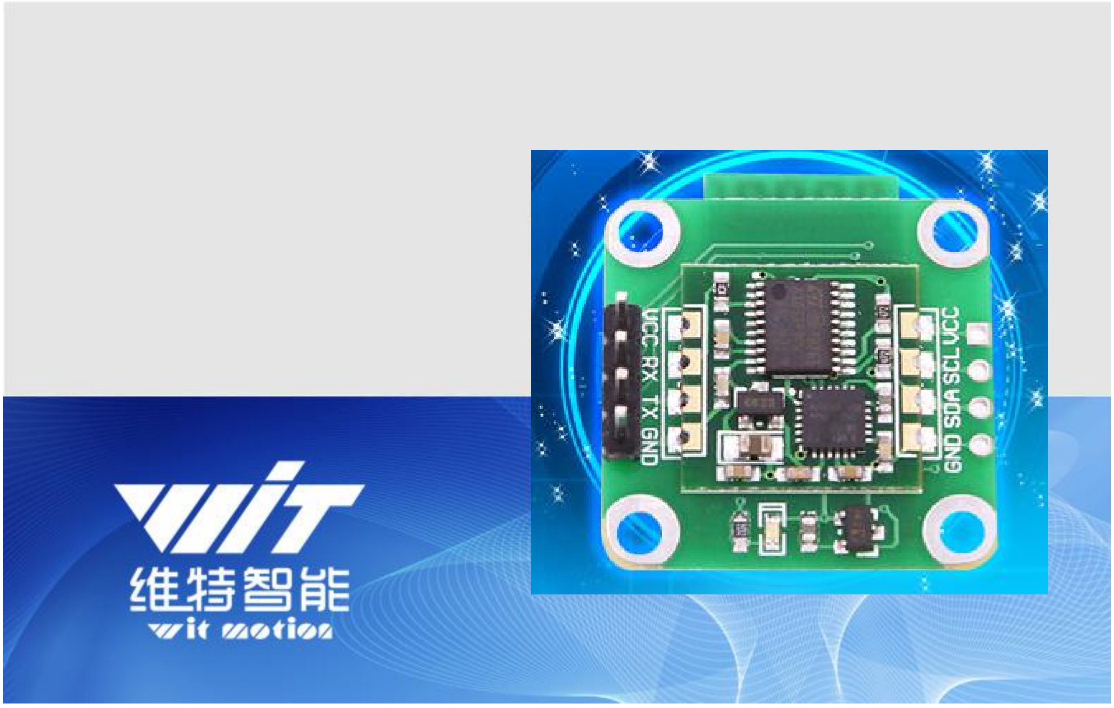
BWT61 Bluetooth Attitude Angle Sensor

APECIFICATION



Model ：BWT61

Description ：Six axis Bluetooth attitude angle sensor

Production Standard

Enterprise quality system standard: ISO9001:2016

Tilt switch production standard：GB/T191SJ 20873-2016

Criterion of detection：GB/T191SJ 20873-2016

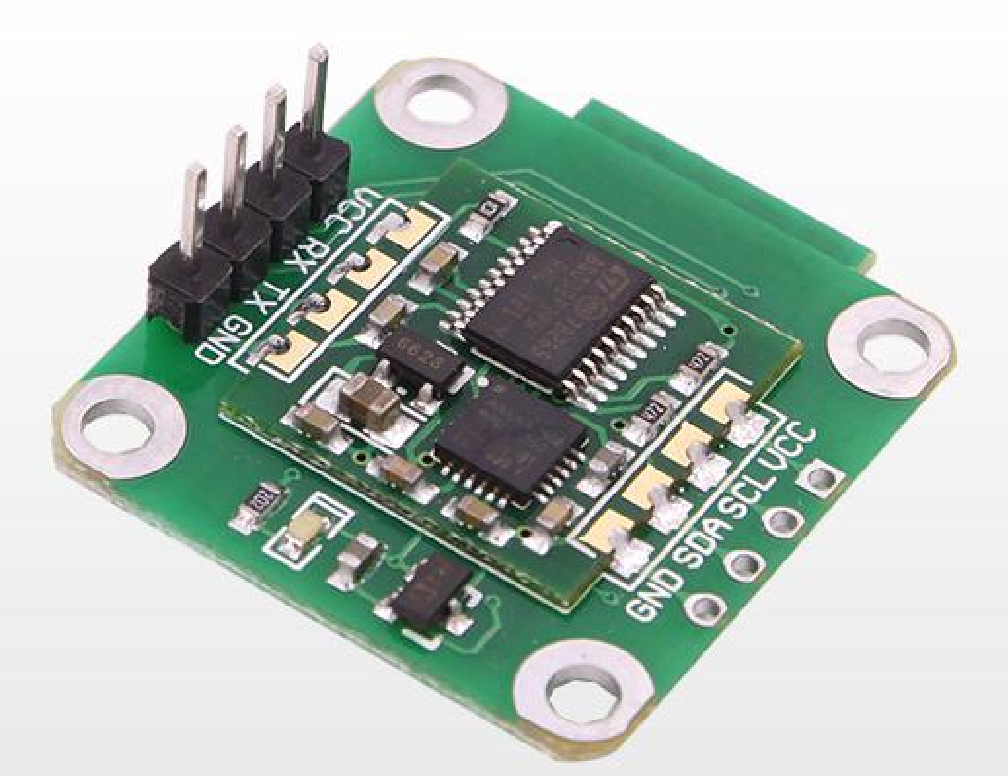
Revision date：2018.08.13

Version	Update content	Author	Date
V1.0	Release	Kelsey	20180813

Catalog

1 Description

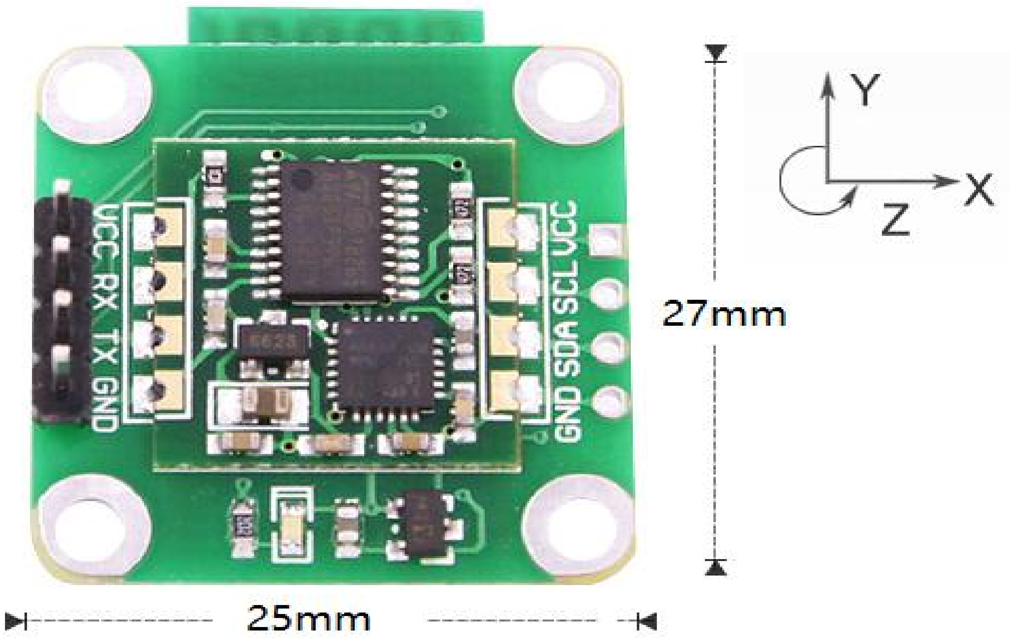
- The product built-in JY61 chip, on the basis of the original function of the addition of Bluetooth interface, Bluetooth can be connected to the PC software and mobile phone app, to achieve wireless transmission
- The module integrates high-precision gyroscopes, accelerometer,high-performance microprocessors and advanced dynamics solves dynamic Kalman filter algorithm to quickly solve the current real-time movement of the module attitude .
- The advanced Kalman filtering technology of this product can effectively reduce the measurement noise and improve the measurement accuracy.
- Integrates gesture solver, with dynamic Kalman filter algorithm, can get the accurate attitude in dynamic environment, attitude measurement precision is up to 0.05 degrees with high stability, performance is even better than some professional Inclinometer.
- The module has its own voltage stabilization circuit, working voltage is 3.3v ~ 5v, pin level compatible 3.3V and 5V embedded system and connection convenience .
- Support serial port UART(TTL) or UART(232), interface to facilitate the user to choose the best way to connect.
- Using the gold plating technology of stamp hole,can be embedded in the user´s PCB board.
- 4-storey PCB board process, thinner, smaller, more reliable.



2 Features

1) Input voltage: 3.3V-5V.
2) Consumption current: <40mA.
3) Volume: 25mm X 27mm X 5mm.
4) Measuring dimensions:
   Acceleration:X Y Z
   Angular Velocity:X Y Z
   Attitude angle: X Y Z
5) Range: Acceleration: ± 16g
   Angular velocity: ± 2000 ° / s.
   Angle: X Z axis ±180° Y axis ±90°
6) Stability: Acceleration:0.01g
   Angular velocity:0.05°/s
7) Measurement precision: 0.05°
8) Data output: time, acceleration, angular velocity, angle.
9) Data output frequency: 100Hz
10) Data interface: Serial port TTL communication, baud rate default 115200(not changeable)
11) Bluetooth transmission distance:>10m
12) Support for android system

3 Product display



Volume	25mm X 27mm X 5mm
Weight	4.1g

4 Pin Description

Pin	Function
VCC	Power supply，3.3V/5V input
RX	Serial data input，TTL level
TX	Serial data output，TTL level
GND	GND
SCL	IIC clock line
SDA	IIC signal line

5 Axial Direction

As shown in the figure above,the upper is the X axis, the left is Y axis, the vertical module is Z axis outward. The direction of rotation is defined by the right hand rule, that is, the thumb of the right hand is pointed to the axial direction. The bending direction of four fingers is the direction of rotation around the axis. The angle of X axis is the angle of rotation direction around X axis and the angle of Y axis is the angle of rotation direction of Y axis and the angle of Z axis is the angle of rotation direction of Z axis.

6 Hardware connection and usage method

6.1 Serial port connection

Note: Through the serial port wired connection sensor, can only obtain data, can not set the sensor. If set up the sensor, need a Bluetooth connection.

