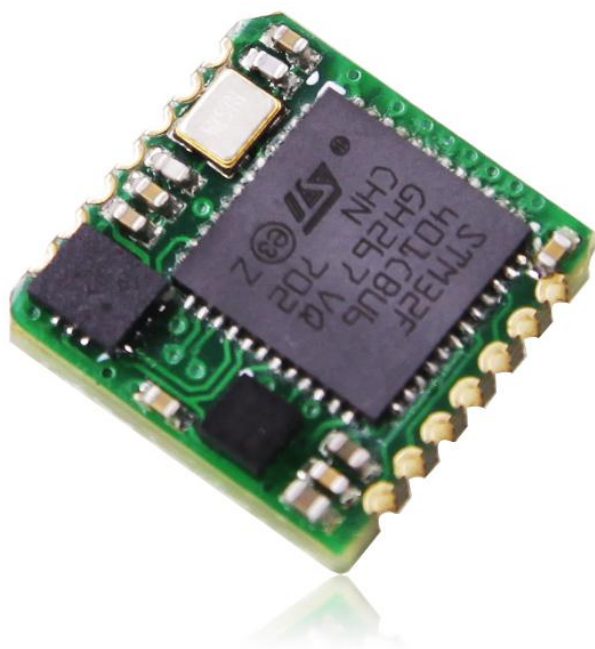


# USER MANUAL WT931

## Inclinometer Sensor



## Tutorial link

[Google Drive](#)

**Link to instructions DEMO:**

[WITMOTION Youtube Channel](#)

[WT931 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 WT931 is a multi-sensor device detecting acceleration, angular velocity, angle as well as magnetic field. 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.

WT931'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.

WT931 is employed where the highest measurement accuracy is required. It 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, 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.
- 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.

The software will be continuously improved and upgraded according to user's feedback. There will be a few differences between the current user interface and new version. Your understanding is highly appreciated.

[Link to WT931's demo video](#)

#### 2.1.1 Serial Connection

**Step 1.** Need to embed WT931 in evaluation board first and then connect the sensor with a serial converter / Micro-USB cable PIN Connection(serial cable is required):

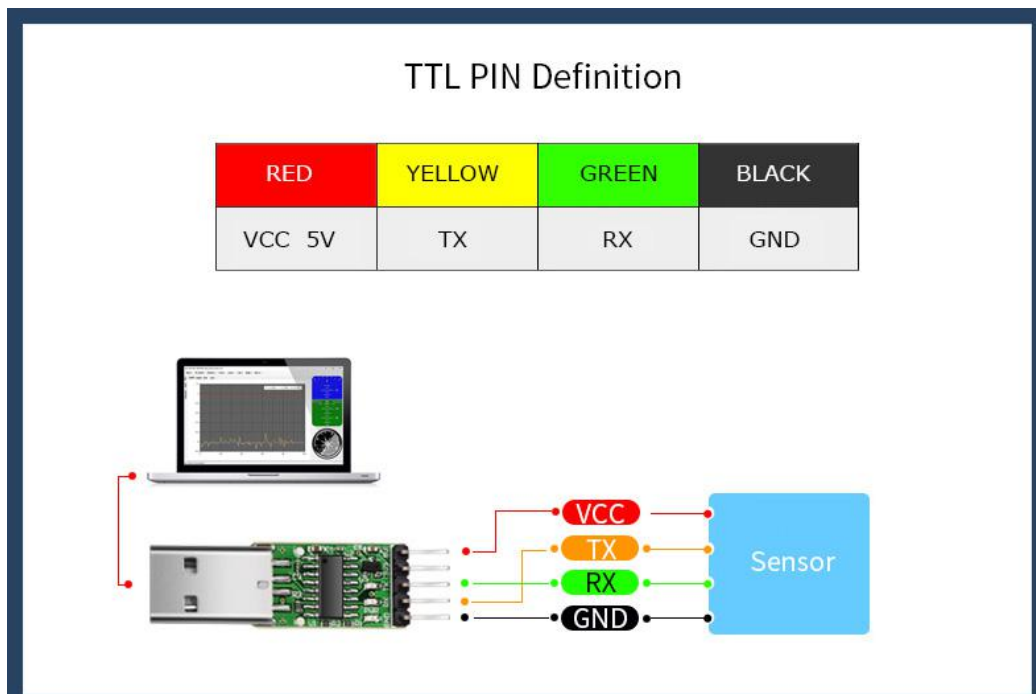
VCC - 5V

TX - RX

RX - TX

GND - GND

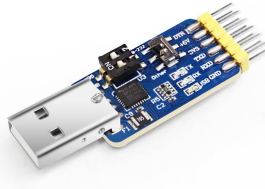
(When connecting with computer, VCC-5V is recommended.)



