

USER MANUAL

HWT905(TTL)

IP67 Inclinometer



Tutorial Link

[Google Drive](#)

Link to instructions DEMO:

[WITMOTION Youtube Channel](#)

[HWT905 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 Introduction

The HWT905 is a multi-sensor device detecting acceleration, angular velocity, angle as well as magnetic field. The robust housing and the small outline makes it perfectly suitable for industrial retrofit applications such as condition monitoring and predictive maintenance. Configuring the device enables the customer to address a broad variety of use cases by interpreting the sensor data by smart algorithms.

HWT905'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.

HWT905 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 , 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

1.1 Warning Statement

- Putting more than 5 Volt across the sensor wiring of the main power supply can lead to permanent damage to the sensor.
- VCC cannot connect with GND directly, otherwise it will lead to the burning of the circuit board.
- For proper instrument grounding: use WITMOTION with its original factory-made cable or accessories.
- Do not access the I2C interface.
- For secondary developing project or integration: use WITMOTION with its compiled sample code.

2 Use Instructions with PC

2.1 Connection Method

PC software is only compatible with Windows system.

[Link to HWT905's demo video](#)

2.1.1 Serial Connection

Step 1. Connect the sensor with a serial converter

PIN Connection:

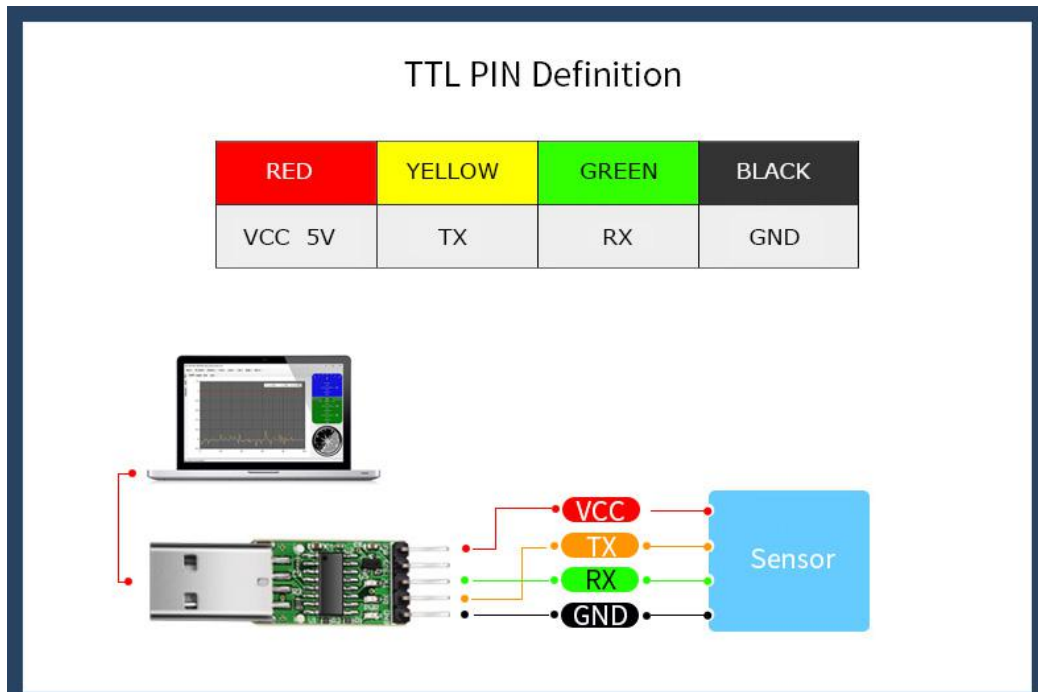
VCC - 5V

TX - RX

RX - TX

GND - GND

(When connecting with computer, VCC-5V is recommended.)

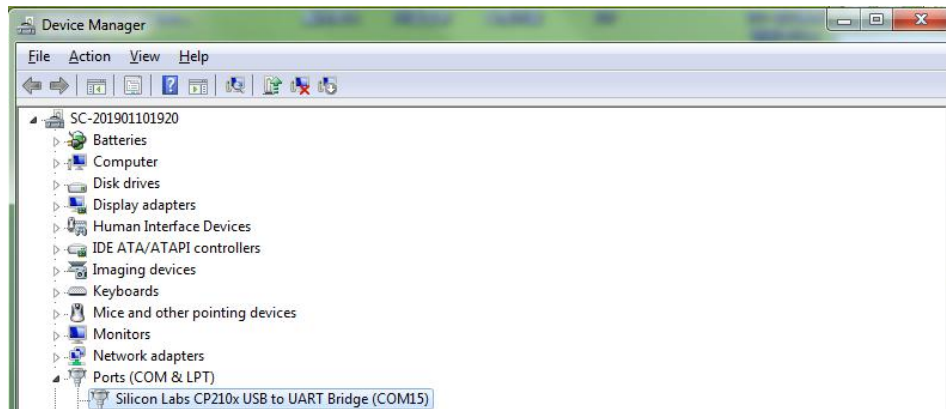


Recommended tools:

[Link to tutorial of 3-in-1 serial converter\(CH340 driver\)](#)

[Link to tutorial of 6-in-1 serial converter \(CP2102 driver\)](#)

Step 1. Unzip the software and install the driver CH340 or CP2102
(Depending on which accessory for usage.)



Step 2. Insert the converter to computer and confirm the “com port” in device manager

Step 3. Open the software(Minimu.exe)
Data will appear after auto-search finishes

Notice: If not successful, please operate manually
Choose the com port and baud rate 9600, data will be shown on the software.

2.2 Software Introduction

[Link to download software](#)

2.3 Main Menu



Main Menu of software		
Button		Function
File		Launch recorded HEX file (Bin format)
Tools		Hide or display tools box on left side
Record		Record function
3D		3D DEMO
Config		Configuration setting
Help	Language	English or Chinese
	Bluetooth Set	Binding device or unbind
	Firmware update	Option for firmware update
	About Minimu	Info about Minimu.exe
	Factory test	For manufacturer internal test only
Auto-search		Auto searching the sensor
Port		Com port selection

Baud	Baud rate selection
Type	Fixed setting as Normal for HWT905
Open	Open com port
Close	Close com port

2.4 Menu of Configuration

Normal - Config ×

Read Config Lock Unlock Calibrate Time

System

Reset Sleep Alarm

Algorithm: 9 - axis Install Direction: Horizontal ☐ Instruction Startup

Calibrate

Acceleration Magnetic Filed Reset Z-axis Angle ☒ Gyro Auto Calibrate

Reset Height Angle Reference

Range

Acceleration: 16 g Gyro: 2000 deg/s Band Width: 20 Hz GPS Time Zone: UTC-12

Communication

Baud Rate: 9600 Output Rate: 10Hz Device Address: 0x50 change

Content

☒ Time ☒ Acceleration ☒ Velocity ☒ Angle ☒ Magnetism ☐ Port

☐ Pressure ☐ Location ☐ PDOP ☐ Quaternion ☐ Positioning Accuracy ☐ GPS Original

Port

D0 model: AIN pulse width: 0 ▼ ▲ cycle: 0 ▼ ▲

D1 model: AIN pulse width: 0 ▼ ▲ cycle: 0 ▼ ▲

D2 model: AIN pulse width: 0 ▼ ▲ cycle: 0 ▼ ▲

D3 model: AIN pulse width: 0 ▼ ▲ cycle: 0 ▼ ▲

■ Online

Save Config

Read Configuration Completed

Menu of Configuration	
Button	Function
Read Config	Reading the current configuration
Lock	Lock the sensor
Unlock	Unlock the sensor
Calibrate Time	Calibration time of chip
Save Config	Save configuration

System

Algorithm:
 Install Direction:
☐ Instruction Startup

Menu of System	
Button	Function
Reset	Reset to factory setting
Sleep	Sleep function
Alarm	Alarm function
Algorithm	6-axis algorithm or 9-axis
Installation Direction	Vertical or horizontal installation
Instruction Start-up	Instructions sending to start-up the sensor

Calibrate

☒ Gyro Auto Calibrate

Menu of Calibrate	
Button	Function
Acceleration	Accelerometer calibration
Magnetic Field	Magnetometer calibration
Reset Height	Reset height data to 0 (only for sensor built-in barometer, including WT901B, WTGAHRS2, WTGAHRS1, HWT901B)
Reset Z-axis Angle	Reset Z-axis angle to 0 degree, not available for HWT905 in 9-axis algorithm
Angle Reference	Setting current angle as 0 degree
Gyro Auto Calibrate	Auto-calibration of gyroscope

Range

Acceleration:
 Gyro:
 Band Width:
 GPS Time Zone:

Menu of Range	
Button	Function
Acceleration	Acceleration measurement range
Gyro	Gyroscope measurement range
Band Width	Bandwidth range
GPS Time Zone	GPS positioning of time zone

Communication

Baud Rate:
 Output Rate:
 Device Address:

Menu of Communication	
Button	Function
Baud Rate	Baud rate selection
Output Rate	Return rate selection
Device Address	Interface for R&D





Content

☒ Time
 ☒ Acceleration
 ☒ Velocity
 ☒ Angle
 ☒ Magnetism
 ☐ Port

☐ Pressure
 ☐ Location
 ☐ PDOP
 ☐ Quaternion
 ☐ Positioning Accuracy
 ☐ GPS Original

Menu of Content	
Button	Function
Time	Time data output
Acceleration	Acceleration data output
Velocity	Angular velocity data output
Angle	Angle data output
Magnetism	Magnetic field data output
Port	Port data output
Pressure	Pressure output, only available with the sensor built-in barometer like HWT901B, WTGAHRS1, WTGAHRS2, WT901B, etc
Location	Latitude&Longitude data output, only for GPS IMU series, such as WTGAHRS1, WTGAHRS2
PDOP	Ground velocity data output, only for GPS IMU series, such as WTGAHRS1, WTGAHRS2
Quaternion	Quaternion data output
Positioning Accuracy	Option for GPS positioning accuracy output, including Satellite quantity, PDOP, HDOP, VDOP data, only for GPS IMU series, such as WTGAHRS1, WTGAHRS2
GPS Original	Only output GPS raw data, only for GPS IMU series, such as WTGAHRS1, WTGAHRS2
Menu of Port	
D0 Model	Extended port D0
D1 Model	Extended port D1
D2 Model	Extended port D2
D3 Model	Extended port D3
Pulse width	Pulse width of PWM
Cycle	Cycle of PWM

Port

D0 model:	AIN ▾	pulse width:	0 ▾		cycle:	0 ▾
D1 model:	AIN ▾	pulse width:	0 ▾		cycle:	0 ▾
D2 model:	AIN ▾	pulse width:	0 ▾		cycle:	0 ▾
D3 model:	AIN ▾	pulse width:	0 ▾		cycle:	0 ▾

2.5 Calibration

Preparation:

Make sure the sensor is "Online".

Calibration on PC software:

It is required to calibrate for the first time usage.