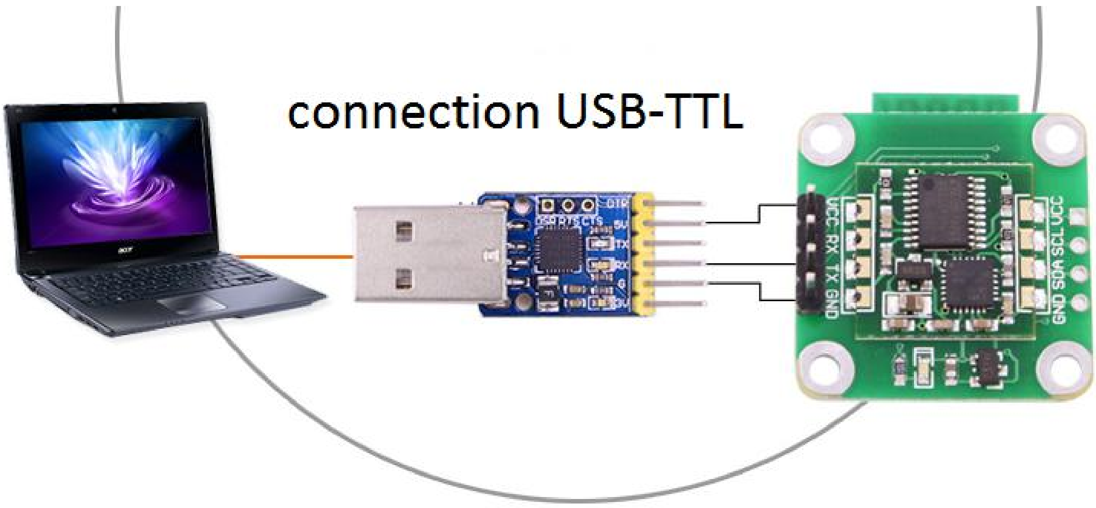
Hardware connection:

USB - TTL serial port module: Firstly connect the module with the USB - TTL and then connect them to the computer. The ways of connecting module with USB -TTL are:

VCC TX RX GND of the module connected to +3.3/5V RX TX GND of the serial module respectively. It is noteworthy that TX and RX need to be crossed TX connected to RX, RX connected to TX, TX connected to RX.

USB -TTL module:

https://www.aliexpress.com/store/product/Usb-converter-cp2102-usb-ttl-485-232-3-3v-and-5v-output-three-multifunctional-functions/2029054_32873159970.html

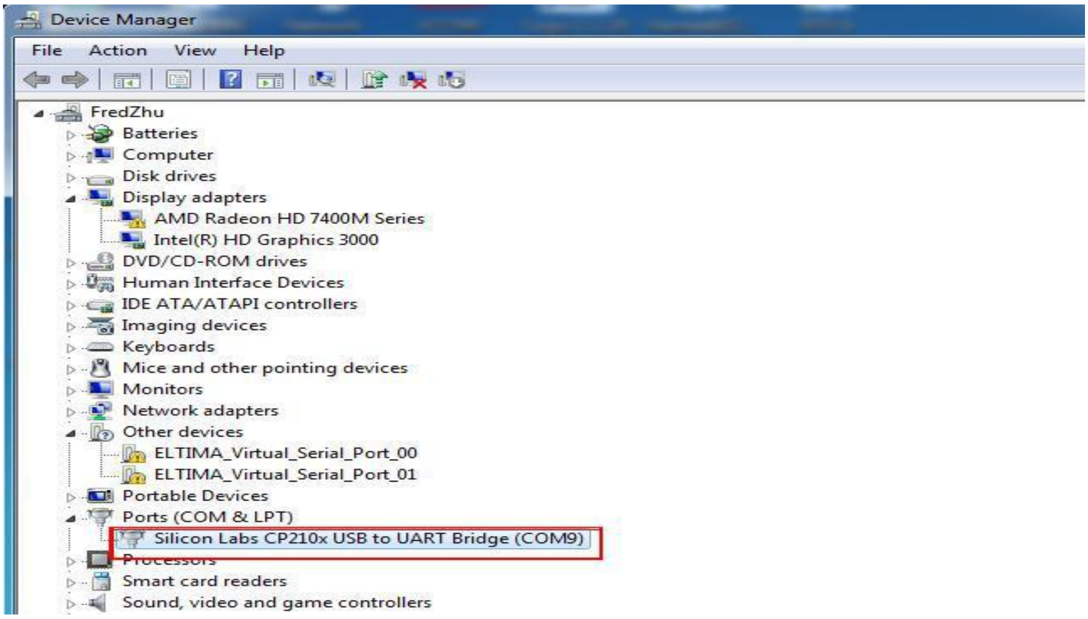


Install driver:

USB serial port module usually need to install the driver CP210X or CH340, After installing the driver, and will see the corresponding COM number in the device manager, the driver is:

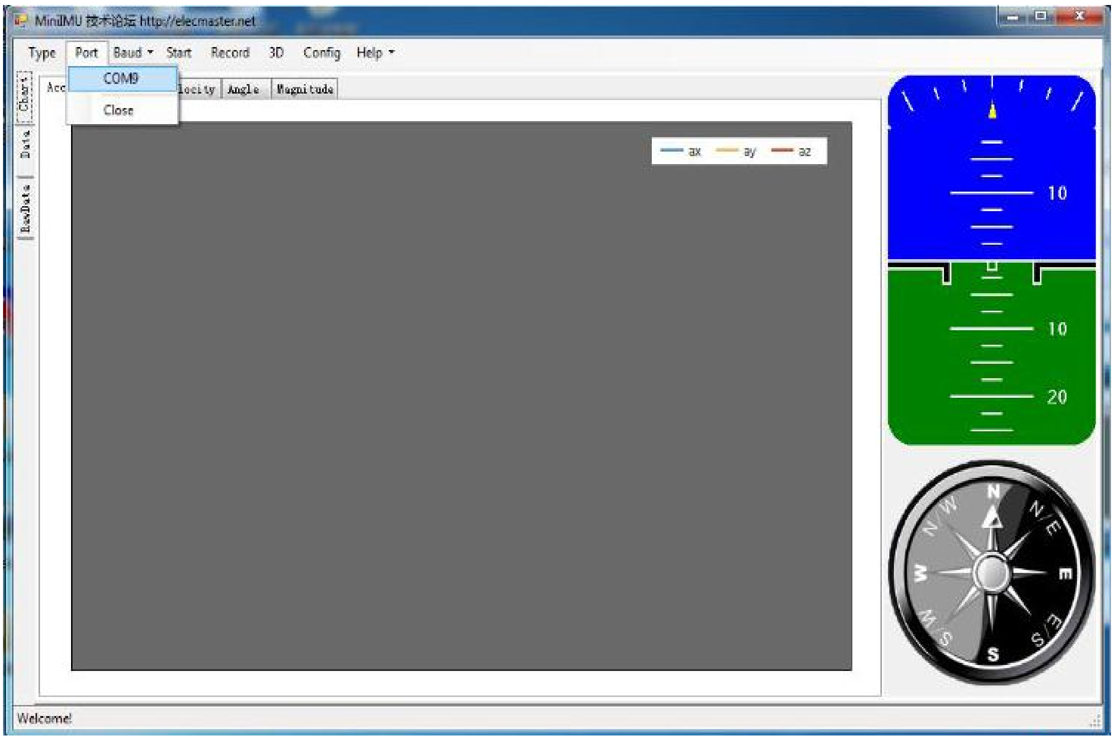
CP210X: https://wiki.wit-motion.com/english/doku.php?id=communication_module

CH340:https://wiki.wit-motion.com/english/doku.php?id=communication_module

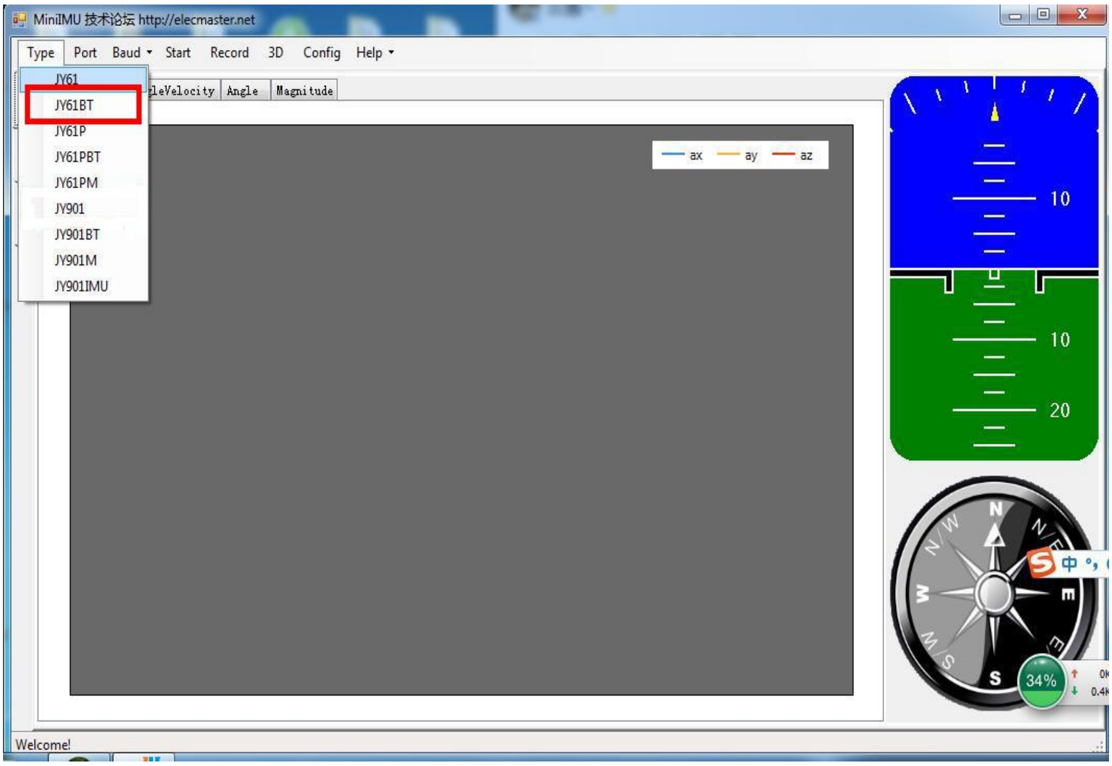


PC software connection:

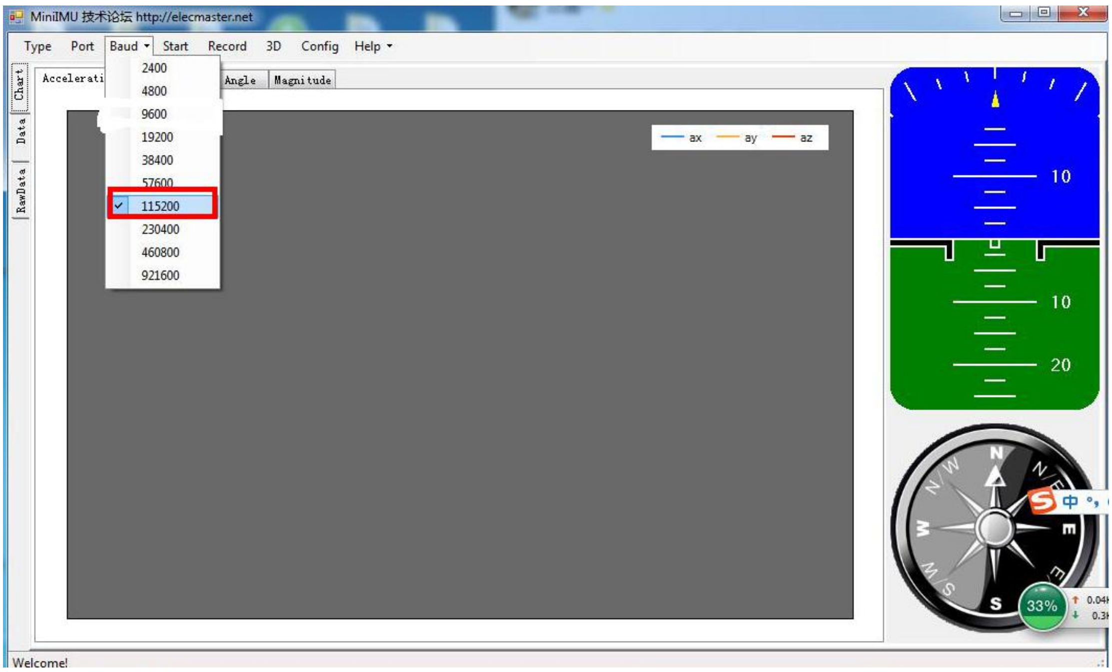
Open the software MiniIMU.exe, Click “Port” and select the COM number you just saw in the device manager.

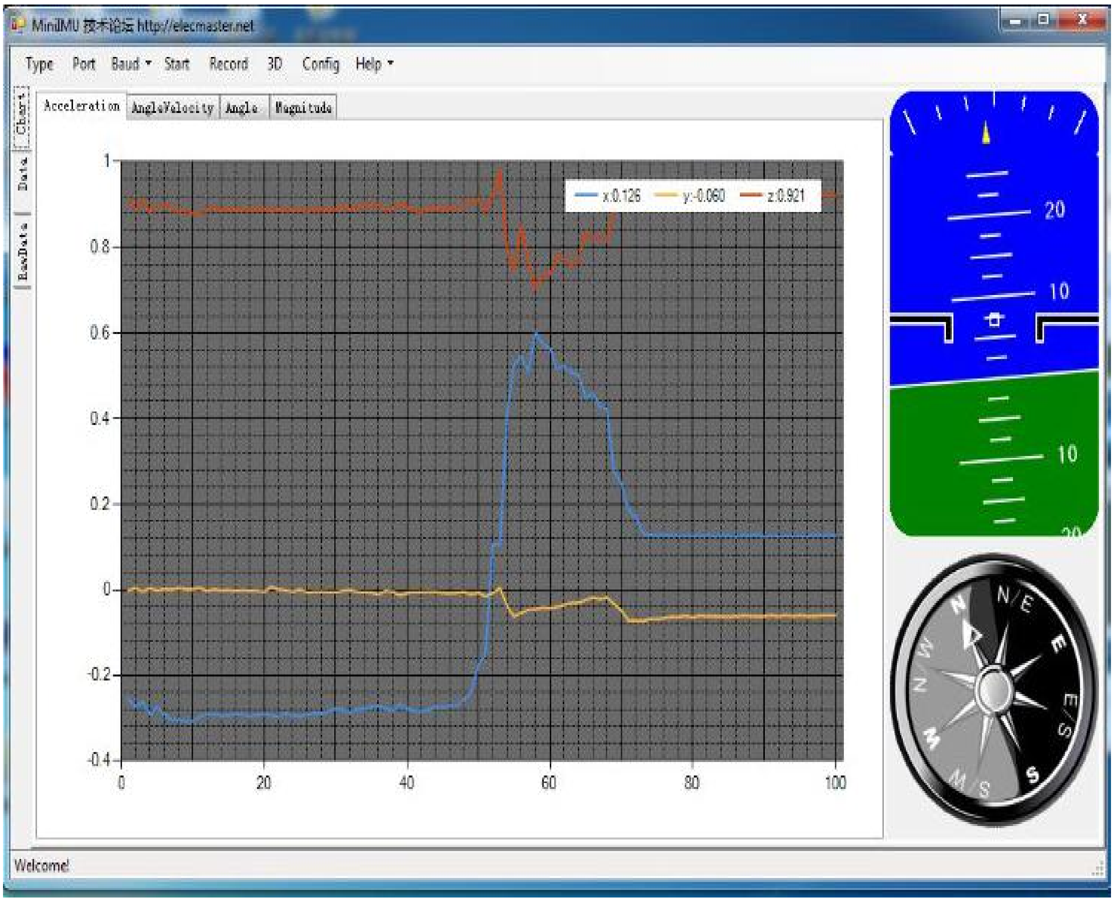


Click the “Type” and select model “JY61BT”.



Click the "Baud" and select "115200", after all those selections are completed, the software can display data.

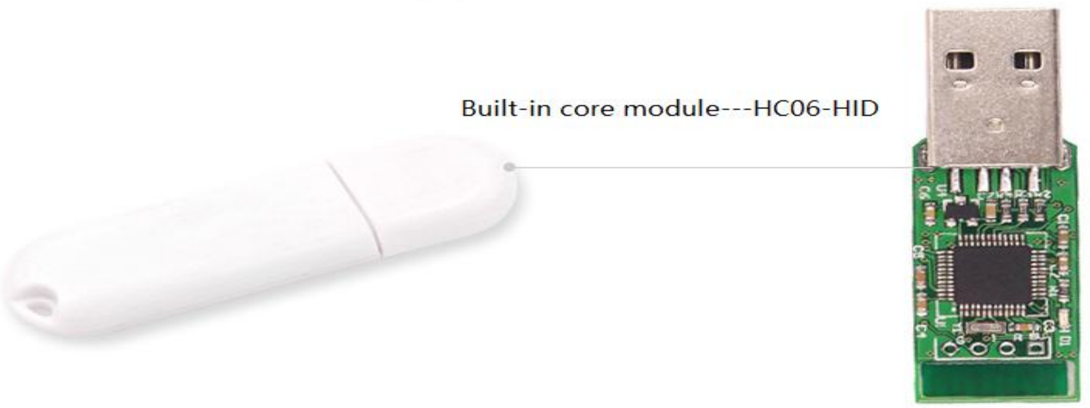


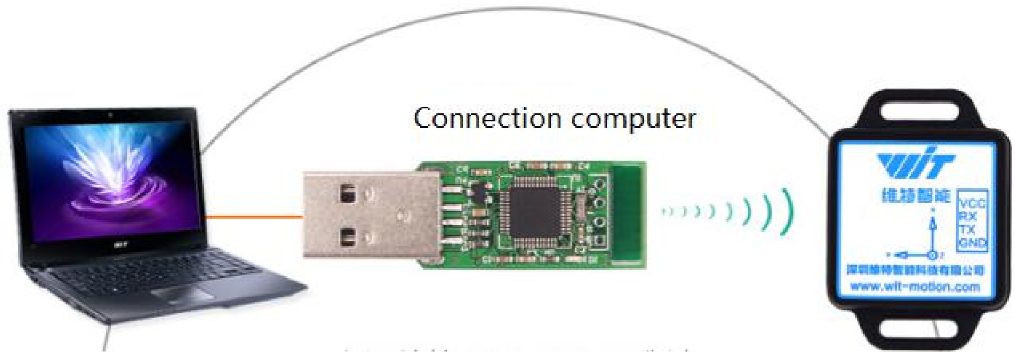


6.2 Bluetooth connection

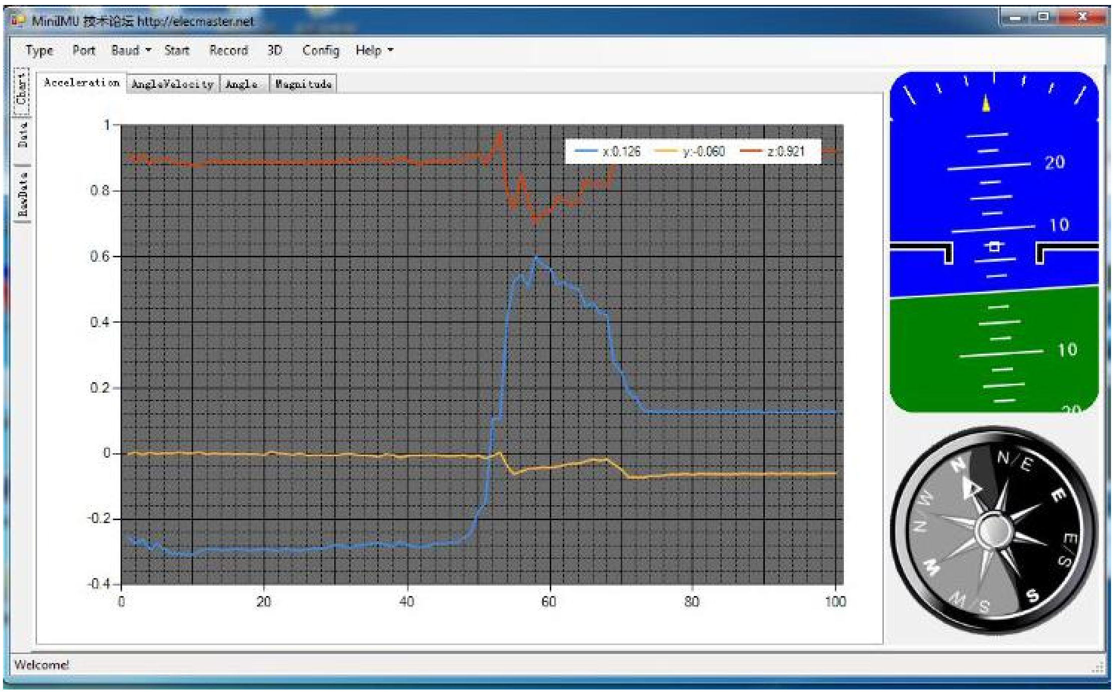
6.2.1 USB -HID connection

The USB -HID is plugged into the USB interface of the computer to supply power to the attitude sensor. At this time, the red light on the USB -HID flashes and the blue light on the attitude sensor flashes, indicating that Bluetooth is pairing connection.





