

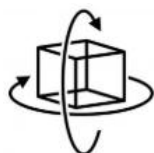
## Bluetooth AHRS IMU sensor | BWT61CL

*The Robust Acceleration, Angular Velocity, Angle Detector*

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*The BWT61CL is a Bluetooth 2.0 multi-sensor device, detecting acceleration, angular velocity, as well as angle. 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



## Tutorial Link

[Google Drive](#)

**Link to instructions DEMO:**

[WITMOTION Youtube Channel](#)

[BWT61CL Playlist](#)

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

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# 1 Overview

BWT61CL's scientific name is AHRS IMU sensor. A sensor measures 3-axis angle, angular velocity, acceleration. Its strength lies in the algorithm which can calculate three-axis angle accurately.

BWT61CL is an CE certified accelerometer. It is employed where the highest measurement accuracy is required. BWT61CL 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 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 , and sample code for MCU integration including 51 serial, STM32, Arduino, Matlab, Raspberry Pi, communication protocol for project development
- WITMOTION sensors have been praised by thousands of engineers as a recommended attitude measurement solution



## 2 Features

- Built-in WT61 module, for detailed parameters, please refer to the instructions.
- The baud rate of this device is 115200 and cannot be changed.
- The interface of this product only leads to a serial port, expansion port function is not available.
- The module consists of a high precision gyroscope and accelerometer 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.
- The attitude solver is integrated into the module, and the dynamic Kalman filter algorithm can accurately output the current attitude of the module in the dynamic environment.
- Maximum 100Hz data output rate. Output content can be arbitrarily selected, the output speed 100HZ .

## 3 Specification

### 3.1 Parameter

Parameter	Specification
➤ Voltage	3.3V-5V
➤ Current	<40mA
➤ Battery	250mAh, 3.7V
➤ Working hour	A.4h every charge(battery) B.Power source of 5V
➤ Size	51.3mm x36mm X15mm/ 2.02" x 1.41" x 0.59"
➤ Output content	Angle: X Y Z, 3-axis Acceleration: X Y Z, 3-axis Angular Velocity: X Y Z, 3-axis Time
➤ Output frequency	100Hz
➤ Interface	Serial TTL level Baud rate--115200 (default, can not be changed ) Interface standard: SH2.54-4P
➤ Bluetooth	Range: ≤10m Built-in Chip: HC-06 Version: EDR Bluetooth 2.0

## 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
➤ Angle/ Inclinator	X, Y, Z, 3-axis X, Z axis: ±180° Y axis: ±90° (Y-axis 90° is singular point)	Accuracy: X, Y-axis: 0.05° Z-axis: 1° Angle of Z-axis will have accumulated error

## 3.2 Size

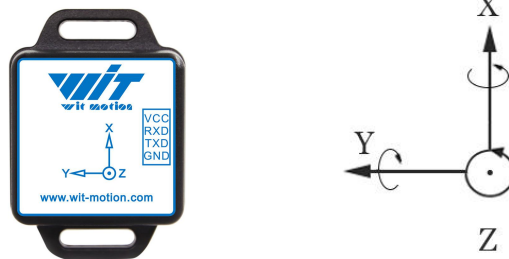


Parameter	Specification	Tolerance	Comment
Length	51.3	$\pm 0.2$	Unit: millimeter.
Width	36	$\pm 0.2$	
Height	15	$\pm 0.2$	
Weight	20	$\pm 0.2$	Unit: gram