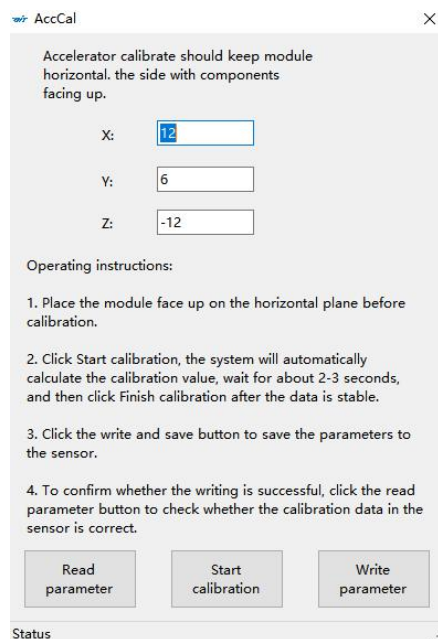
2.5.1 Accelerometer Calibration

Purpose:

The accelerometer calibration is used to remove the zero bias of the accelerometer. Before calibration, there will be different degrees of bias error. After calibration, the measurement will be accurate.

Methods:

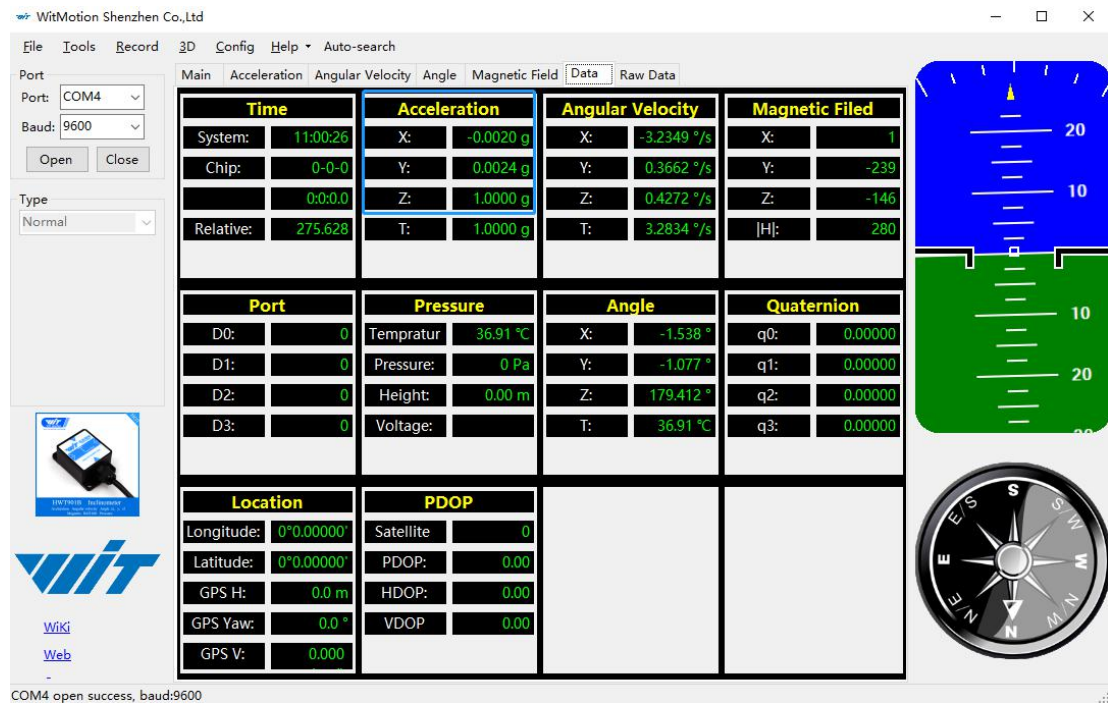
- Step 1. Keep the module horizontally stationary
- Step 2. Click the accelerometer calibration
- Step 3. Click the "Start calibration" and wait for 3 seconds



The screenshot shows a software window titled "AccCal" with a close button (X) in the top right corner. Inside the window, there is a text instruction: "Accelerator calibrate should keep module horizontal, the side with components facing up." Below this, there are three input fields for calibration parameters: "X:" with a value of "12", "Y:" with a value of "6", and "Z:" with a value of "-12". Below the input fields, there is a section titled "Operating instructions:" followed by four numbered steps: 1. Place the module face up on the horizontal plane before calibration. 2. Click Start calibration, the system will automatically calculate the calibration value, wait for about 2-3 seconds, and then click Finish calibration after the data is stable. 3. Click the write and save button to save the parameters to the sensor. 4. To confirm whether the writing is successful, click the read parameter button to check whether the calibration data in the sensor is correct. At the bottom of the window, there are three buttons: "Read parameter", "Start calibration", and "Write parameter". A "Status" label is located at the bottom left of the window.

Step 4. Click "Complete Calibration"

Step 5. Judge the result--confirm if there is 1g on Z-axis acceleration



1. After 1 ~ 2 seconds, the three axial acceleration value of the module is about 0, 0, 1, the X and Y axis Angle is around 0°. After calibration, the x-y axis Angle is accurate.

Note: When putting the module horizontal, there is 1g of gravitational acceleration on the Z-axis.

2.5.2 Magnetic Field Calibration

Purpose:

Magnetic calibration is used to remove the zero bias of the magnetic field sensor. Usually, the magnetic field sensor will have a large zero error when it is manufactured. If it is not calibrated, it will bring a large measurement error, which will affect the accuracy of the measurement of the z-axis Angle of the heading Angle.

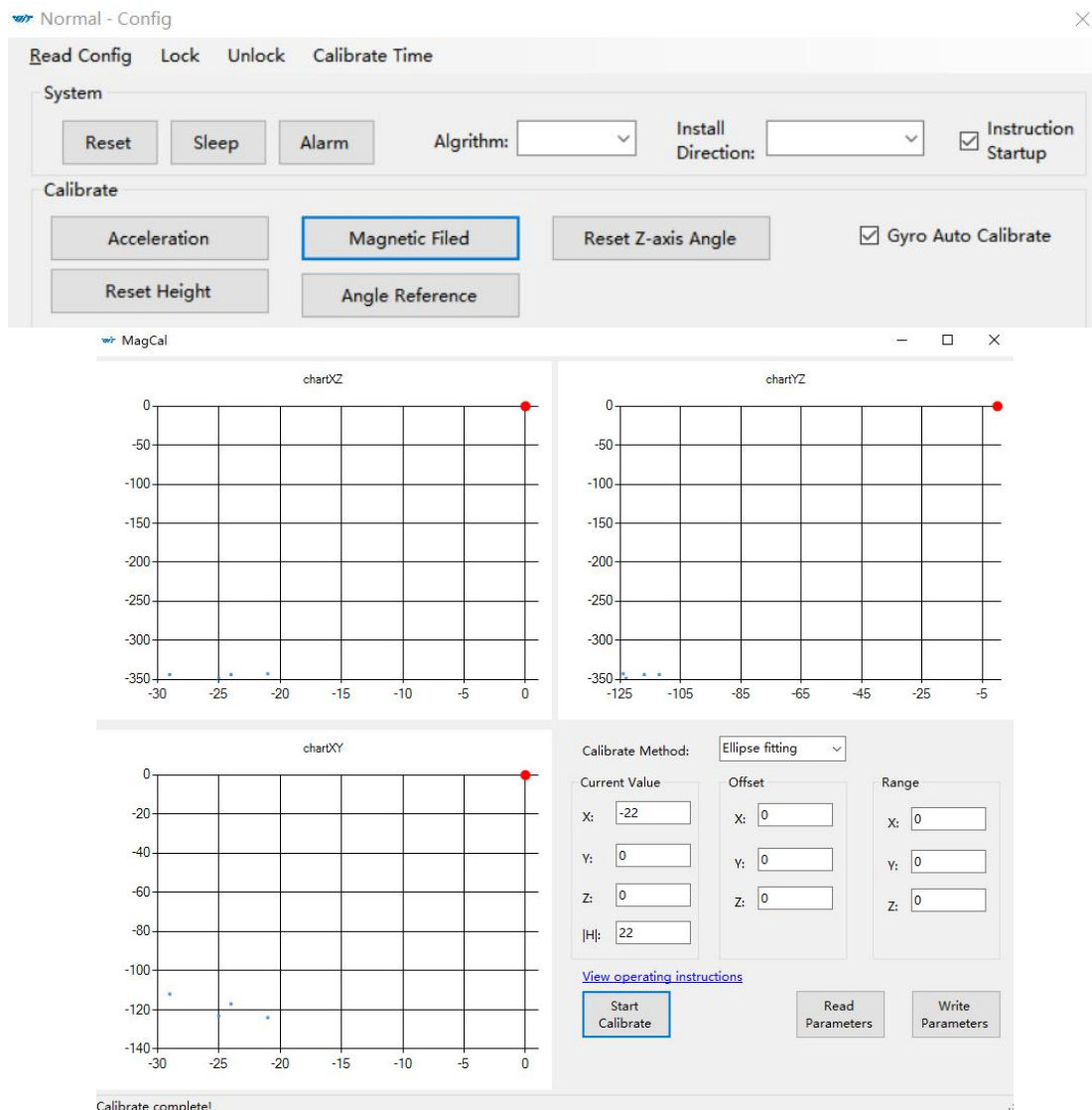
Preparation:

Sensors should be 20CM away from magnetic and iron and other materials

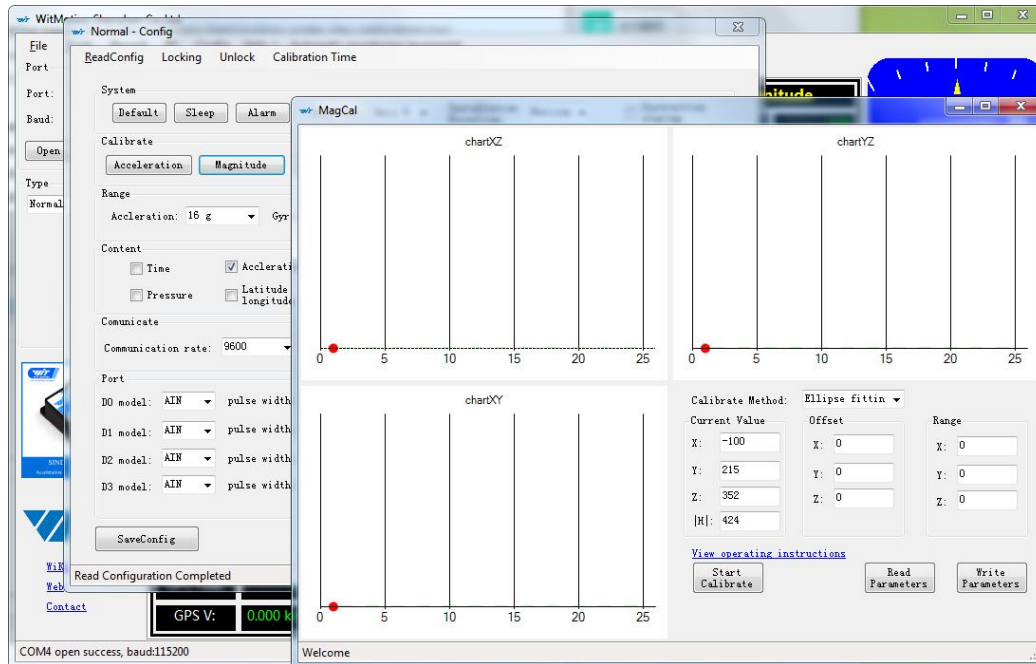
Methods:

Step 1. Open the Config menu

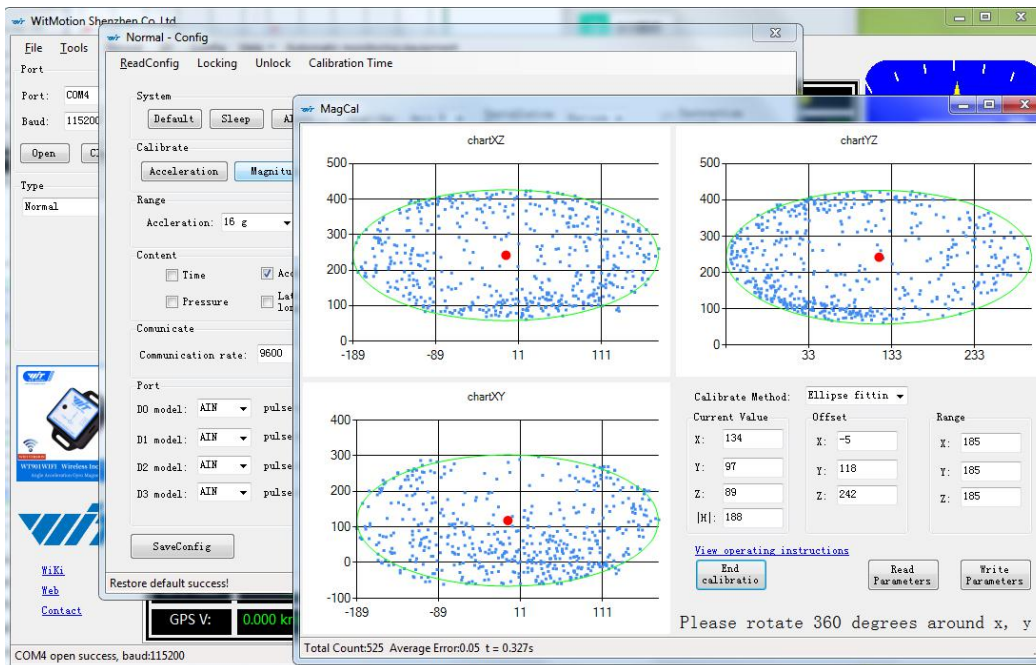
Step 2. Click the magnetic field calibration button. click the "Start calibration"



Step 3. Slowly rotate the module 360° around X, Y, Z, 3-axis accordingly



Step 4. After rotation, click "End calibration"



Successful result:

Most of data dots will be within the ellipse.

If not successful, please stay away from the objective that can create magnetic field interference.

2.5.3 Gyroscope Automatic Calibration

The gyroscope calibration is to calibrate the angular velocity, and the sensor will calibrate automatically.

It is recommended that the automatic calibration of gyroscopes can be inactivated only if the module rotates at a constant speed.

2.5.4 Reset Z-axis Angle

Note: If you want to avoid magnetic interference, you can change the algorithm to 6-axis, function of resetting Z-axis angle can be used.

The z-axis angle is an absolute angle, and it takes the northeast sky as the coordinate system can not be relative to 0 degree.

Z axis to 0 is to make the initial angle of the z axis angle is relative 0 degree. When the module is used before and z - axis drift is large, the z - axis can be calibrated, When the module is powered on, the Z axis will automatically return to 0.

Calibration methods as follow: firstly keep the module static, click the "Config" open the configuration bar and then click "Reset Z-axis Angle" option, you will see the the angle of the Z axis backs to 0 degree in the module data bar.

2.5.5 Reset Height to 0

Only available for the module built-in barometer like WT901B, HWT901B, WTGAHRS1, WTGAHRS2.

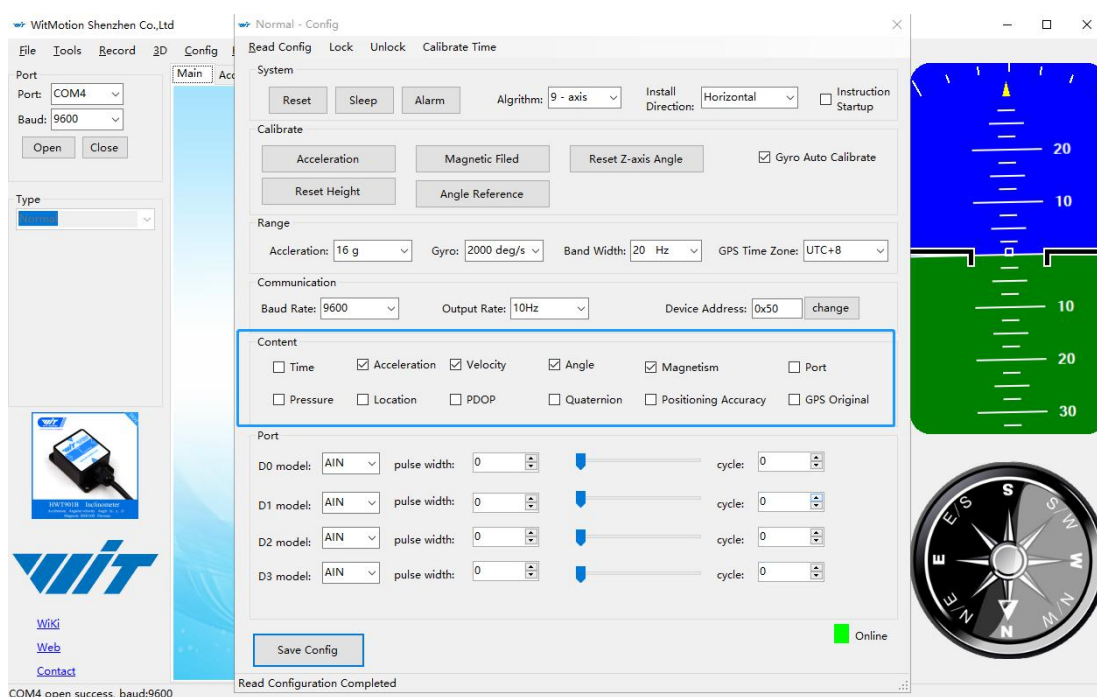
2.6 Configuration

2.6.1 Return Content

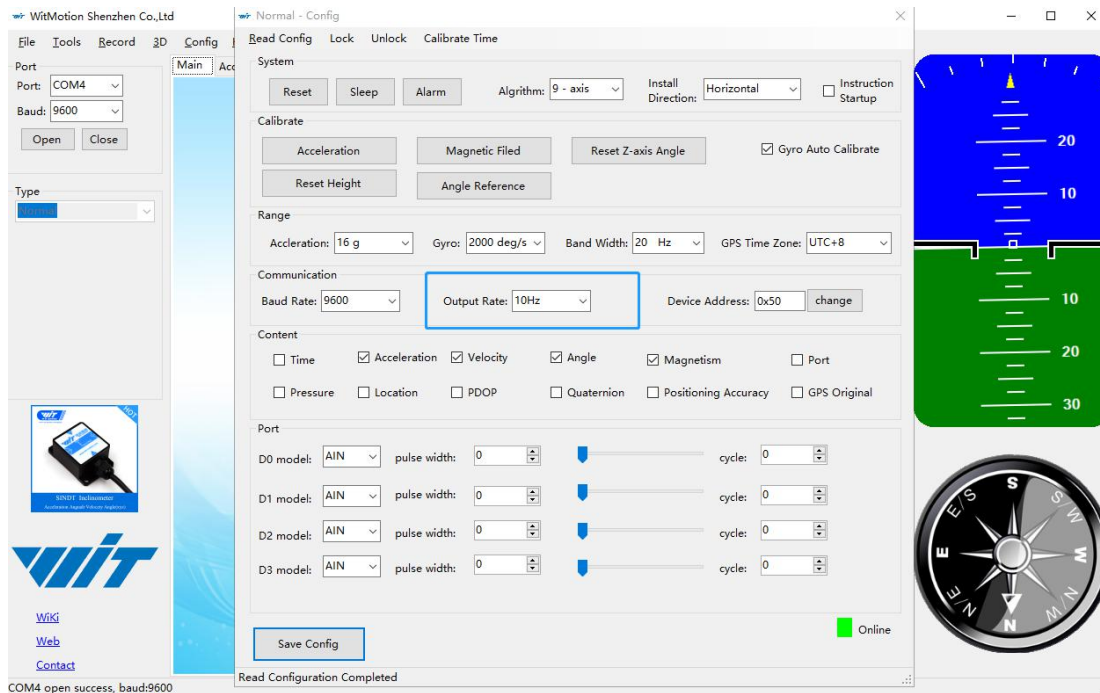
Setting method: The content of the data return can be set according to user needs, click the configuration option bar, and check the data content to be output.

Taking HWT905 as an example, the default output of the module is acceleration, angular velocity, angle, and magnetic field.

Notice: If choosing the GPS Original, there will be no other data output.



2.6.2 Output Rate



The default return rate of the module is 10Hz, the highest return rate supports 200Hz.

10Hz refers to the return of 10 data packets in 1S. 1 data packet is 33 bytes by default.

Note: If there are more backhaul contents and the communication baud rate is lower, it may not be possible to transmit so much data. Then the module will automatically reduce the frequency and output at the maximum allowable output rate. To put it simply, if the return rate is high, the baud rate should also be set higher, generally 115200.

2.6.3 Baud Rate

The module supports multiple baud rates, and the default baud rate is 9600. To set the baud rate of the module, you need to select the baud rate to be changed in the communication rate drop-down box in the configuration bar based on the correct connection between the software and the module.