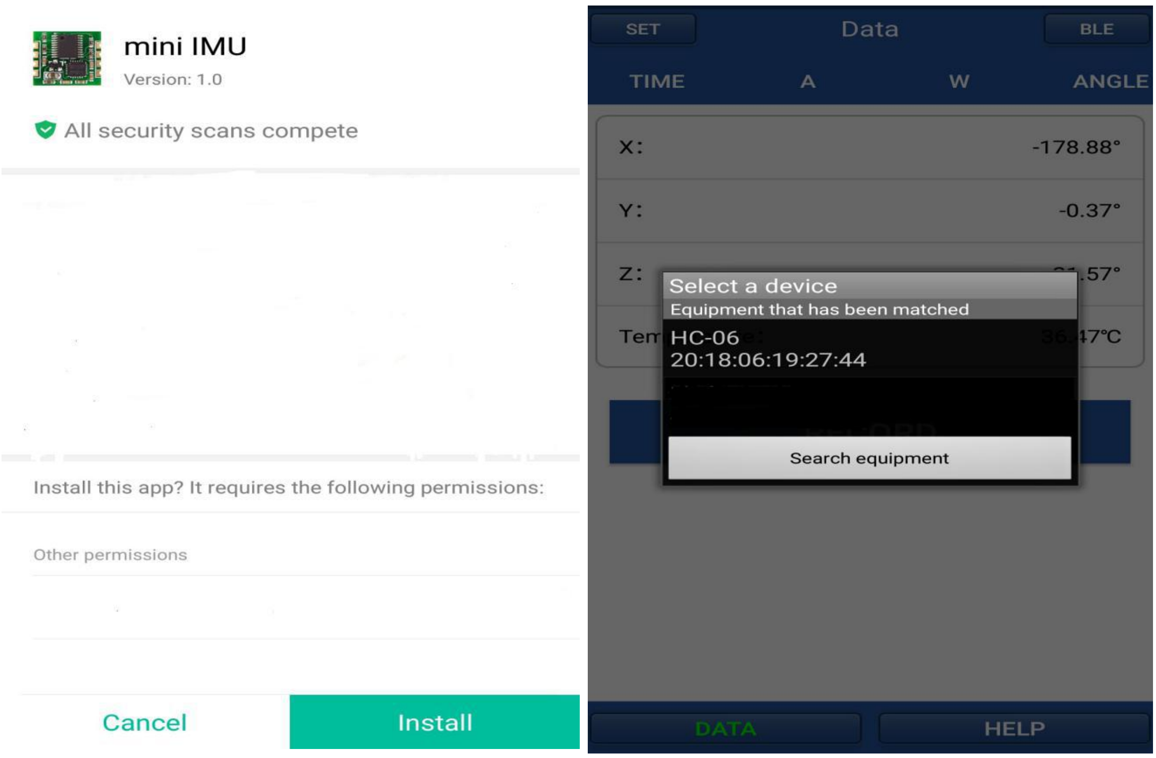
When the blue light on the sensor is always on and the USB -HID red light is also on, it shows that the Bluetooth pair is connected successfully,open the PC software, the baud rate is selected 115200, and the data transmission can be seen. This method is easy to operate and easy to use.

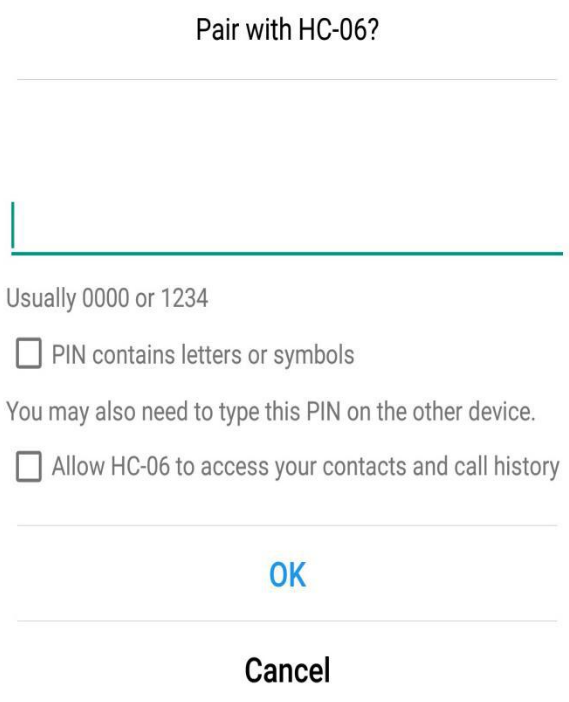


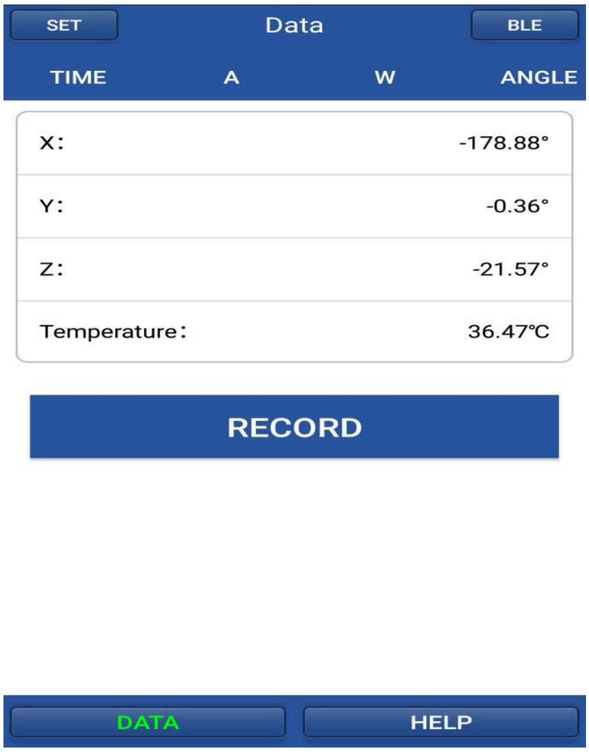
6.2.2 Mobile phone connection

1.First, install the app, then supply power the BWT61 module and turn on the phone Bluetooth
2. Search for Bluetooth in the upper right corner of APP, named "HC-06", for connection pairing. The password is: 1234
3. When the pair is complete, you can view the data with the mobile phone APP.
APP download address:

https://wiki.wit-motion.com/english/doku.php?id=module



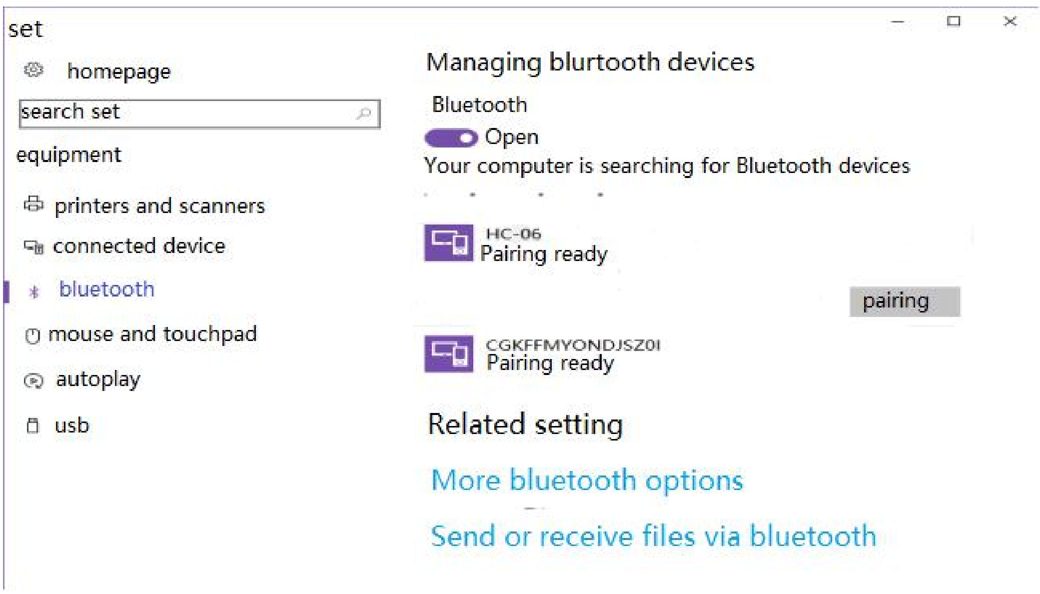




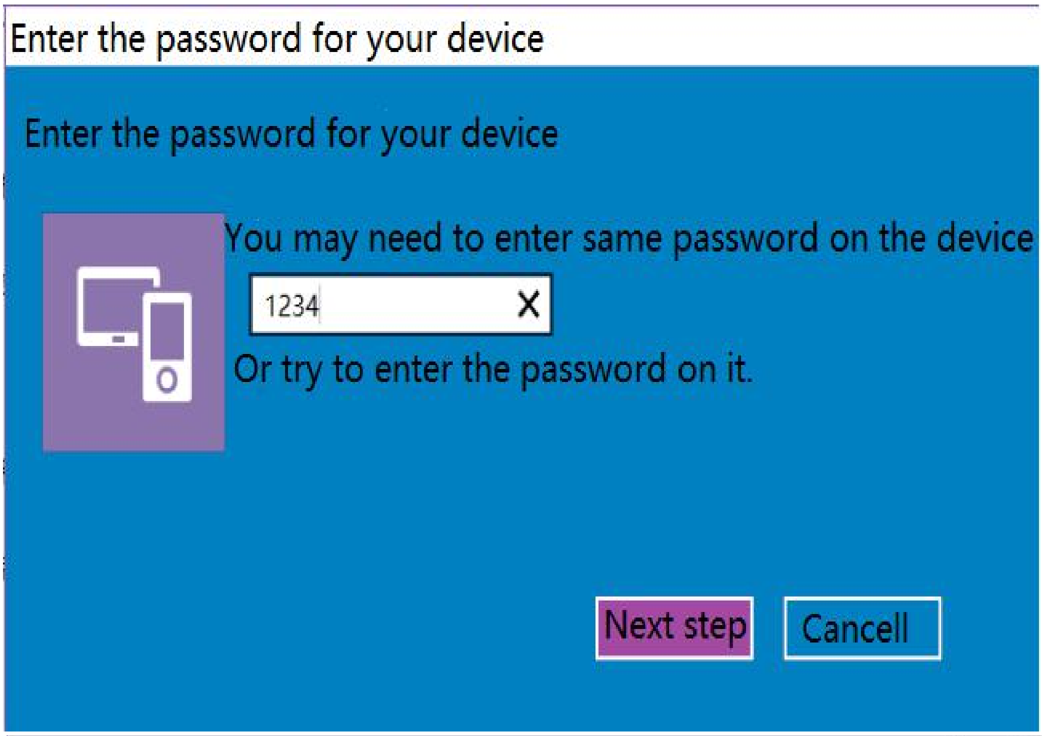
6.2.3Computer Bluetooth connection

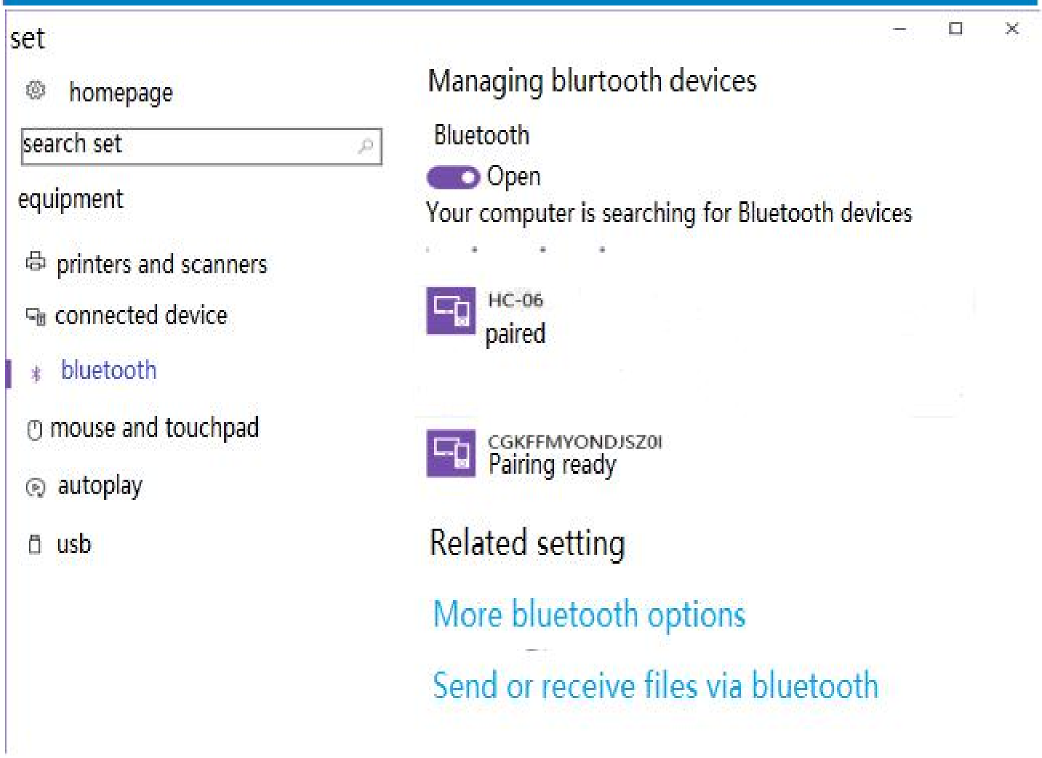
When the computer has its own Bluetooth, can directly search the device on the computer Bluetooth. Take WIN10 as an example:

1、Open computer Bluetooth search device, module device name is "HC-06", right-click device name, pairing connection

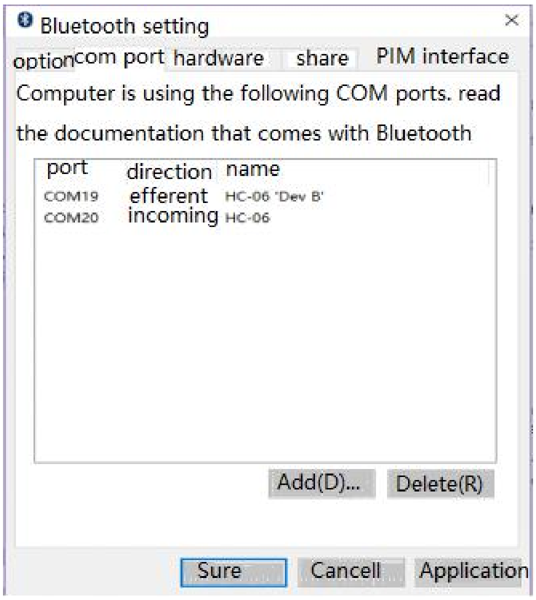


2、Enter Bluetooth pairing password "1234", COM number will be generated automatically when the connection is successful.

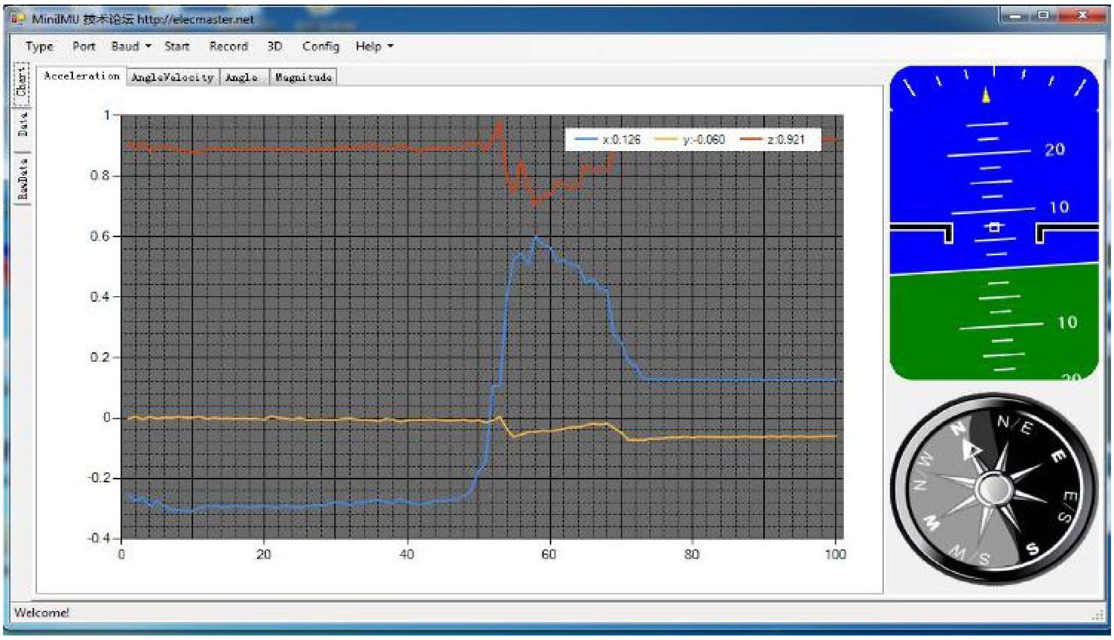




3、Open the computer Bluetooth settings and view the COM number.



4、Open the PC software, select a model, baud rate, and generate the corresponding outgoing COM number (as shown above select COM19), can display data on the PC software.