## Recommended tools:



3-in-1 serial converter



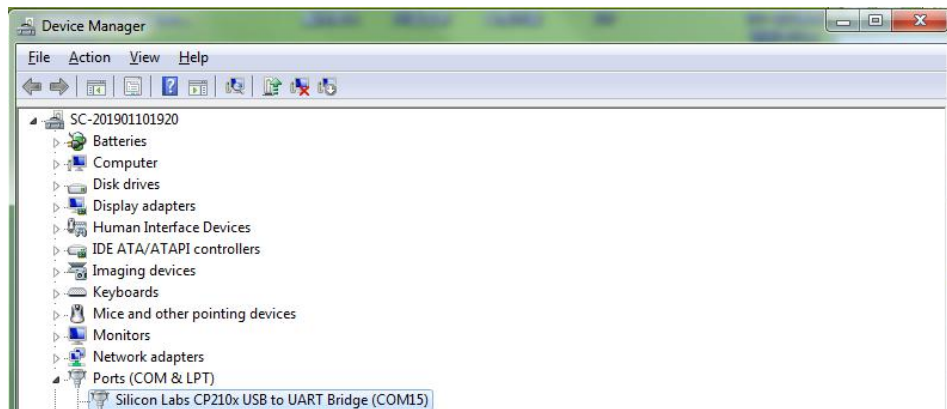
6-in-1 serial converter

**Step 2.** Unzip the software and install the driver CH340 or CP2102 (Depending on which accessory for usage.)

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

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

**Step 3.** Plug in the converter to computer and confirm the “com port” in device manager



**Step 4.** 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](#)

### 2.2.1 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 WT931
Open		Open com port
Close		Close com port

## 2.2.2 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

Save Config

Online

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

Reset

Sleep

Alarm

Algorithm: 

9 - axis

Install Direction: 

Horizontal

☐ 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

### Instruction Start-up:

This function is used to prevent the data sent by the module after connecting to the computer to conflict with the mouse, causing the mouse to jump. After checking this function, the function will take effect the next time the module is used, or it can take effect when the module is powered on again.

Calibrate

Acceleration

Magnetic Filed

Reset Z-axis Angle

☒ Gyro Auto Calibrate

Reset Height

Angle Reference

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, WTHARS1, HWT901B)
Reset Z-axis Angle	Reset Z-axis angle to 0 degree, not available for WT931 in 9-axis algorithm
Angle Reference	Not available
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	IIC address

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, 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 GPS IMU

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

## 2.3 Calibration

Preparation:

Make sure the sensor is "Online".

Calibration on PC software:

It is required to calibrate for the first time usage.