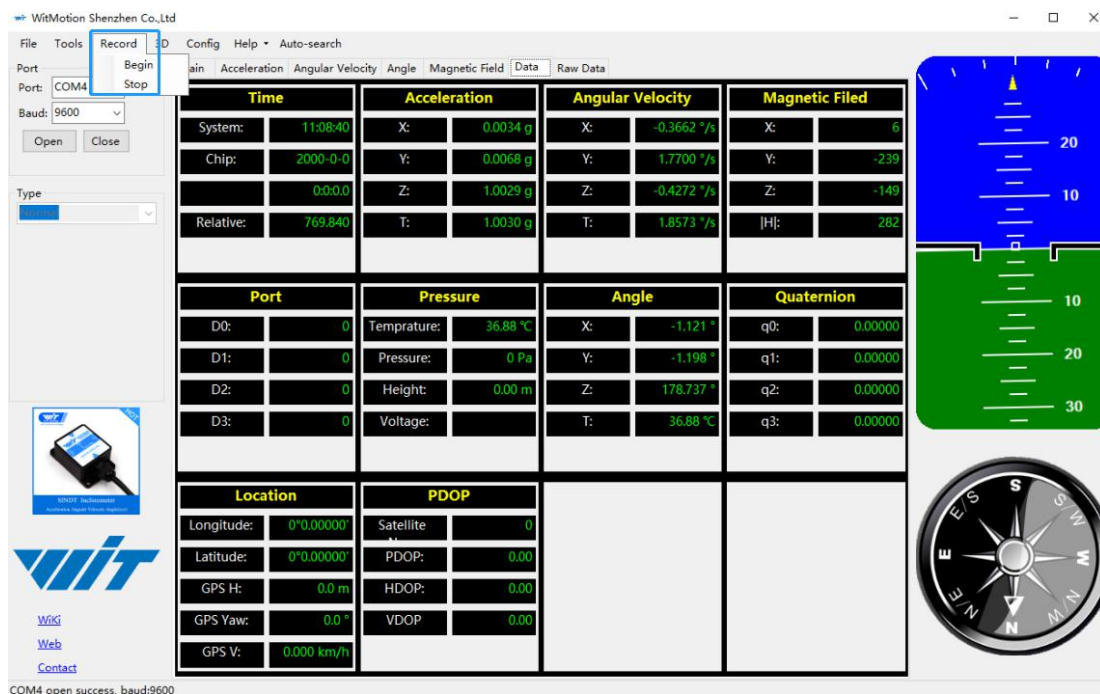
Note: After the change, the module will no longer output data at the original baud rate. The data will be output only when the baud rate that has been changed is selected on the PC software again.

2.6.4 Data Recording

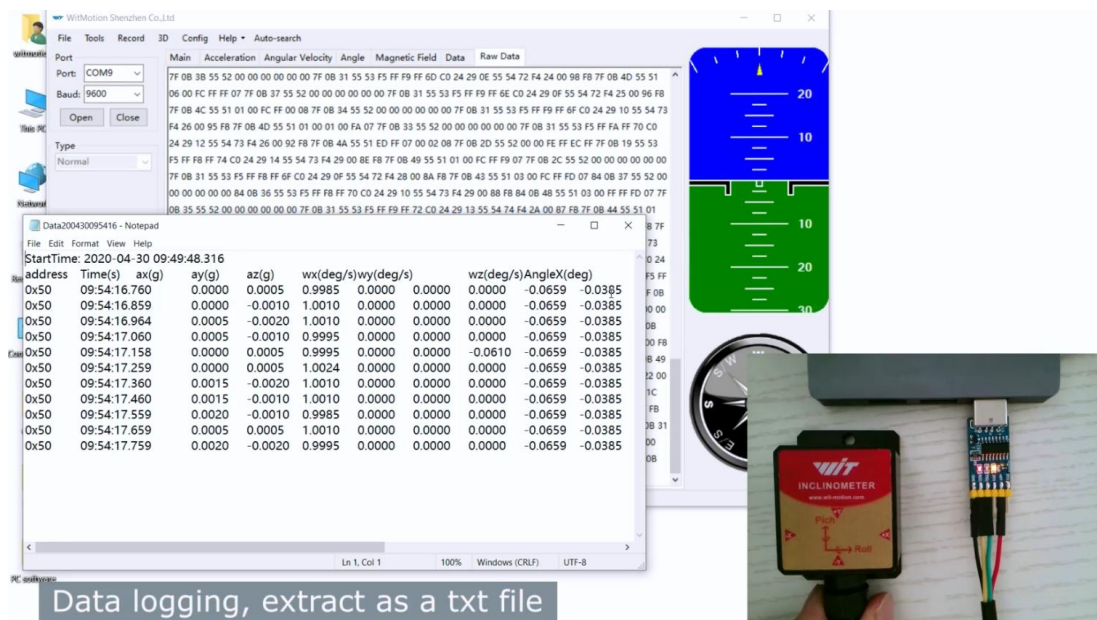
Method are as follows:

Step 1: Click "Record" and "Begin"

Step 2: Click "Stop"



Step 3: Extract the data as "txt" file



Notice: If there is repeated "TIME" of data, that's caused by low-resolution of the Windows system's time. The changes in other data is correct.

It is highly recommended that data can be pasted to a Excel file. In this way, all data will be shown in order.

StartTime: 2020-04-11 16:54:24.437															
address	Time(s)	ChipTime	ax(g)	ay(g)	az(g)	wx(deg/s)	wy(deg/s)	wz(deg/s)	AngleX(deg)	AngleY(deg)	AngleZ(deg)	T(°)	hx	hy	hz
0x50	43:06.4	02:40.4	0.4443	0.1777	-0.8696	3.1738	-0.3662	-29.541	166.0364	-29.2072	120.6299	29.97	0	50	313
0x50	43:06.5	02:40.5	0.02	0.5796	-0.7739	-192.0166	283.9355	-700.2563	142.0532	-24.884	154.8907	30	-29	7	312
0x50	43:06.6	02:40.6	-0.2896	0.8599	-0.5571	-8.2397	-3.7842	-264.5264	124.0741	20.0171	-158.2196	30	-7	-85	291
0x50	43:06.7	02:40.7	-0.771	0.5322	-0.4761	36.0718	43.8232	-226.8677	132.984	41.4514	-138.0872	30	38	-93	289
0x50	43:06.8	02:40.8	-0.5601	0.4233	-0.5562	55.7861	101.9897	274.1699	144.5087	35.5792	-132.4292	30	22	-58	301
0x50	43:06.9	02:40.9	-0.0059	0.5503	-1.0103	139.0991	-32.7759	432.251	141.4929	1.8073	-174.1113	30	-22	-9	308
0x50	43:07.0	02:41.0	0.2656	0.3887	-0.8594	124.3896	7.8735	341.1865	154.6985	-15.5896	157.3077	30.01	-14	46	307
0x50	43:07.1	02:41.1	0.3911	0.1104	-0.8467	40.7715	11.9019	257.1411	177.3303	-25.7684	127.7325	30	0	104	294
0x50	43:07.2	02:41.2	0.3896	0.3022	-0.8994	-90.0879	135.3149	-268.9819	163.4601	-31.9867	128.6829	30.03	-2	67	308
0x50	43:07.3	02:41.3	0.2939	0.9531	-0.2837	-251.5259	48.645	-750.4272	119.0149	-0.3625	-174.1608	30.03	-30	-56	295
0x50	43:07.4	02:41.4	-0.4614	0.7075	-0.3384	-27.3438	-19.4702	-226.9287	112.8021	30.6519	-161.4001	30	33	-122	272
0x50	43:07.5	02:41.5	-0.7988	0.6279	-0.5044	28.0762	81.7261	122.1924	122.0087	39.8035	-151.1389	30	63	-110	275
0x50	43:07.6	02:41.6	-0.2495	0.8135	-0.5327	36.377	5.6763	93.0176	121.8494	15.7214	-161.109	30	12	-108	288
0x50	43:07.7	02:41.7	0.3057	0.7432	-0.5996	74.0356	-0.061	379.7607	126.7603	-11.4478	-176.6711	30.03	-51	-68	295
0x50	43:07.8	02:41.8	0.4922	0.4653	-0.7129	134.7656	24.231	268.9819	145.3656	-32.4756	163.3832	30.02	-83	10	295
0x50	43:07.9	02:41.9	0.4507	0.4272	-0.7871	-186.5234	-36.3159	420.6543	166.2616	-49.1583	130.2924	30.02	-86	71	292
0x50	43:08.0	02:42.0	0.6045	-0.062	-0.8027	37.9028	7.6294	-138.0005	173.4357	-45.8514	118.0206	30.03	-66	75	298
0x50	43:08.1	02:42.1	0.4712	0.6011	-0.5688	-172.6685	-7.1411	-537.6587	137.6312	-31.2396	163.8171	30.03	-78	20	300
0x50	43:08.2	02:42.2	-0.0649	0.873	-0.4028	-115.6616	2.3193	-276.2451	113.6481	4.6417	-169.8761	29.98	-37	-101	283
0x50	43:08.3	02:42.3	-0.4092	0.856	-0.1816	-134.8877	-38.208	-155.7007	99.8822	26.933	-165.943	30.03	32	-166	244
0x50	43:08.4	02:42.4	-0.5171	0.8809	-0.1152	84.1064	0.9155	86.2427	94.8285	33.2666	-167.5415	30.06	72	-186	218
0x50	43:08.5	02:42.5	-0.1782	0.9595	-0.2793	243.2861	29.3579	406.8604	110.7367	13.3429	-169.0686	30.03	29	-156	254

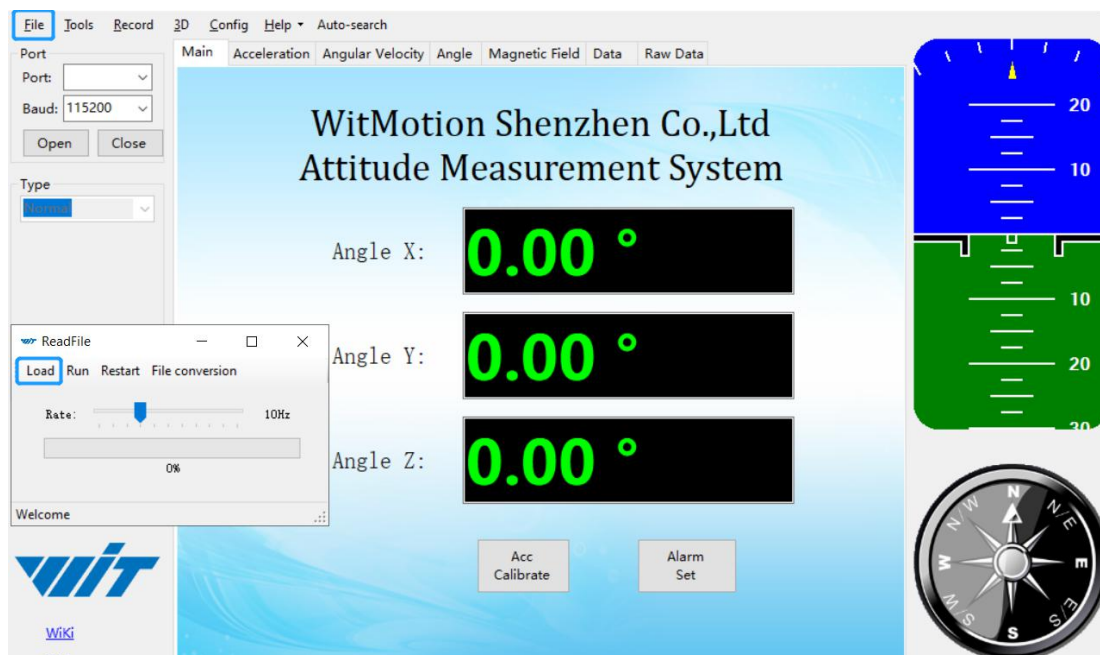
2.6.5 Data Playback

New function: When creating recorded file each time, there will a BIN file created in the folder of record file in path of installed software meanwhile.