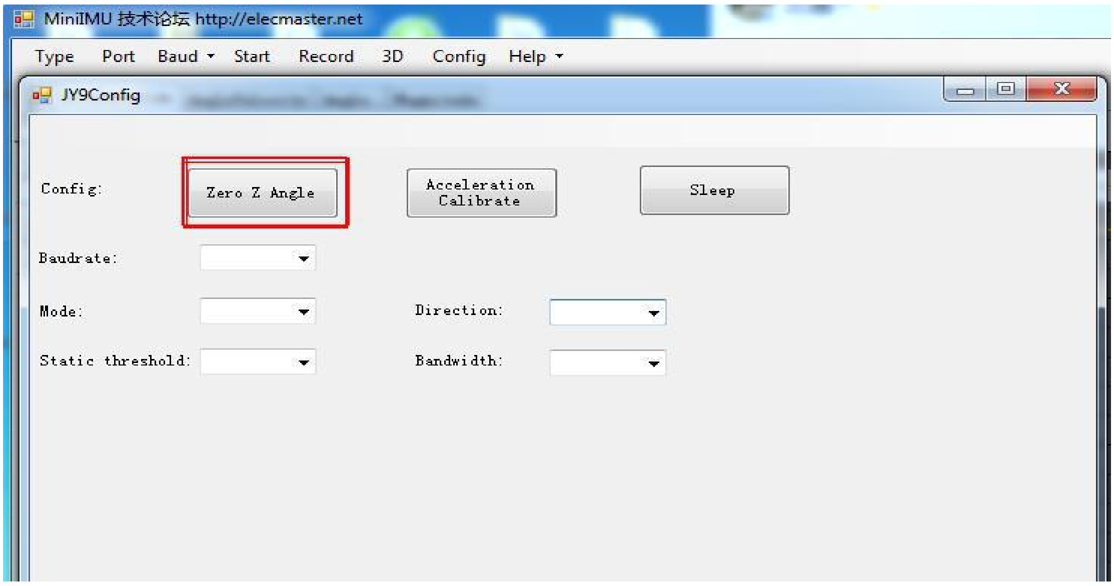
6.3 Calibration method

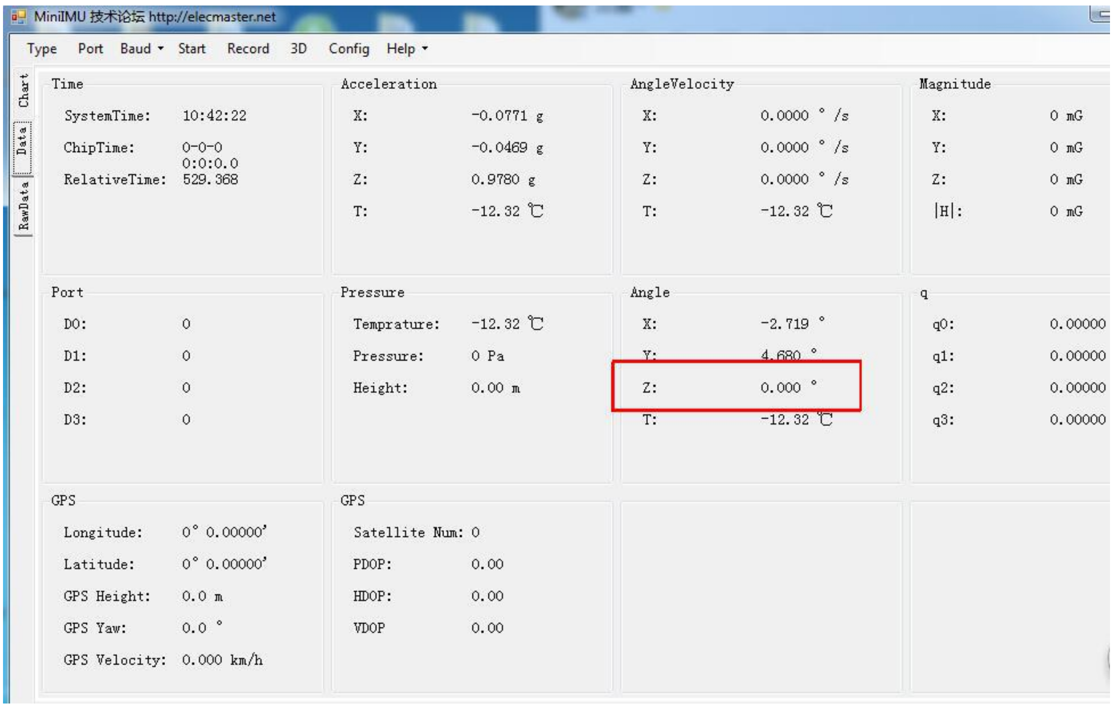
Note: the PC software calibration and setting method, can only be operated through Bluetooth connection, serial connection is not set. When the module is in normal use, calibration is all it takes.

6.3.1 Z-axis to 0

Z-axis to 0 is to make the initial angle of z-axis relative 0 degree angle. You should take the "Z-axis to 0" before you use the module or there being a large Z-axis drift. When the module is powered on, the z-axis will automatically return to 0.

Methods are as follows: firstly put the module placed horizontally, and then click "Config" to open the configuration bar, choose the "Zero Z Angle" option, the z-axis angle inside the module data column returns to 0.

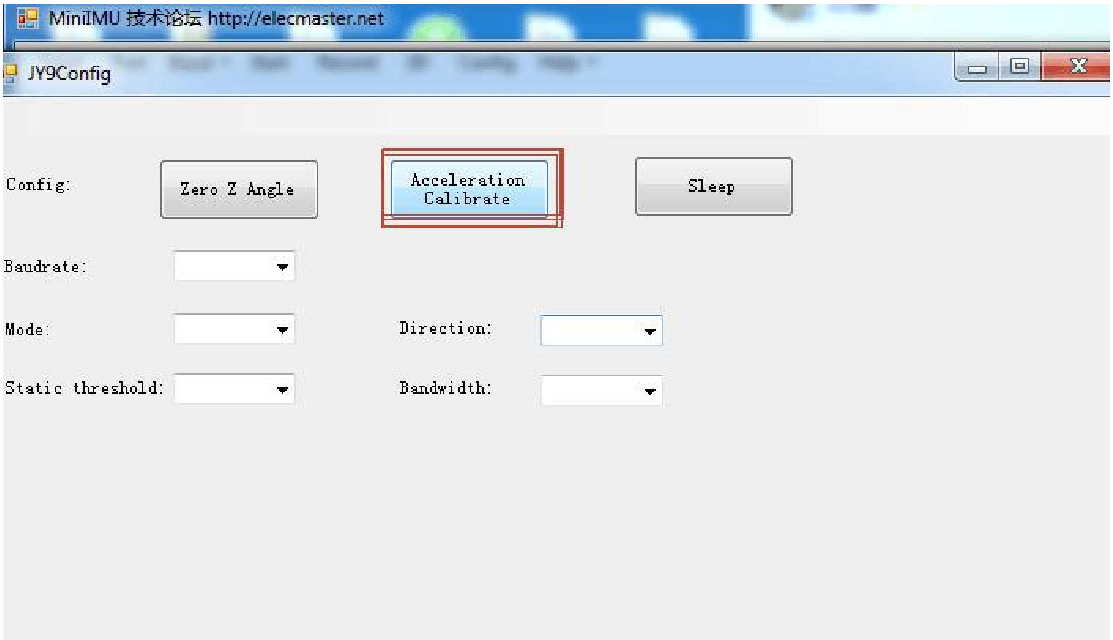


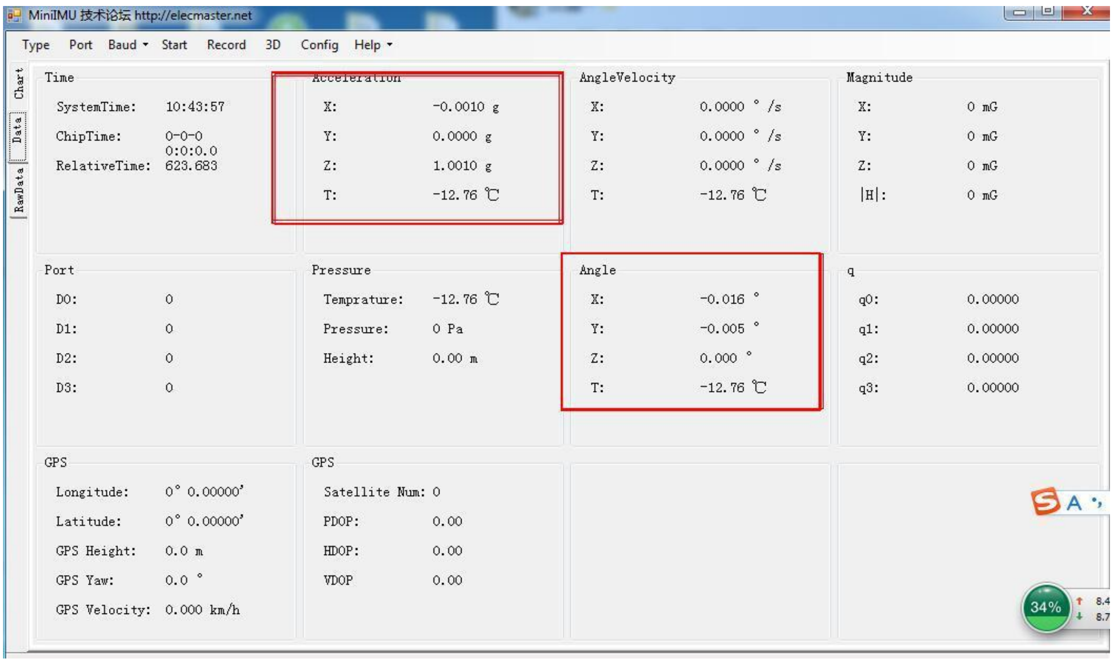


6.3.2 Accelerometer calibration

The accelerometer calibration is used to remove the zero bias of the accelerometer. When the sensor is out of the factory, there will be different degrees of bias error. After manual calibration, the measurement will be accurate.

Methods are as follows: Firstly keep the module horizontal, click "Config" and 'Acceleration calibration' the acceleration of X Y Z will be at 0,0,1. The angle of X-axis and Y-axis will be at 0. After calibration, the X Y axis angle is more accurate.

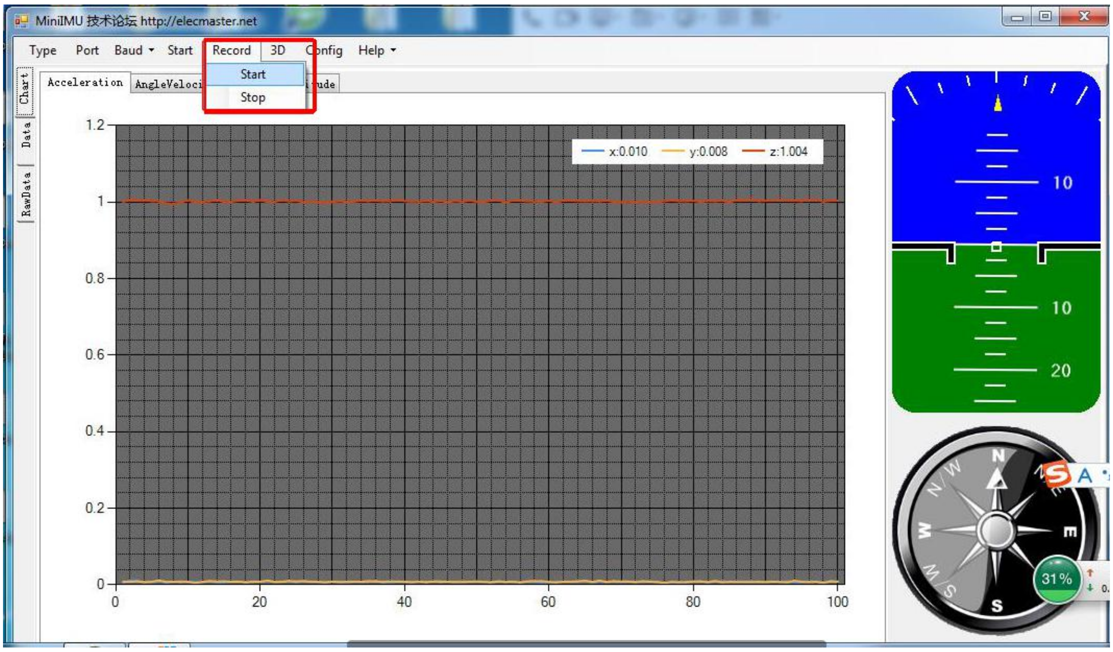




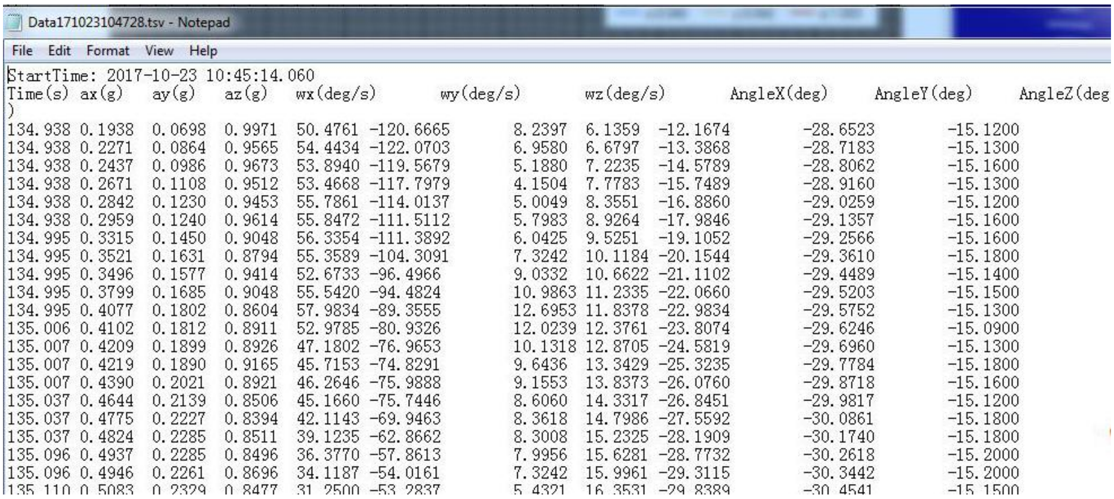
6.4 Data recording

There is no memory chip in the sensor module, and the data can be recorded and saved in the software.