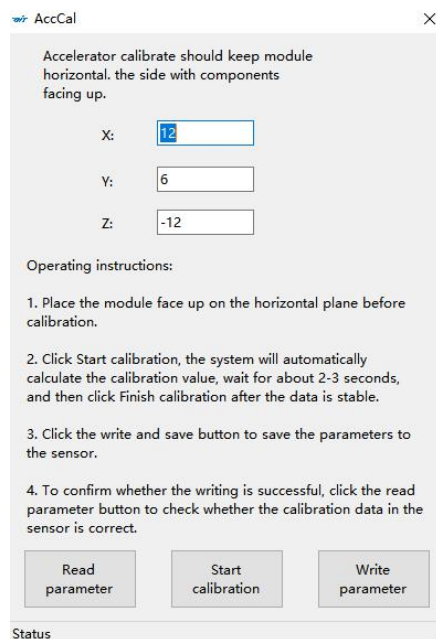
### 2.3.1 Accelerometer Calibration

#### 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:

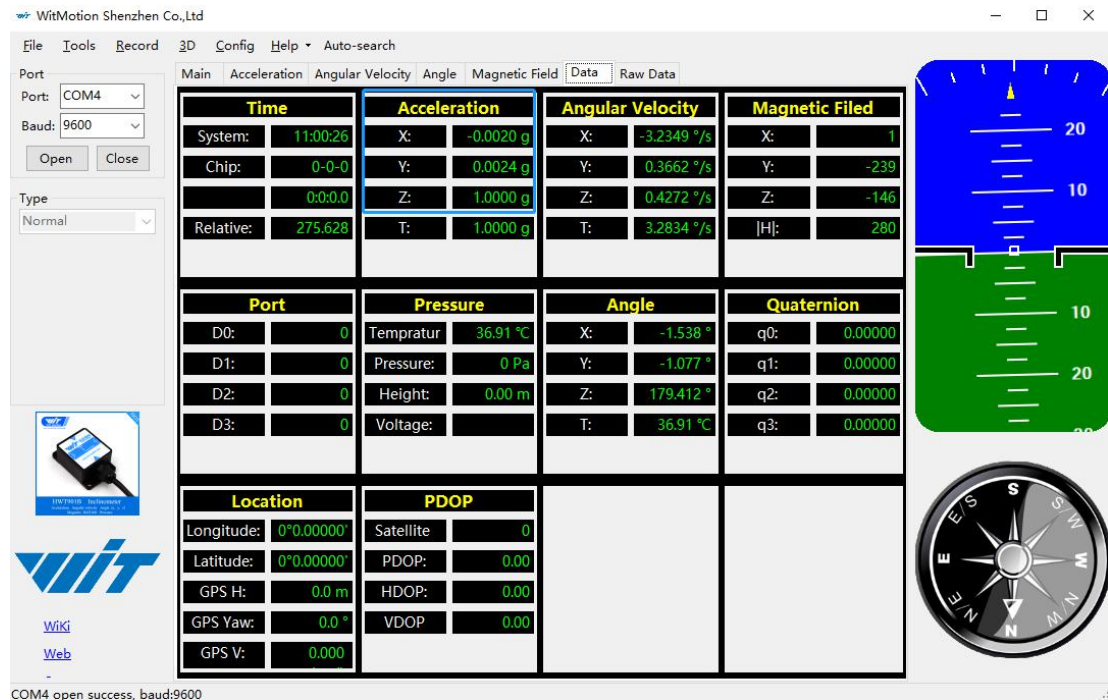
- Step 1. Keep the module horizontally stationary
- Step 2. Click the accelerometer calibration