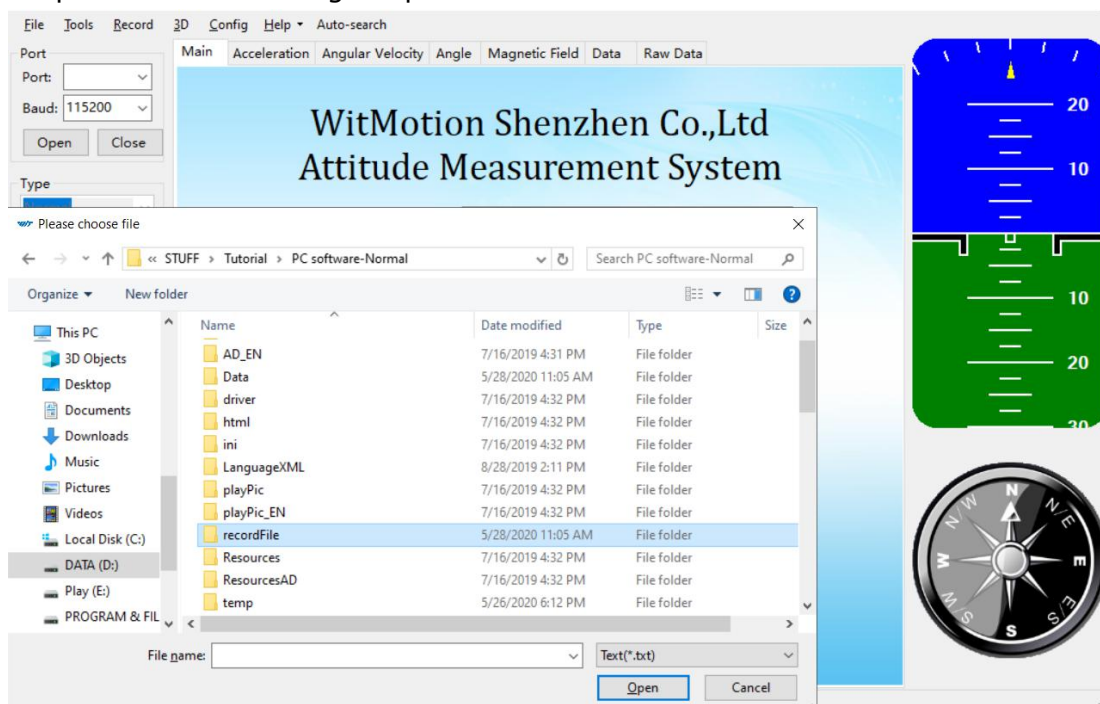
Recorded data playback method:

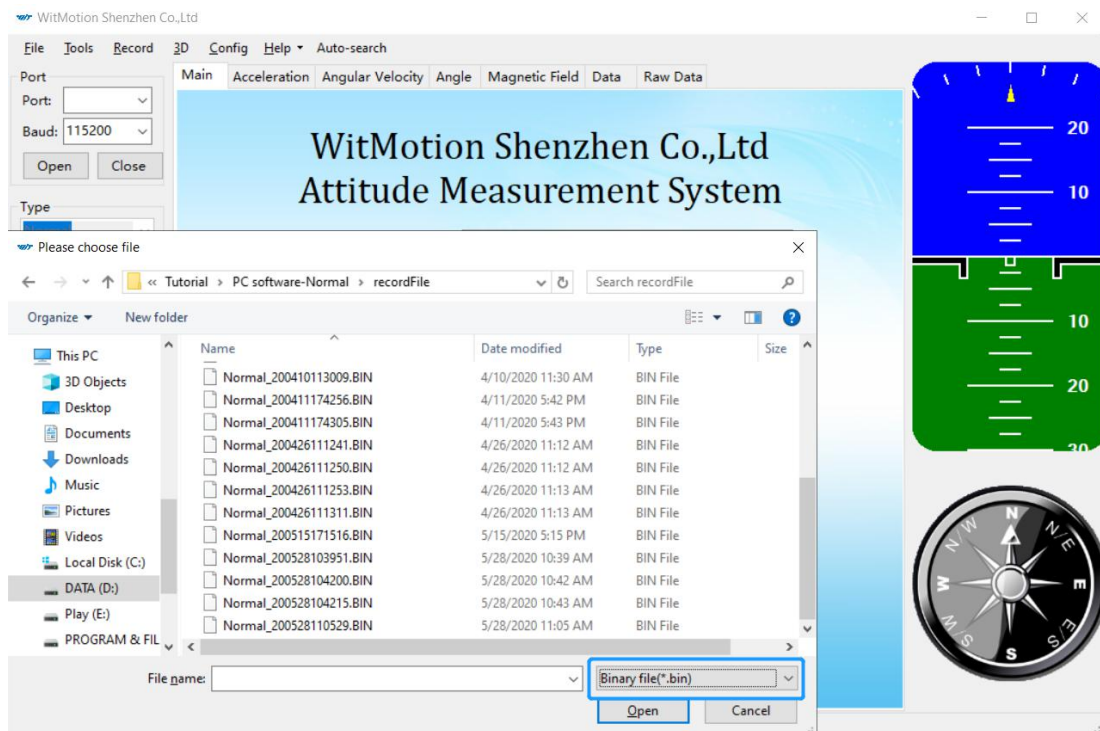
Step 1: Disconnect the sensor

Step 2: Click "File" Button and then click "Load"



Step 3: Choose the original path of software installation and load the Bin file





Step 4: Click "Run" and the Binary file will be playback
When playback, the rate can be editable.

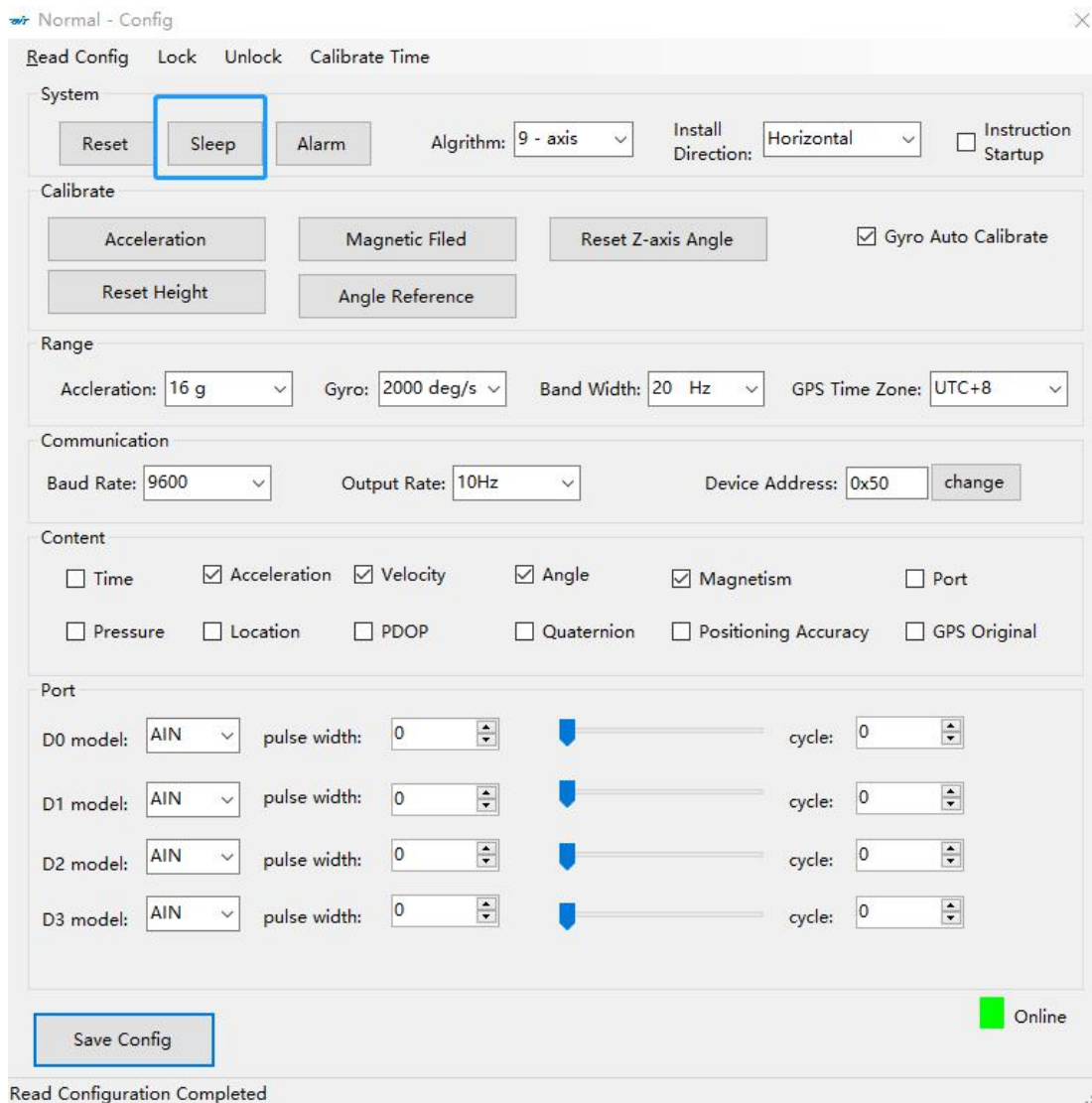


2.6.6 Standby and Wake Up

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 the 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.



The screenshot shows the 'Normal - Config' window of the WIT software. The 'System' section contains buttons for 'Reset', 'Sleep' (highlighted with a blue box), and 'Alarm'. It also includes dropdowns for 'Algorithm' (set to '9 - axis') and 'Install Direction' (set to 'Horizontal'), and a checkbox for 'Instruction Startup'. The 'Calibrate' section has buttons for 'Acceleration', 'Magnetic Filed', 'Reset Z-axis Angle', 'Reset Height', and 'Angle Reference', along with a checked checkbox for 'Gyro Auto Calibrate'. The 'Range' section features dropdowns for 'Acceleration' (16 g), 'Gyro' (2000 deg/s), 'Band Width' (20 Hz), and 'GPS Time Zone' (UTC+8). The 'Communication' section shows 'Baud Rate' (9600), 'Output Rate' (10Hz), and 'Device Address' (0x50) with a 'change' button. The 'Content' section has checkboxes for various data types: Time, Acceleration, Velocity, Angle, Magnetism, Port, Pressure, Location, PDOP, Quaternion, Positioning Accuracy, and GPS Original. The 'Port' section displays settings for D0, D1, D2, and D3 models, including 'AIN' selection, 'pulse width' (0), and 'cycle' (0). At the bottom, there is a 'Save Config' button and an 'Online' status indicator (green square). A status bar at the very bottom reads 'Read Configuration Completed'.