### 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 Pin Definition

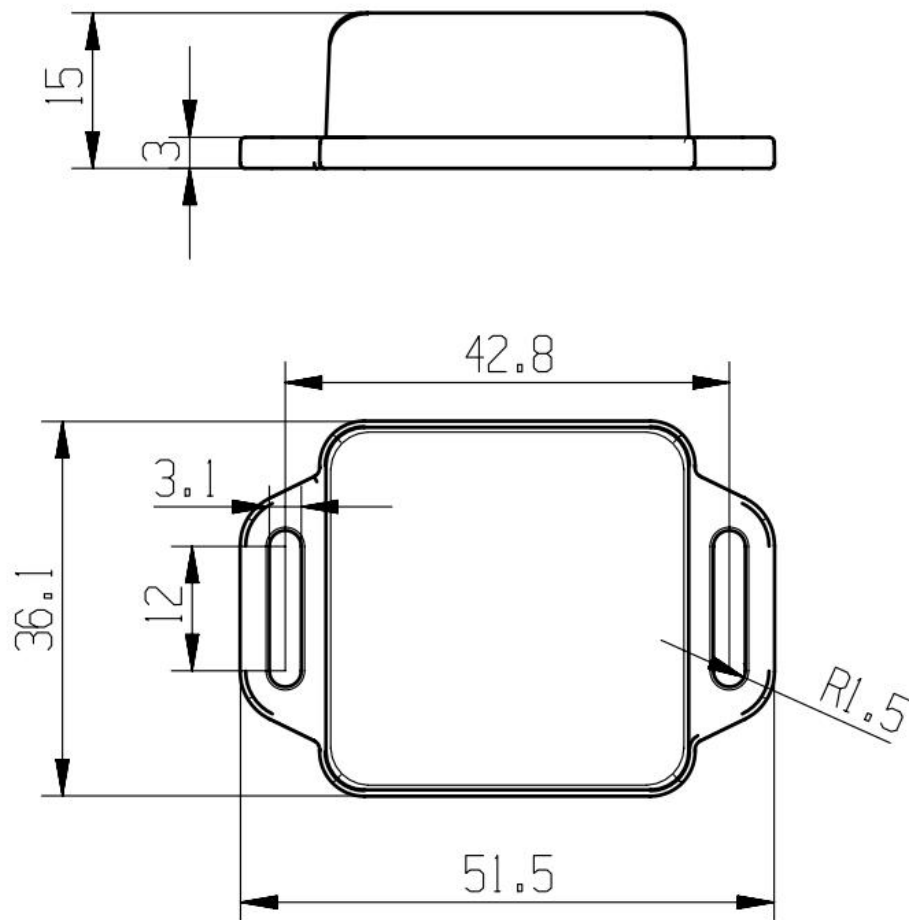
Interface Standard



XH2.54-4P

PIN	Function
➤ VCC	3.3-5V input supply
➤ RX	Serial data input, TTL interface
➤ TX	Serial data output, TTL interface
➤ GND	Ground

## 5 Casing Specification





## **6 Communication Protocol**

Level : TTL level

Band rate : 115200, Stop bit 1, check digit 0.

### **6.1 Output Data Format**

### 6.1.1 Acceleration Output

Data Number	Data Content	Implication
0	0x55	Header of packet
1	0x51	Acceleration pack
2	AxL	X axis acceleration low type
3	AxH	X axis acceleration high type
4	AyL	Y axis acceleration low type
5	AyH	Y axis acceleration high type
6	AzL	Z axis acceleration low type
7	AzH	Z axis acceleration high type
8	TL	Temperature low type
9	TH	Temperature high type
10	Sum	Checksum

Formula for calculating acceleration:

$ax = ((AxH < 8) | AxL) / 32768 * 16g$  (g is gravity acceleration, 9.8m/s<sup>2</sup>)

$ay = ((AyH < 8) | AyL) / 32768 * 16g$  (g is gravity acceleration, 9.8m/s<sup>2</sup>)

$az = ((AzH < 8) | AzL) / 32768 * 16g$  (g is gravity acceleration, 9.8m/s<sup>2</sup>)

Formula for calculating temperature:

$T = ((TH < 8) | TL) / 340 + 36.53^{\circ}C$

Checksum:

$Sum = 0x55 + 0x51 + AxH + AxL + AyH + AyL + AzH + AzL + TH + TL$

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:

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 Angular Velocity Output

Data Number	Data Content	Implication
0	0x55	Header of packet
1	0x52	Angular velocity
2	wxL	X axis angular low type
3	wxH	X axis angular high type
4	wyL	Y axis angular low type
5	wyH	Y axis angular high type
6	wzL	Z axis angular low type
7	wzH	Z axis angular high type
8	TL	Temperature low type
9	TH	Temperature high type
10	Sum	Checksum

Formula for calculating angular velocity:

$$wx = ((wxH < 8) | wxL) / 32768 * 2000 (^\circ/s)$$

$$wy = ((wyH < 8) | wyL) / 32768 * 2000 (^\circ/s)$$

$$wz = ((wzH < 8) | wzL) / 32768 * 2000 (^\circ/s)$$

Formula for calculating temperature:

$$T = ((TH < 8) | TL) / 340 + 36.53 ^\circ C$$

Checksum:

$$Sum = 0x55 + 0x52 + wxH + wxL + wyH + wyL + wzH + wzL + TH + TL$$

### 6.1.3 Angle Output

Data Number	Data Content	Implication
0	0x55	Header of packet
1	0x53	Angle packet
2	RollL	X axis angle low type
3	RollH	X axis angle high type
4	PitchL	Y axis angle low type
5	PitchH	Y axis angle high type
6	YawL	Z axis angle low type
7	YawH	Z axis angle high type
8	TL	Temperature low type
9	TH	Temperature high type
10	Sum	Checksum