Method are as follows: Click “Record”, “Start” and “stop” will save the data as a file.



The saved file is in the directory of the software Data.tsv



Data171023104728.tsv - Notepad

File Edit Format View Help

StartTime: 2017-10-23 10:45:14.060

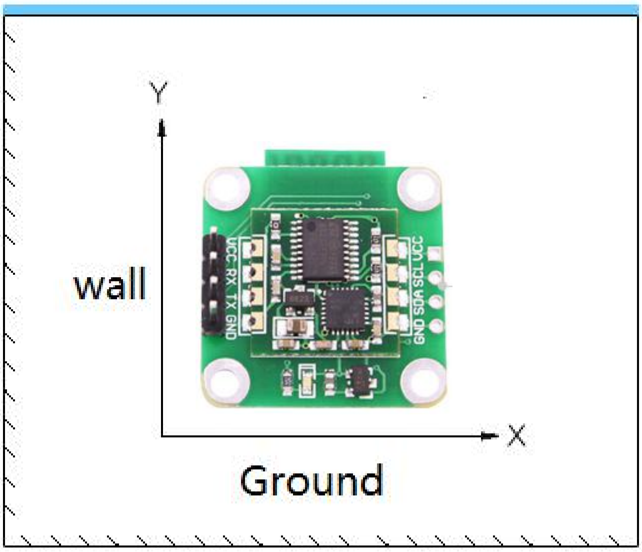
Time(s) ax(g) ay(g) az(g) wx(deg/s) wy(deg/s) wz(deg/s) AngleX(deg) AngleY(deg) AngleZ(deg
)

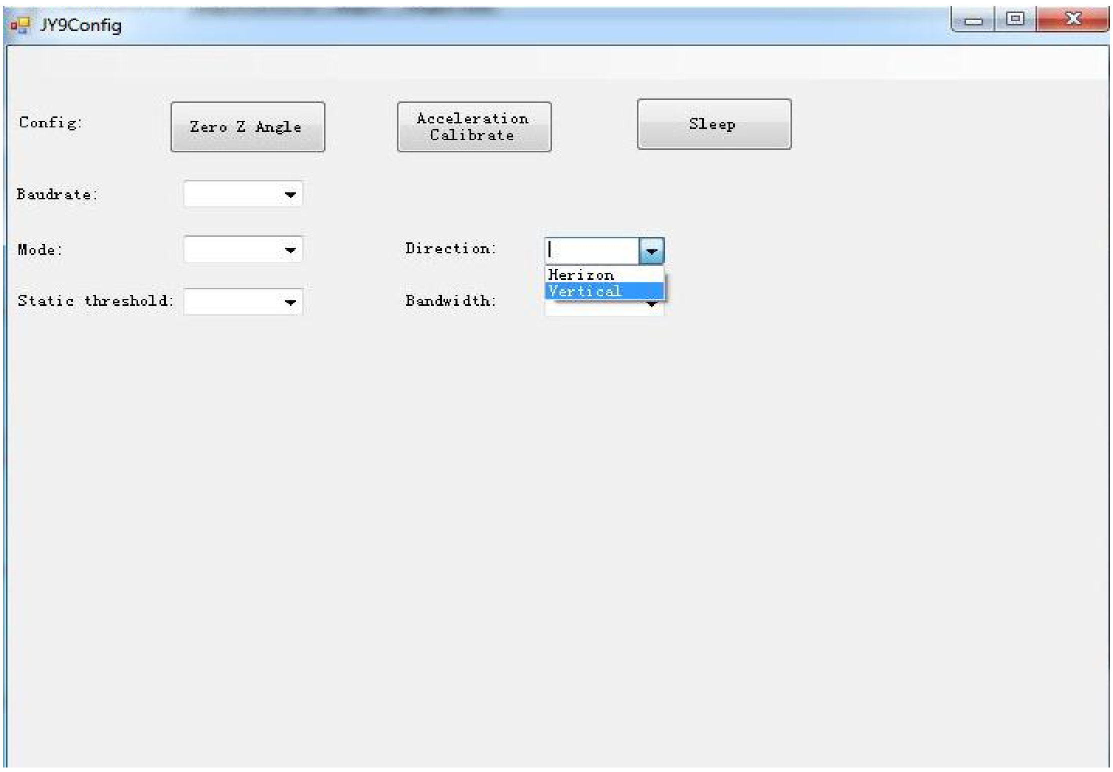
134.938	0.1938	0.0698	0.9971	50.4761	-120.6665	8.2397	6.1359	-12.1674	-28.6523	-15.1200
134.938	0.2271	0.0864	0.9565	54.4434	-122.0703	6.9580	6.6797	-13.3868	-28.7183	-15.1300
134.938	0.2437	0.0986	0.9673	53.8940	-119.5679	5.1880	7.2235	-14.5789	-28.8062	-15.1600
134.938	0.2671	0.1108	0.9512	53.4668	-117.7979	4.1504	7.7783	-15.7489	-28.9160	-15.1300
134.938	0.2842	0.1230	0.9453	55.7861	-114.0137	5.0049	8.3551	-16.8860	-29.0259	-15.1200
134.938	0.2959	0.1240	0.9614	55.8472	-111.5112	5.7983	8.9264	-17.9846	-29.1357	-15.1600
134.995	0.3315	0.1450	0.9048	56.3354	-111.3892	6.0425	9.5251	-19.1052	-29.2566	-15.1600
134.995	0.3521	0.1631	0.8794	55.3589	-104.3091	7.3242	10.1184	-20.1544	-29.3610	-15.1800
134.995	0.3496	0.1577	0.9414	52.6733	-96.4966	9.0332	10.6622	-21.1102	-29.4489	-15.1400
134.995	0.3799	0.1685	0.9048	55.5420	-94.4824	10.9863	11.2335	-22.0660	-29.5203	-15.1500
134.995	0.4077	0.1802	0.8604	57.9834	-89.3555	12.6953	11.8378	-22.9834	-29.5752	-15.1300
135.006	0.4102	0.1812	0.8911	52.9785	-80.9326	12.0239	12.3761	-23.8074	-29.6246	-15.0900
135.007	0.4209	0.1899	0.8926	47.1802	-76.9653	10.1318	12.8705	-24.5819	-29.6960	-15.1300
135.007	0.4219	0.1890	0.9165	45.7153	-74.8291	9.6436	13.3429	-25.3235	-29.7784	-15.1800
135.007	0.4390	0.2021	0.8921	46.2646	-75.9888	9.1553	13.8373	-26.0760	-29.8718	-15.1600
135.037	0.4644	0.2139	0.8506	45.1660	-75.7446	8.6060	14.3317	-26.8451	-29.9817	-15.1200
135.037	0.4775	0.2227	0.8394	42.1143	-69.9463	8.3618	14.7986	-27.5592	-30.0861	-15.1800
135.037	0.4824	0.2285	0.8511	39.1235	-62.8662	8.3008	15.2325	-28.1909	-30.1740	-15.1800
135.096	0.4937	0.2285	0.8496	36.3770	-57.8613	7.9956	15.6281	-28.7732	-30.2618	-15.2000
135.096	0.4946	0.2261	0.8696	34.1187	-54.0161	7.3242	15.9961	-29.3115	-30.3442	-15.2000
135.110	0.5083	0.2329	0.8477	31.2500	-53.2837	5.4321	16.3531	-29.8389	-30.4541	-15.1500

6.5 Installation direction

The default installation direction of the module is horizontal installation. When the module needs to be vertically placed, it can be installed vertically.

Vertical installation method: Put the module around X-axis rotation 90 degrees vertical placement. In the "Config" of the software, click "Vertical" option. The calibration can be used after the setup is completed.





6.6 Sleep/ Wake up

Sleep: The module paused working and entered the standby mode. Power consumption is reduced after sleeping.

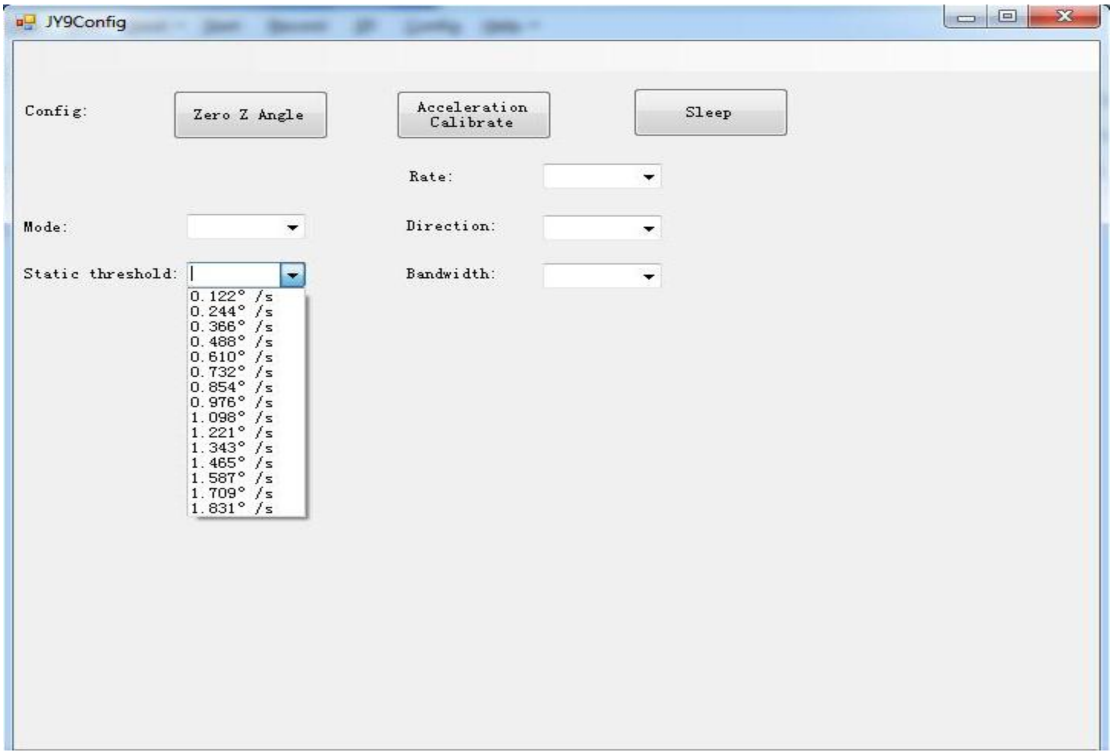
Wake up: The module enters the working state from standby state.