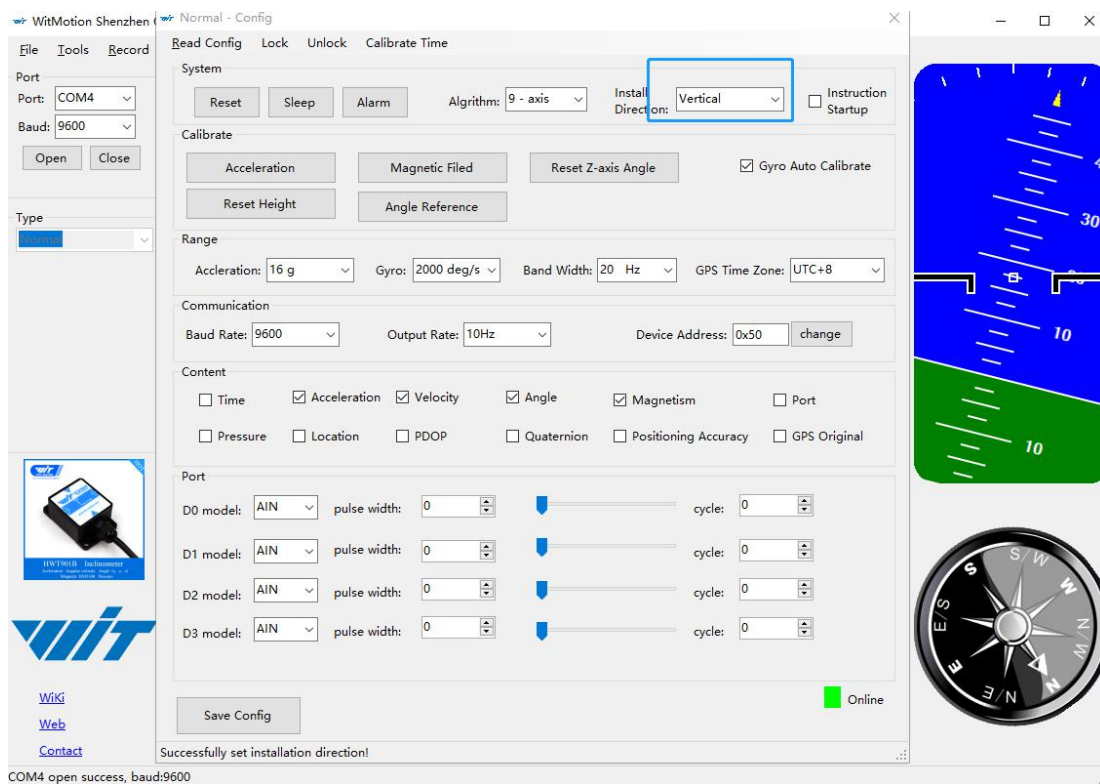
2.6.7 Placement Direction

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

Step 1: Rotate the module 90 degrees around the X-axis

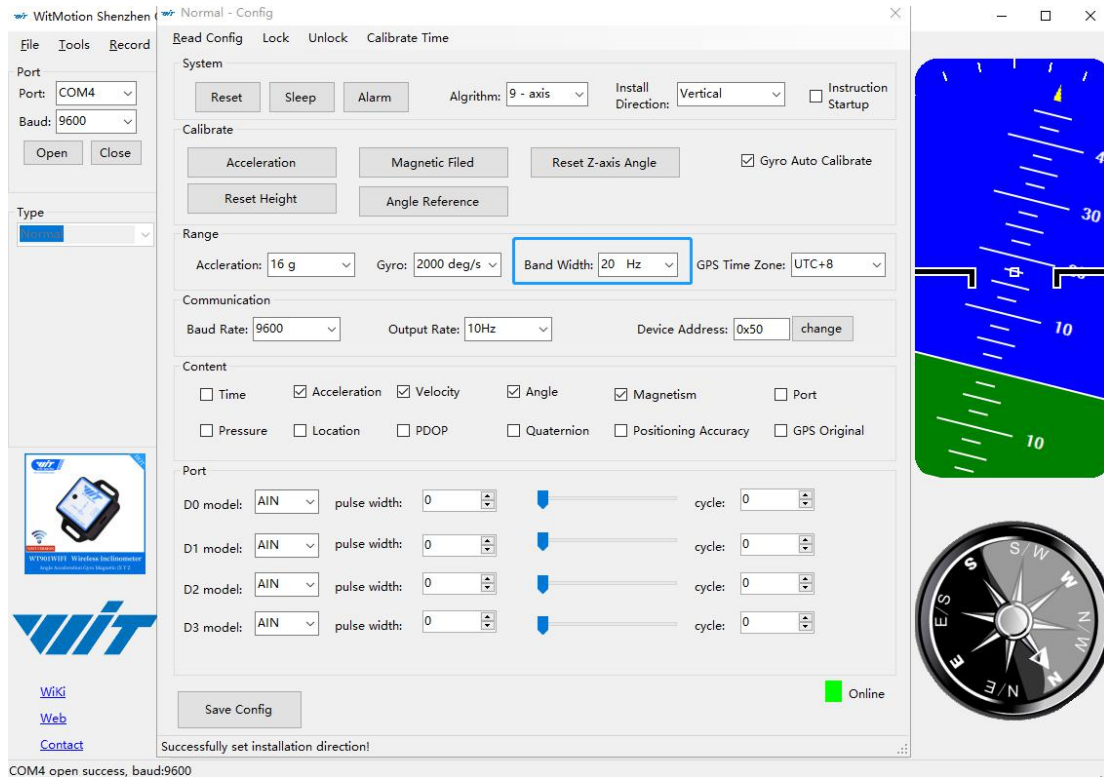
Step 2: Place the sensor 90 degrees vertically

Step 3: Click “Vertical” as install directions on “Config” menu



2.6.8 Bandwidth

Default bandwidth is 20Hz.

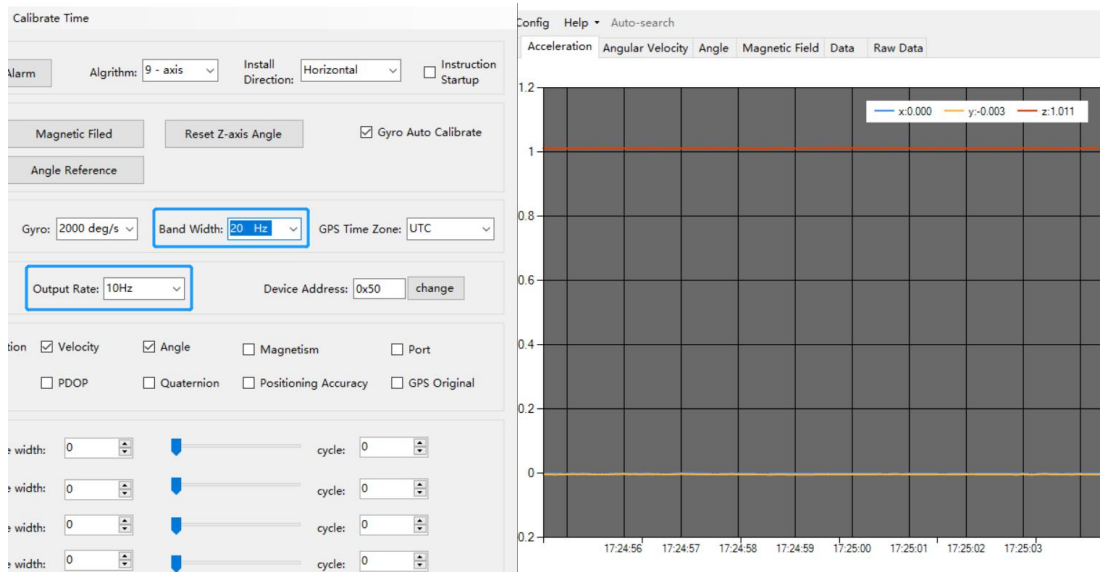


Function:

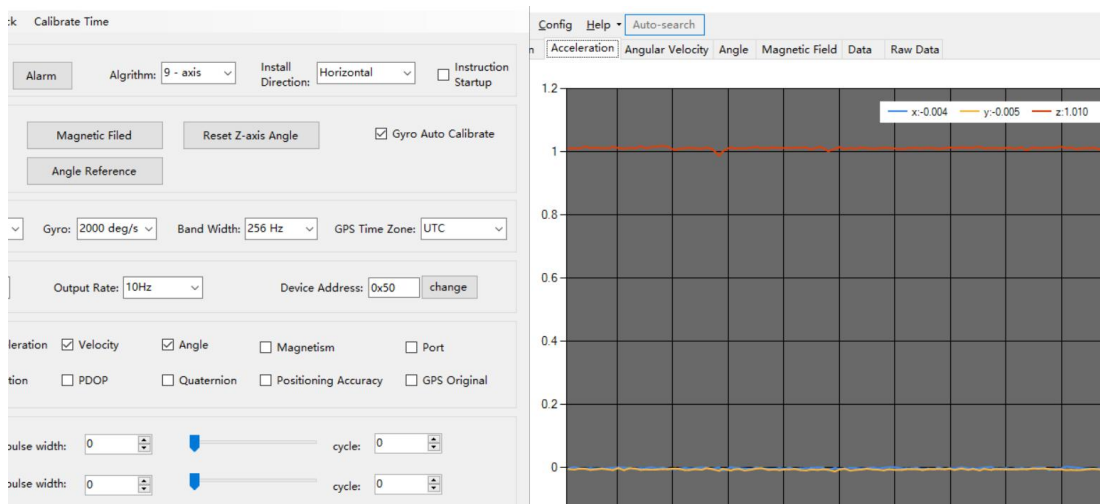
1. The higher rate of bandwidth setting will lead to the higher fluctuation in data waveform. Conversely, the lower rate of bandwidth, data will become more fluent.

For example:

Bandwidth as 20Hz, Output rate as 10Hz. The waveform is very steady.



Bandwidth as 256Hz, Output rate as 10Hz. The waveform will show more fluctuation.



2. The higher rate of bandwidth will solve the data-repeating problem.

For example, if the bandwidth setting is 20Hz, retrieval rate as 100Hz, there will be 5 repeating data.

If you prefer there is no repeating data, it is required to increase the bandwidth more than 100Hz.

2.6.9 Restore Factory Setting

Operation method:

Connect the HWT905 to the computer through the USB to serial port module, click the configuration option, open the configuration bar, and click "Reset".

After restoring the factory settings, power on the module again. (This method needs to know the baud rate of the module in advance, if the baud rate does not match the instruction will not take effect.)

2.6.10 6-axis/ 9-axis Algorithm

6-axis algorithm: Z-axis angle is mainly calculated based on angular velocity integral. There will be calculated error on Z-axis angle.

9-axis algorithm: Z-axis angle is mainly calculated and analyzed based on the magnetic field. Z-axis angle will have few drift.