Formula for calculating angle:

Roll angle(x axis)  $\text{Roll} = ((\text{RollH} < 8) | \text{RollL}) / 32768 * 180(^{\circ})$

The pitching angle(y axis)  $\text{Pitch} = ((\text{PitchH} < 8) | \text{PitchL}) / 32768 * 180(^{\circ})$

Yaw angle(zaxis)  $\text{Yaw} = ((\text{YawH} < 8) | \text{YawL}) / 32768 * 180(^{\circ})$

Formula for calculating temperature:

$T = ((\text{TH} < 8) | \text{TL}) / 340 + 36.53^{\circ}\text{C}$

Checksum:

$\text{Sum} = 0x55 + 0x53 + \text{RollH} + \text{RollL} + \text{PitchH} + \text{PitchL} + \text{YawH} + \text{YawL} + \text{TH} + \text{TL}$

Attention:

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 on Chapter 3.3, direction right is the X-axis, the direction forward 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.

## 6.2 Config Commands

Instruction content	Function	Remark
0xFF 0xAA 0x52	Angle initialization	Z-axis to 0
0xFF 0xAA 0x67	Accelerometer Calibration	X,Y axis to 0
0xFF 0xAA 0x60	Dormancy/break dormancy	Standby state/working state
0xFF 0xAA 0x61	Use serial port, disable IIC	Set to serial output
0xFF 0xAA 0x62	Disable serial port, use IIC	Set to IIC interface output
0xFF 0xAA 0x65	Horizontal installation	Horizontal placed
0xFF 0xAA 0x66	Vertical installation	Vertical placed

Introductions :

1. When the module is on, it needs to be static first. Because the MCU inside the module will be automatically calibrated when it is static. After calibration, the angle of the Z-axis will be initialized to 0, Which can be considered as a signal that has been calibrated.
2. The factory default setting uses a serial port with a baud rate of 115200 and a frame rate of 100Hz. Configuration can be configured through the host computer software, because all configurations are saved after power-off, so only need to configure once.



## 6.3 Data Analysis and Sample Code

```
double a[3],w[3],Angle[3],T;

void DecodeIMUData(unsigned char chrTemp[])

{

    switch(chrTemp[1])

    {

        case 0x51:

            a[0] = (short(chrTemp[3]<<8|chrTemp[2]))/32768.0*16;

            a[1] = (short(chrTemp[5]<<8|chrTemp[4]))/32768.0*16;

            a[2] = (short(chrTemp[7]<<8|chrTemp[6]))/32768.0*16;

            T = (short(chrTemp[9]<<8|chrTemp[8]))/340.0+36.25;

            break;

        case 0x52:

            w[0] = (short(chrTemp[3]<<8|chrTemp[2]))/32768.0*2000;

            w[1] = (short(chrTemp[5]<<8|chrTemp[4]))/32768.0*2000;

            w[2] = (short(chrTemp[7]<<8|chrTemp[6]))/32768.0*2000;

            T = (short(chrTemp[9]<<8|chrTemp[8]))/340.0+36.25;

            break;

        case 0x53:

            Angle[0] = (short(chrTemp[3]<<8|chrTemp[2]))/32768.0*180;
```

```
Angle[1] = (short(chrTemp[5]<<8|chrTemp[4]))/32768.0*180;

Angle[2] = (short(chrTemp[7]<<8|chrTemp[6]))/32768.0*180;

T = (short(chrTemp[9]<<8|chrTemp[8]))/340.0+36.25;

printf("a = %4.3f\t%4.3f\t%4.3f\t\r\n",a[0],a[1],a[2]);

printf("w = %4.3f\t%4.3f\t%4.3f\t\r\n",w[0],w[1],w[2]);

printf("Angle

= %4.2f\t%4.2f\t%4.2f\tT=%4.2f\r\n",Angle[0],Angle[1],Angle[2],T);

    break;

}

}
```

## 6.4 Data Analysis Sample Under Embedded Environment

The code is divided into two parts, one of them is interrupt reception. Find the header of the data and then put the data-packet into an array. The other one is data analysis, which is put into the main program section.