The module defaults to a working state, in the "Config" of the software, click "Sleep" option to enter the sleep state, click "Sleep" again to release sleep.

6.7 Static threshold/ Bandwidth

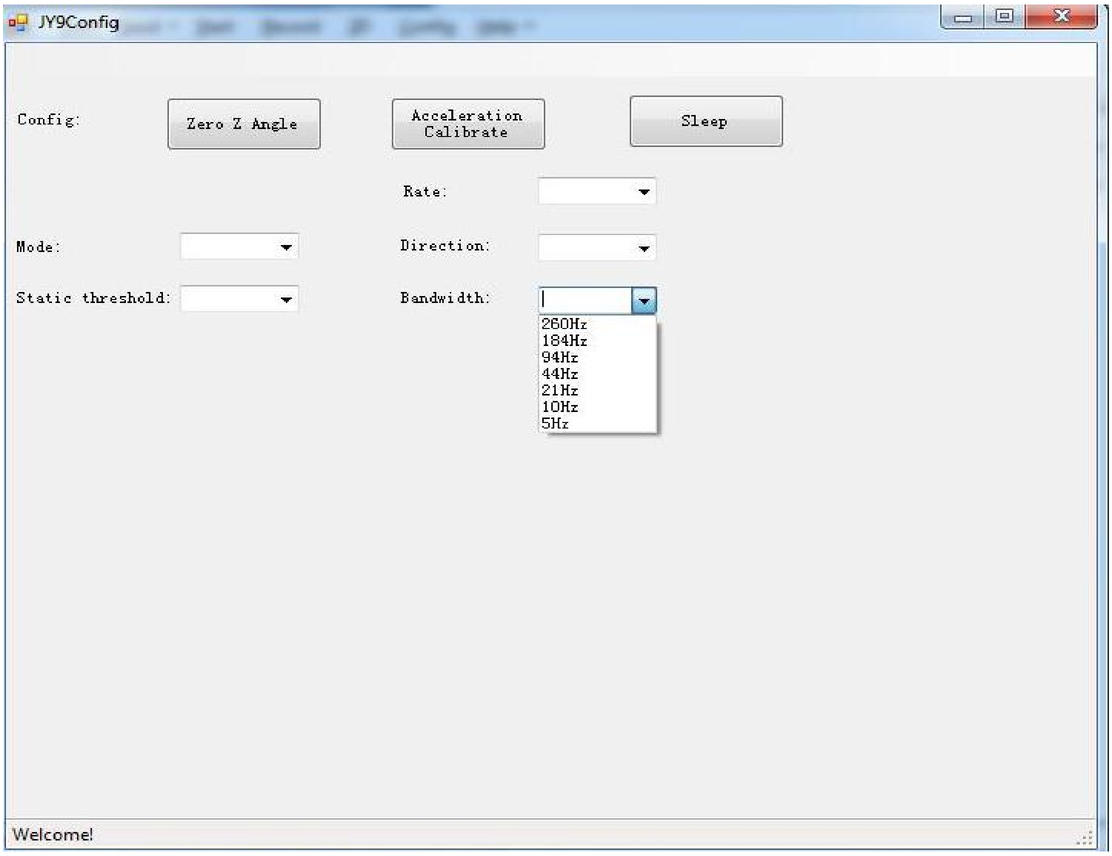
Static threshold: When the module is stationary, the angular velocity measured by the gyroscope chip varies slightly. The function of static threshold is that when the angular velocity is less than the threshold, the output angular velocity is 0.

In the "Config" of the software, click "Static threshold" to set the static threshold, the default is 0.122°/s.



Bandwidth: The module outputs only the data within the measurement bandwidth, and the data which is larger than the bandwidth will be filtered automatically.

In the "Config" of the software, click "Bandwidth" option to set it, the default setting is 10HZ.



Note: static threshold and measurement bandwidth are generally default, do not need to set.

7 Communication Protocol

Level: The TTL level(if the module is connected to the RS232 level, it may cause damage to module)

Baud rate: 115200   Stop bit: 1   Check bit: 0

7.1 PC software to module

Instruction	Function	Remarks
0xFF 0xAA 0x52	Angle initialization	Z axis angle to 0
0xFF 0xAA 0x67	Accelerometer calibration	X Y axis angle to 0
0xFF 0xAA 0x60	Sleep and wake up	Standby mode/active mode
0xFF 0xAA 0x65	Horizontal installation	Horizontal placement
0xFF 0xAA 0x66	Vertical installation	Vertical placement

Reminder：

1.After the module is powered up, the MCU will be automatically calibrated at first to eliminate the gyro zero drift, and Z axis will be re initialized to 0.

2. Factory default settings when using serial port, baud rate 115200, frame rate 100 Hz. Configuration can be configured through the PC software, because all configurations are power-down, so only once configuration is OK.

7.2 Module to PC Software

The module sends the data to the host computer into 3 data packets, acceleration packet, angular velocity packet and the angle packet, and the 3 packet are sent in sequence .

7.2.1 Acceleration Output

Data number	Data content	Implication
0	0x55	Packet header
1	0x51	Acceleration packet
2	AxL	X-axis acceleration low byte
3	AxH	X-axis acceleration high byte
4	AyL	Y-axis acceleration low byte
5	AyH	Y-axis acceleration high byte
6	AzL	Z-axis acceleration low byte
7	AzH	Z-axis acceleration high byte
8	TL	Temperature low byte
9	TH	Temperature high byte
10	Sum	Checksum

Calculate formula：

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)

Temperature calculated formular：

T=((TH<<8)|TL) /340+36.53 ℃

Checksum：

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

7.2.2 Angular Velocity Output

Data number	Data content	Implication
0	0x55	Packet header
1	0x52	Angular velocity packet
2	wxL	X-axis angular velocity low byte
3	wxH	X-axis angular velocity high byte
4	wyL	Y-axis angular velocity low byte

5	wyH	Y-axis angular velocity high byte
6	wzL	Z-axis angular velocity low byte
7	wzH	Z-axis angular velocity high byte
8	TL	Temperature low byte
9	TH	Temperature high byte
10	Sum	Checksum

Calculated formular:

w_x=((wxH<<8)|wxL)/32768*2000(°/s)

w_y=((wyH<<8)|wyL)/32768*2000(°/s)

w_z=((wzH<<8)|wzL)/32768*2000(°/s)

Temperature calculated formular:

T=((TH<<8)|TL) /340+36.53 ℃

Checksum:

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

7.2.3 Angle Output

Data number	Data content	Implication
0	0x55	Packet header
1	0x53	Angle packet
2	RollL	X-axis angle low byte
3	RollH	X-axis angle high byte
4	PitchL	Y-axis angle low byte
5	PitchH	Y-axis angle high byte
6	YawL	Z-axis angle low byte
7	YawH	Z-axis angle high byte
8	TL	Temperature low byte
9	TH	Temperature high byte
10	Sum	Checksum

Calculated formular:

Roll（x axis）Roll=((RollH<<8)|RollL)/32768*180(°)

Pitch（y axis）Pitch=((PitchH<<8)|PitchL)/32768*180(°)

Yaw（z axis）Yaw=((YawH<<8)|YawL)/32768*180(°)

Temperature calculated formular:

T=((TH<<8)|TL) /340+36.53 ℃

Checksum:

Sum=0x55+0x53+RollH+RollL+PitchH+PitchL+YawH+YawL+TH+TL

Note:

1. Attitude angle use the coordinate system for the Northeast sky coordinate system, the X axis is East,the Y axis is North, Z axis toward sky. Euler coordinate system rotation sequence defined attitude is z-y-x, first rotates around the Z axis. Then, around the Y axis,

and then around the X axis.

2. In fact, the rotation sequence is Z-Y-X, the range of pitch angle (Y axis) is only ±90 degrees, when the pitch angle (Y axis) is bigger than 90 degrees and the pitch angle (Y axis) will become less than 90 degrees. At the same time, the Roll Angle(X axis) will become larger than 180 degree. Please search on Google about more information of Euler angle and attitude information.
3. Since the three axis are coupled, the angle will be independent only when the angle is small. It will be dependent of the three angle when the angle is large when the attitude angle change, such as when the X axis close to 90 degrees, even if the attitude angle around the X axis, Y axis angle will have a big change, which is the inherent characteristics of the Euler angle.

7.3 Data Analysis 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;
	}
}
```

7.4 Data Analysis Sample Code in embedded environment

The code is divided into two parts, one is in interrupt to receive, to find the data's head, and then put the packet into the array. The other is data analysis in the main code.

Interrupt part(The following is the AVR microcontroller code. The other microcontroller will be a little difference)

```
unsigned char Re_buf[11],counter=0;
unsigned char sign;
interrupt [USART_RXC] void usart_rx_isr(void) //USART receive
 {
        Re_buf[counter]=UDR;// Slight difference between different microcontroller
        if(counter==0&&Re_buf[0]!=0x55) return;        // if the first data is not frame header,
skip
        counter++;
        if(counter==11) // Receive 11 data
        {
            counter=0; // Re assignment, prepare for the next frame of data receiving
            sign=1;
        }
 }
```

Main code:

```
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 head
        {
           switch(Re_buf [1])
           {
           case 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;
           }
        }
    }
```

8 Application Area

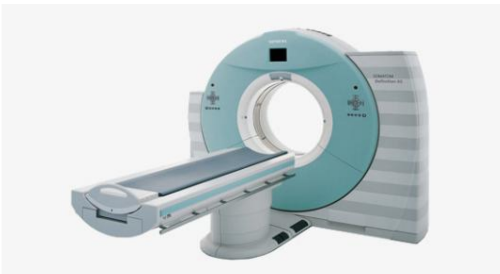
Agricultural machinery

Internet of things

Solar energy

Power monitoring

Medical instruments



Construction machinery

Geological monitoring

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