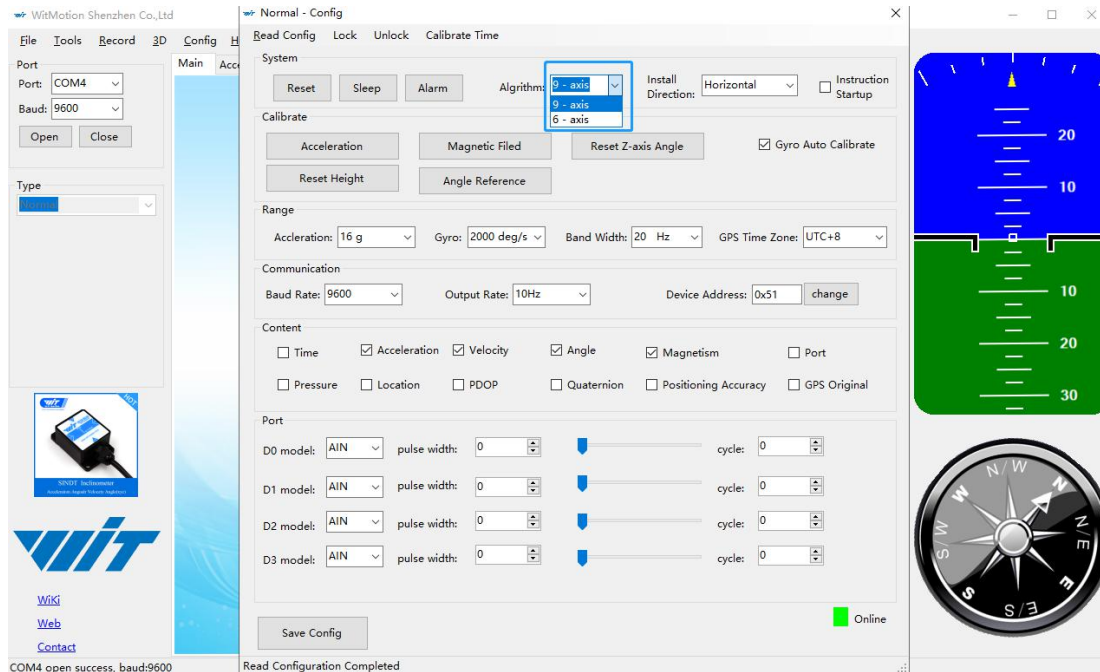
The default algorithm of HWT905 is 9-axis. If there is magnetic field interference around installed environment, it is recommended to switch to 6-axis algorithm to detect the angle.

Method:

Step 1: Switch to the "6-axis" algorithm on "Config" menu

Step 2: Proceed the "Accelerometer calibration" and "Reset Z-axis angle" calibration.

After the calibration is completed, it can be used normally.

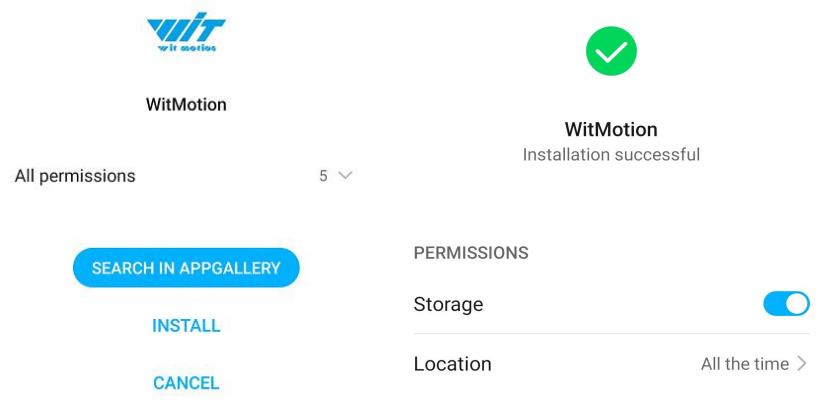


3 Use Instructions with Android Phone

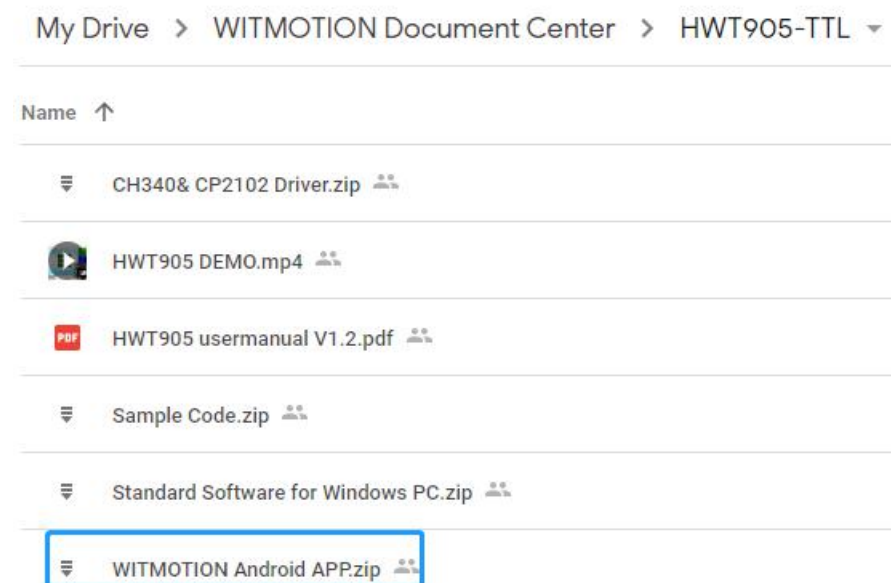
For APP configuration introduction, please referring to the Chapter 2.2

3.1 APP Installation

Install the APK file, give permission of Location and Storage

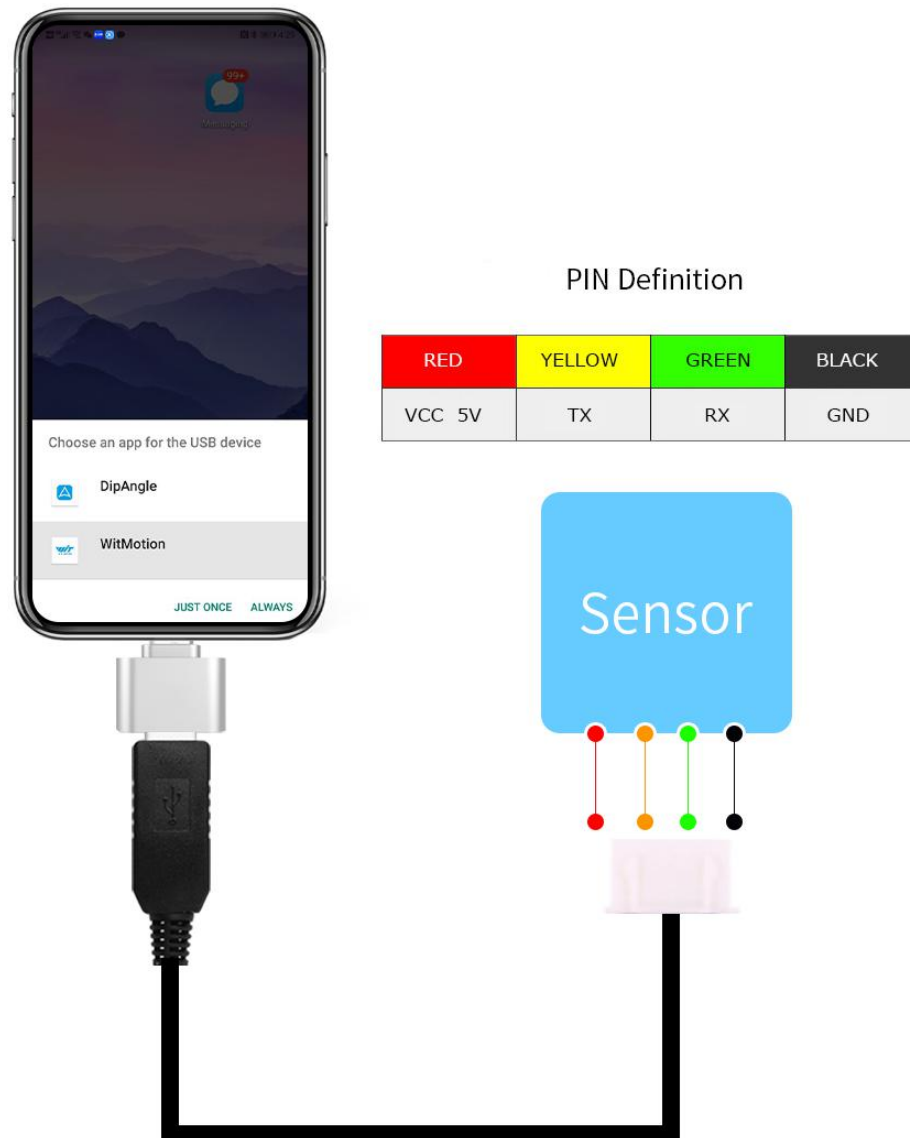


[Link to download Android APP](#)



3.2 Hardware Preparation

Connecting with Android smartphone requires a serial cable and a Type-C converter or OTG converter according to phone's interface.



3.3 Connection

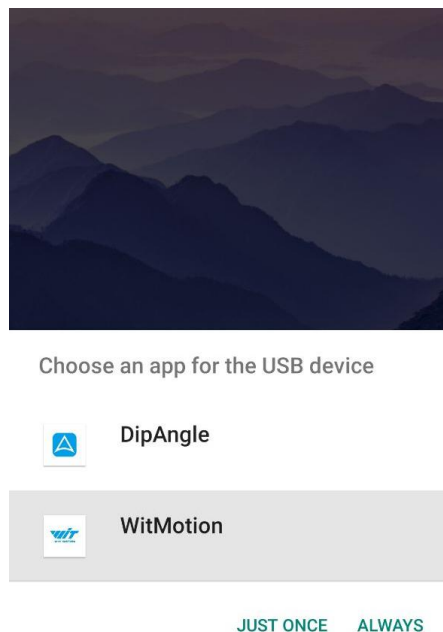
Step 1. Install the APK file, give permission of Storage.

Step 2: Connect the sensor with TTL cable. Then connect the cable with type-c converter. Plug in the device "type-c converter" to the phone.

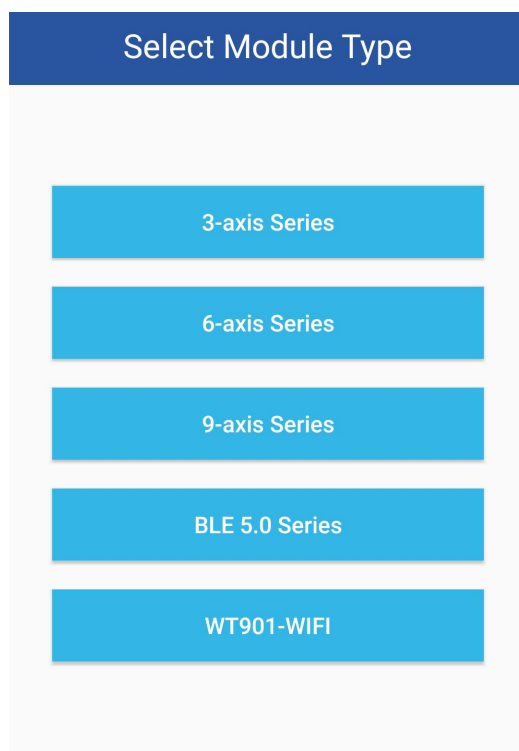
Notice:

1. After successful connection, there will be a notification reminding that "Choose an APP for the USB device", which means that the device has been detected. Choose "WitMotion", " JUST ONCE" or "ALWAYS" is optional.