Interrupt unit(The following is AVR microcontroller code, different MCU reads the register a little different):

```
unsigned char Re_buf[11],counter=0;

unsigned char sign;

interrupt [USART_RXC] void usart_rx_isr(void) //USART serial receiving
interrupt
{

Re_buf[counter]=UDR; //Different micro-controller is slightly
Different

if(counter==0&&Re_buf[0]!=0x55) return; //NO.0 data is not a frame
header ,skip.

counter++;

if(counter==11) //11 data has been received

{ counter=0; // Reassigned,ready for the next frame data reception

sign=1;

}
```

```
}
```

Main program section:

```
float a[3],w[3],angle[3],T;
```

```
extern unsigned char Re_buf[11],counter;
```

```
extern unsigned char sign;
```

```
while(1)
```

```
{
```

```
if(sign)
```

```
{
```

```
sign=0;
```

```
if(Re_buf[0]==0x55) //Check the frame header
```

```
{
```

```
switch(Re_buf [1])
```

```
{c
```

```
ase 0x51:
```

```
a[0] = (short(Re_buf [3]<<8| Re_buf [2]))/32768.0*16;
```

```
a[1] = (short(Re_buf [5]<<8| Re_buf [4]))/32768.0*16;
```

```
a[2] = (short(Re_buf [7]<<8| Re_buf [6]))/32768.0*16;
```

```
T = (short(Re_buf [9]<<8| Re_buf [8]))/340.0+36.25;
```

```
break;
```

```
case 0x52:
```

```
w[0] = (short(Re_buf [3]<<8| Re_buf [2]))/32768.0*2000;
```

```
w[1] = (short(Re_buf [5]<<8| Re_buf [4]))/32768.0*2000;
```

```
w[2] = (short(Re_buf [7]<<8| Re_buf [6]))/32768.0*2000;
```

```
T = (short(Re_buf [9]<<8| Re_buf [8]))/340.0+36.25;
```

```
break;
```

```
case 0x53:
```

```
angle[0] = (short(Re_buf [3]<<8| Re_buf [2]))/32768.0*180;
```

```
angle[1] = (short(Re_buf [5]<<8| Re_buf [4]))/32768.0*180;
```

```
angle[2] = (short(Re_buf [7]<<8| Re_buf [6]))/32768.0*180;
```

```
T = (short(Re_buf [9]<<8| Re_buf [8]))/340.0+36.25;
```

```
break;
```

```
}
```

```
}
```

```
}
```

## 7 Certification

Shenzhen Tongzhou Testing Co.,Ltd.

### EC CERTIFICATE

**Certificate No.** : TZ200301235-C

**Applicant** : WitMotion Shenzhen Co.,Ltd

**Address** : West Industrial Park Tantou 10th building B Building 2nd Floor Songgang Town Baoan District Shenzhen City Guangdong Province

**Product** : 9-axis Bluetooth 2.0 Attitude Sensor

**Trademark** : WITMOTION

**Model(s)** : BWT901CL, BWT901BCL, BWT61PCL, BWT61CL, BWT61, BWT901, BWT61, BWT901

**Manufacturer** : WitMotion Shenzhen Co.,Ltd

**Address** : West Industrial Park Tantou 10th building B Building 2nd Floor Songgang Town Baoan District Shenzhen City Guangdong Province

Essential Requirement	Applied Specifications/ Standards	Documentary Evidence	Result
EMC	Draft ETSI EN 301 489-1 V2.2.0 (2017-03) Draft ETSI EN 301 489-17 V3.2.0 (2017-03) EN 55032: 2015 EN 55035: 2017	Report TZ200301235-RE	Conform
Radio	ETSI EN 300 328 V2.1.1 (2016-11)	Report TZ200301235-EDR	Conform
Health	EN 62479:2010	Report TZ200301235-EMF	Conform
Safety	EN 62368-1: 2014	Report TZ200301235-S	Conform

The EUT described above has been tested by us with the listed standards and found in compliance with the council RED 2014/53/EU. It is possible to use CE marking to demonstrate the compliance with the Directive. The scope of evaluation relates to the submitted documents only.



*Andy Zhang*  
For Chief Executive  
April 3, 2020



Website: [www.sztt-testing.com](http://www.sztt-testing.com)

E-mail: [sztt@sztt-testing.com](mailto:sztt@sztt-testing.com)