate system when the attitude is defined as Z-Y-X, that is, first turn around the Z-axis, then turn around the Y-axis, and then turn around the X-axis. Counterclockwise rotation is positive.

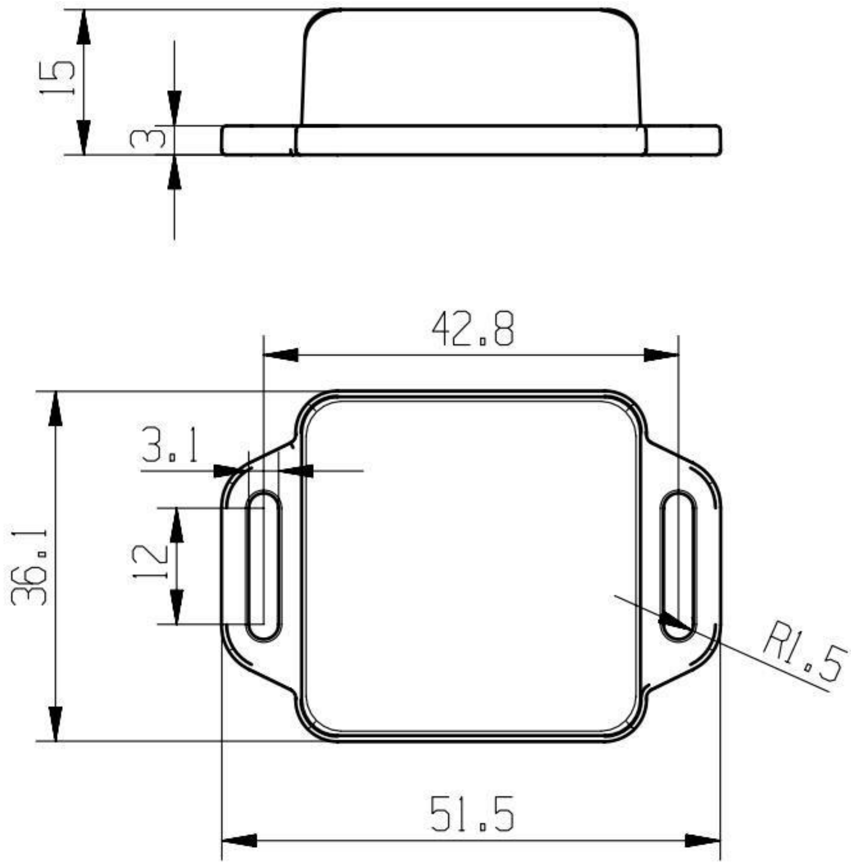


4 Port Definition



PIN	Function
➢ Type-C	3.3-5V input supply Wired Connection with TTL Singal Communication

5 Casing Specification



6 Communication Protocol

6.1 Data Format

Module 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	Flag 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 for attitude angle settlement is the northeast sky coordinate system. Place the module in the positive direction, as shown in Chapter 3.3, direction forward is the X-axis, the direction left is the Y-axis, and direction upward is the Z-axis. Euler angle represents the rotation order of the coordinate system when the attitude is defined as Z-Y-X, that is, first turn around the Z-axis, then turn around the Y-axis, and then turn around the X-axis.

2. Although the range of the roll angle is ± 180 degrees, in fact, since the coordinate rotation sequence is Z-Y-X, when expressing the attitude, the range of the pitch angle (Y-axis) is only ± 90 degrees, and it will change to less than 90 after exceeding 90 degrees Degrees while making the X-axis angle greater than 180 degrees. For detailed principles, please Google Euler angle and posture-related information.

3. Since the three axes are coupled, they will show independent changes only at small angles, and the attitude angles will change at large angles. 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 axis will also change greatly, which is an inherent problem with Euler angles indicating attitude.

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 6.3. 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 power	FF AA 27 64 00

After sending the instructions, the module 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 an accurate value, low byte first, high byte last.

6.1.2.1 Magnetic Field Output

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 module return data to APP: 55 71 3A 00 68 01 69 00 7A 00 00 00 00 00 00 00 00 00 00 00 Total: 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℃

6.2 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 send instructions, the module turns back a data packet 0x55 0x71. There are register addresses and 7 registers data (Fixed upload 8 registers).

6.2.2 Calibration

FF AA 01 01 00	Accelerometer Calibration
FF AA 01 07 00	Magnetic Calibration
FF AA 01 00 00	Quit the calibration
FF AA 01 05 00	Accelerometer Calibration L
FF AA 01 06 00	Accelerometer Calibration R

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

0x01：0.1Hz

0x02：0.5Hz

0x03：1Hz

0x04：2Hz

0x05：5Hz

0x06：10Hz(default)

0x07：20Hz

0x08：50Hz

0x09：100Hz

0x0A：200Hz

6.2.5 Read voltage

FF AA 27 64 00	Read module voltage

6.3 Register Address

Address	Symbol	Function
0x00	SAVE	Save current configuration
0x01	CALSW	Calibration
0x02	RSV	Reserved
0x03	RATE	Return rate
0x04	BAUD	UART Baud rate
0x05	AXOFFSET	X Acceleration zero offset
0x06	AYOFFSET	Y Acceleration zero offset
0x07	AZOFFSET	Z Acceleration zero offset
0x08	GXOFFSET	X Angular velocity zero offset
0x09	GYOFFSET	Y Angular velocity zero offset
0x0a	GZOFFSET	Z Angular velocity zero offset
0x0b	HXOFFSET	X Magnetic field zero offset
0x0c	HYOFFSET	Y Magnetic field zero offset
0x0d	HZOFFSET	Z Magnetic field zero offset
0x0e	D0MODE	D0
0x0f	D1MODE	D1
0x10	D2MODE	D2
0x11	D3MODE	D3
0x12	RSV	Reserved
0x13	RSV	Reserved
0x14	RSV	Reserved
0x15	RSV	Reserved
0x16	RSV	Reserved
0x17	RSV	Reserved
0x18	RSV	Reserved
0x19	RSV	Reserved
0x1a	RSV	Reserved
0x1b	RSV	Reserved
......	......	......
0x30	YYMM	Year, Month
0x31	DDHH	Date, Hour
0x32	MMSS	Minute, Second
0x33	MS	Millisecond

0x34	AX	X Acceleration
0x35	AY	Y Acceleration
0x36	AZ	Z Acceleration
0x37	GX	X Angular velocity
0x38	GY	Y Angular velocity
0x39	GZ	Z Angular velocity
0x3a	HX	X Magnetic field
0x3b	HY	Y Magnetic field
0x3c	HZ	Z Magnetic field
0x3d	Roll	X Angle
0x3e	Pitch	Y Angle
0x3f	Yaw	Z Angle
0x40	TEMP	Module temperature
0x41	D0Status	D0 Status
0x42	D1Status	D1 Status
0x43	D2Status	D2 Status
0x44	D3Status	D3 Status
0x49	RSV	Reserved
0x4a	RSV	Reserved
0x4b	RSV	Reserved
0x4c	RSV	Reserved
0x4d	RSV	Reserved
0x4e	RSV	Reserved
0x4f	RSV	Reserved
0x50	RSV	Reserved
0x51	Q0	Quaternion Q0
0x52	Q1	Quaternion Q1
0x53	Q2	Quaternion Q2
0x54	Q3	Quaternion Q3