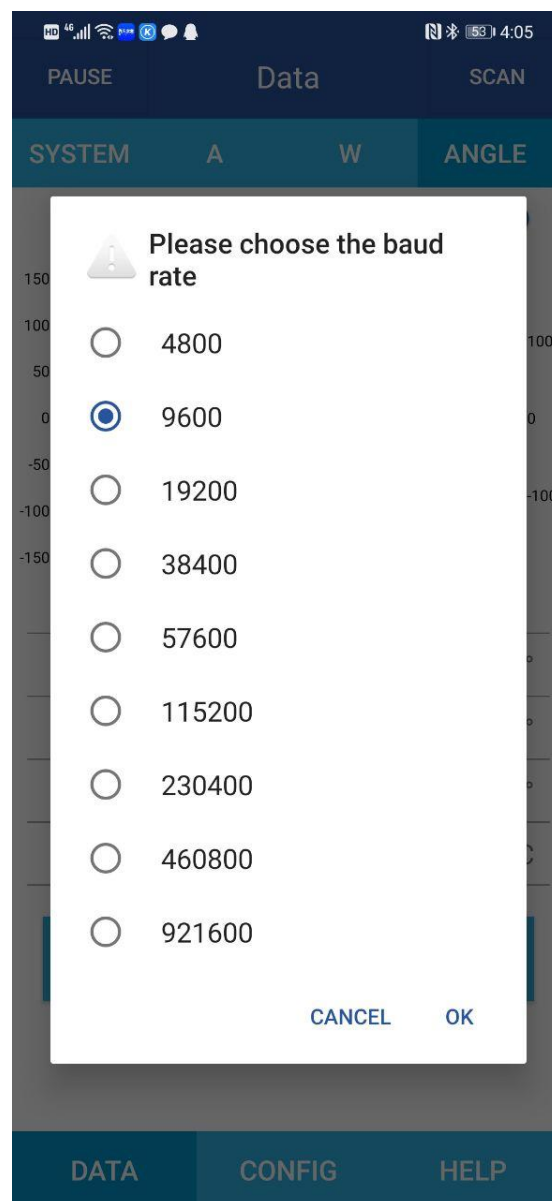
2. Only CH340 driver can be detected via WitMotion APP.



Step 3. Open APP and choose "9-axis Series" as sensor series



Step 4. Select the baud rate- 9600.



After selection and wait for a few seconds, the data will show automatically.



3.4 Calibration

[HWT905 Playlist](#)

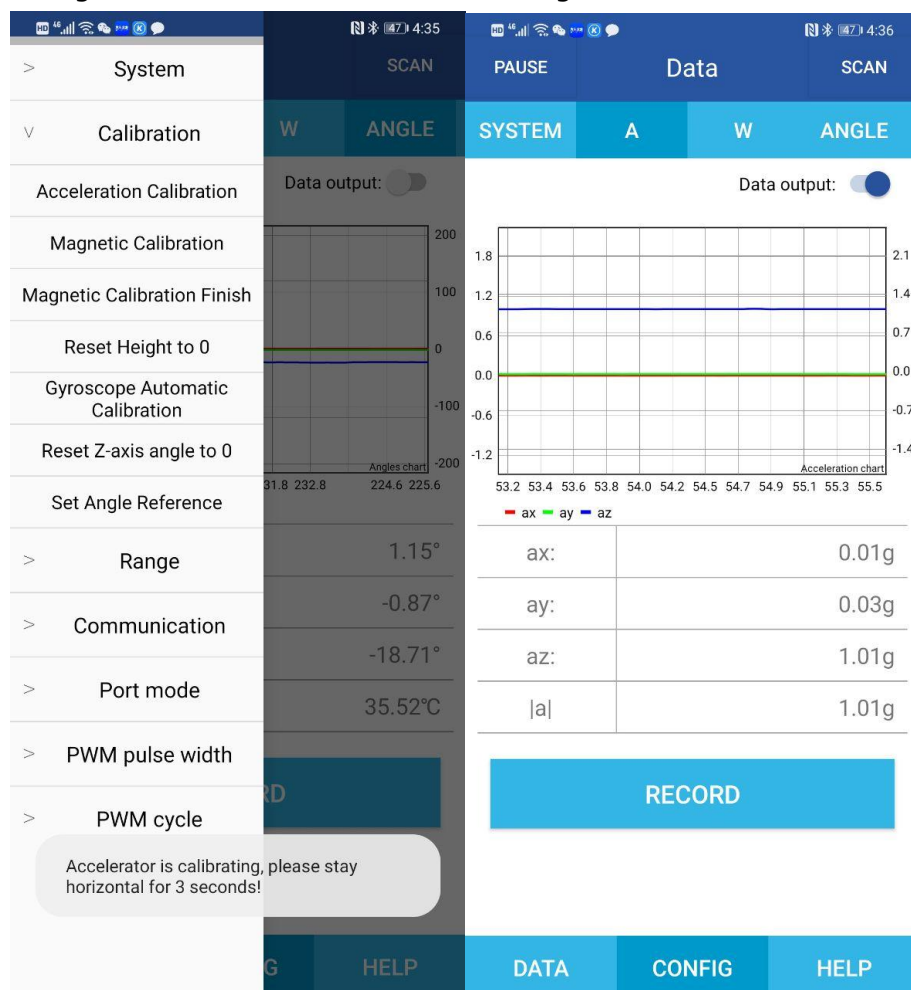
3.4.1 Acceleration Calibration

Step 1. Keep the module horizontally stationary

Step 2. Click the "Calibration" menu

Step 3. Click the "Acceleration Calibration" and wait for 3 seconds

Step 5. Judge the result--confirm if there is 1g on Z-axis acceleration



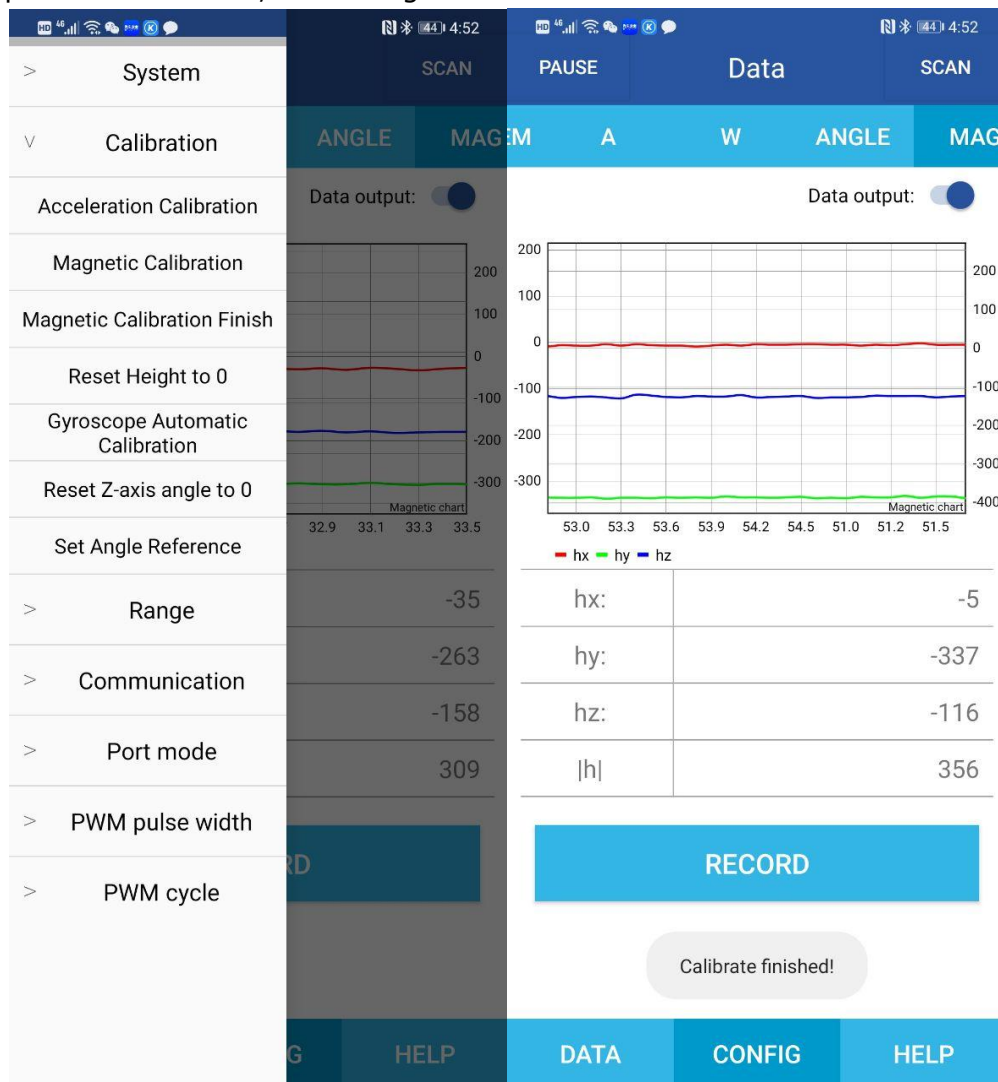
3.4.2 Magnetic Field Calibration

Step 1. Click "Calibration" menu

Step 2. Click the "Magnetic calibration" button

Step 3. Slowly rotate the module 360° around X, Y, Z, 3-axis accordingly

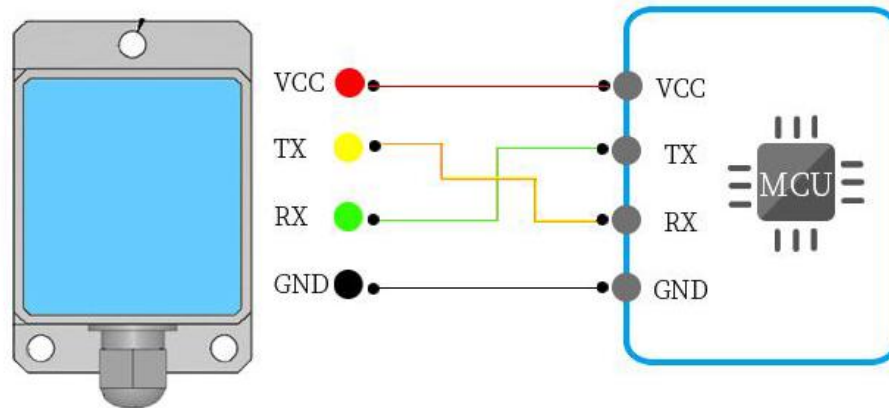
Step 4. After rotation, click "Magnetic Calibration Finish"



Check the result: The Z-axis angle will have fewer drift than before.

Notice: If not successful, please stay away from the objective that can create magnetic field interference.

4 MCU Connection



[Link to download all sample code](#)

[Link to sample code instructions demo](#)

Notice: There is no sample code provided for Linux or Python system at present.

4.1 Arduino

[Download link](#)

[Arduino UNO3 Demo Link](#)

4.2 STM32

[Download link](#)

4.3 Raspberry pi

[Tutorial link](#)

4.4 C#

[DEMO link](#)

4.5 C++

[DEMO link](#)

4.6 Matlab

[Receive Sample Code](#)

[Dataplot DEMO](#)