- Step 3. Click the "Start calibration" and wait for 3 seconds



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.

## 2.3.2 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.

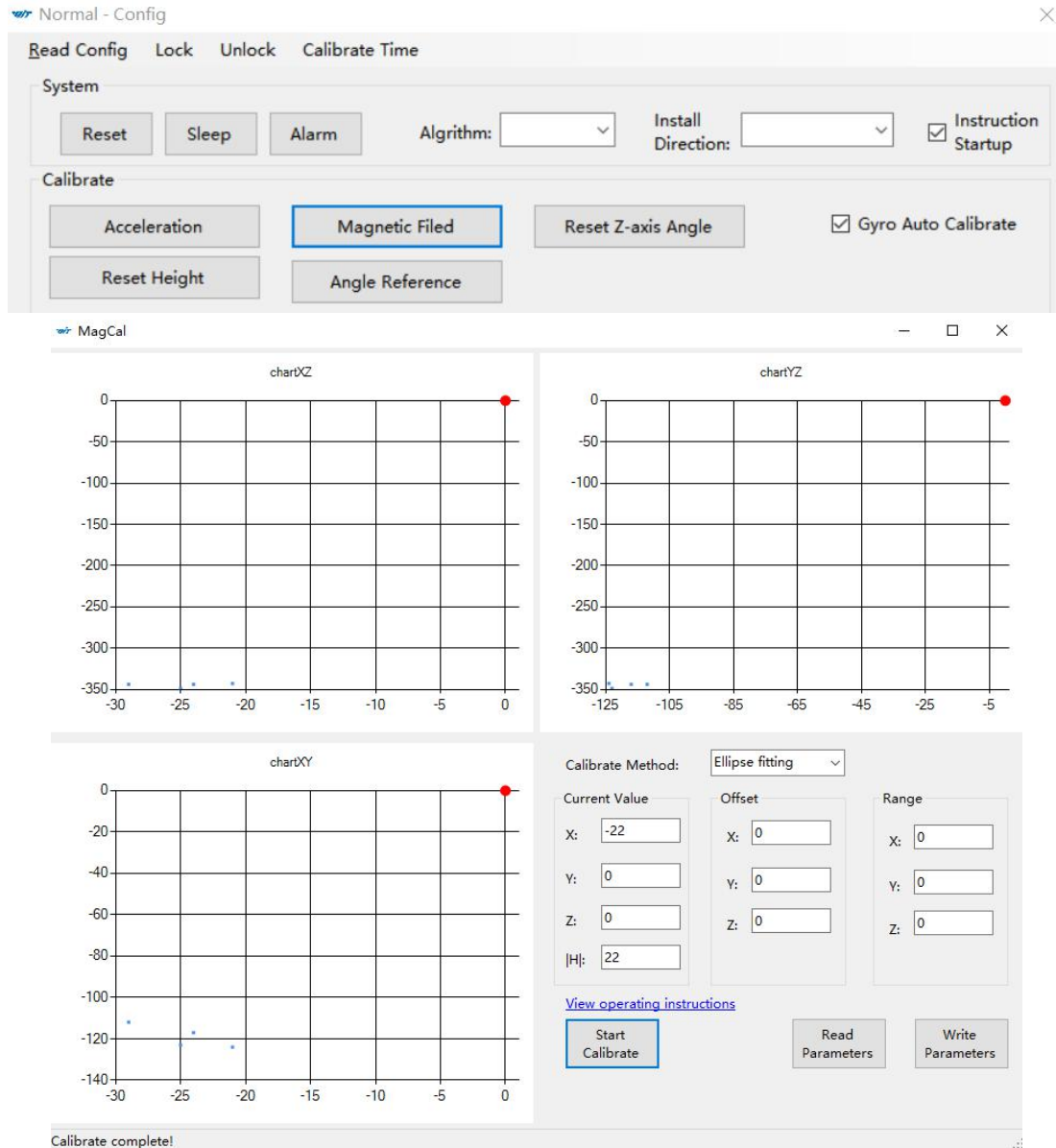
## Preparation:

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

Methods:

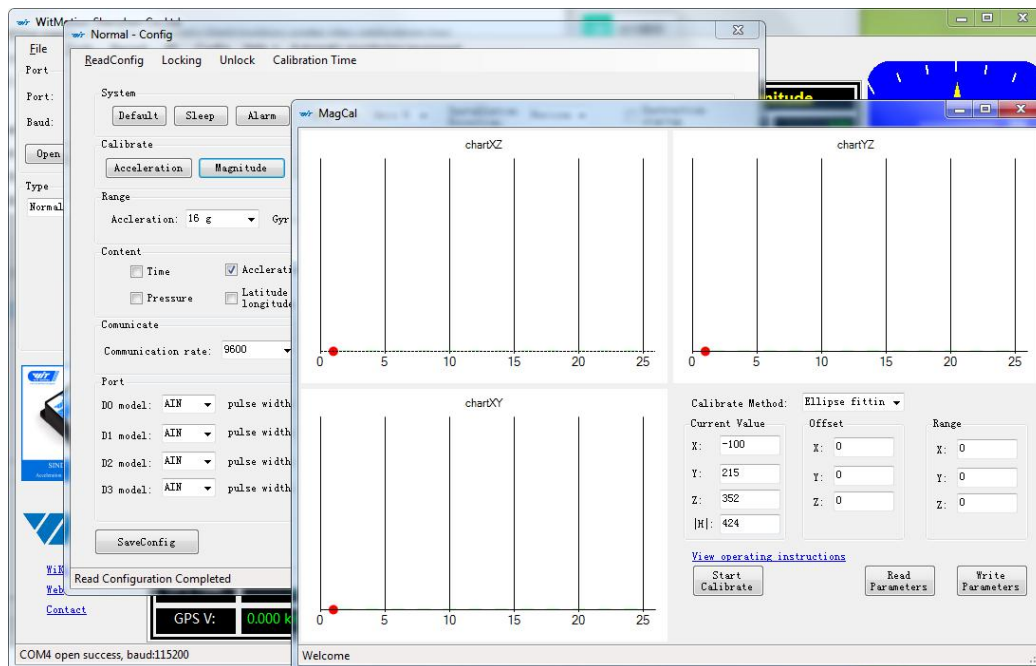
Step 1. Open the Config menu

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

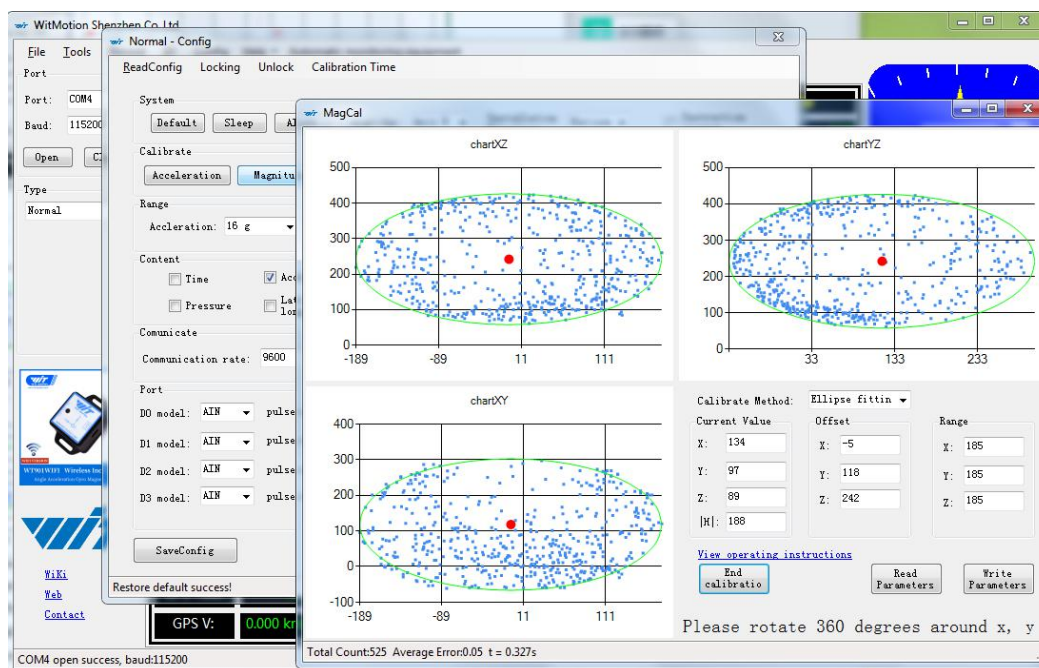


Step 3. Slowly rotate the module 360° around X, Y, Z, 3-axis accordingly





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.

### 2.3.3 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.

### 2.3.4 Reset Z-axis Angle

Note: If you want to avoid magnetic interference, you can change the algorithm to Axis 6, then you can use reset function of "Reset Z-axis angle".

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.

### 2.3.5 Reset Height to 0

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

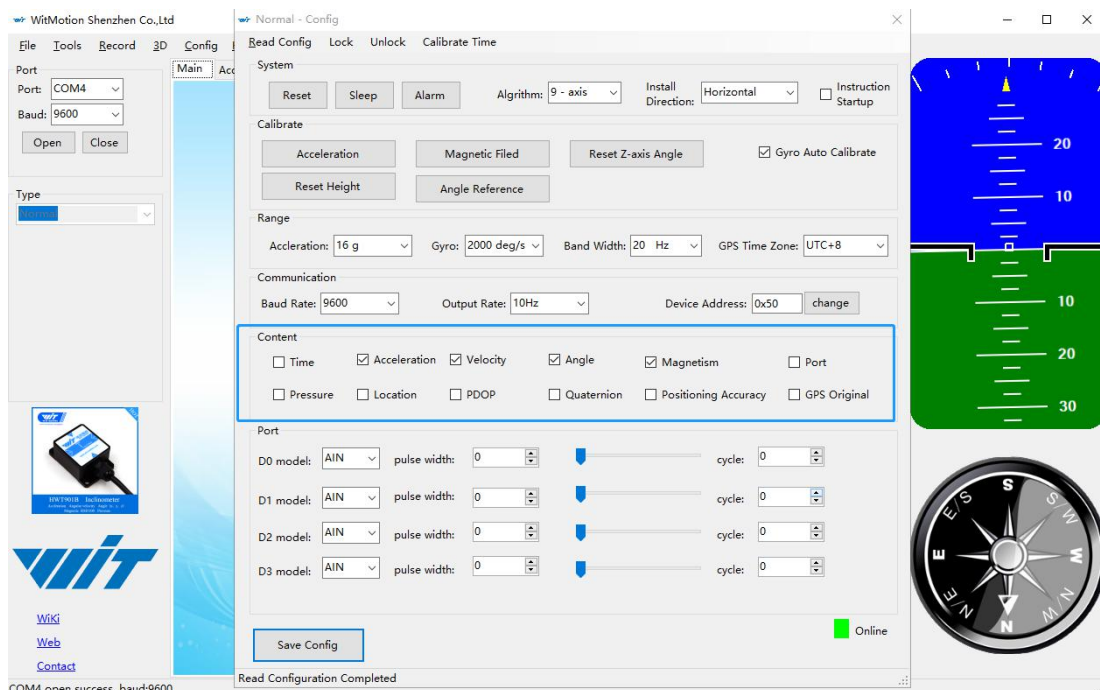
## 2.4 Configuration

### 2.4.1 Return Content

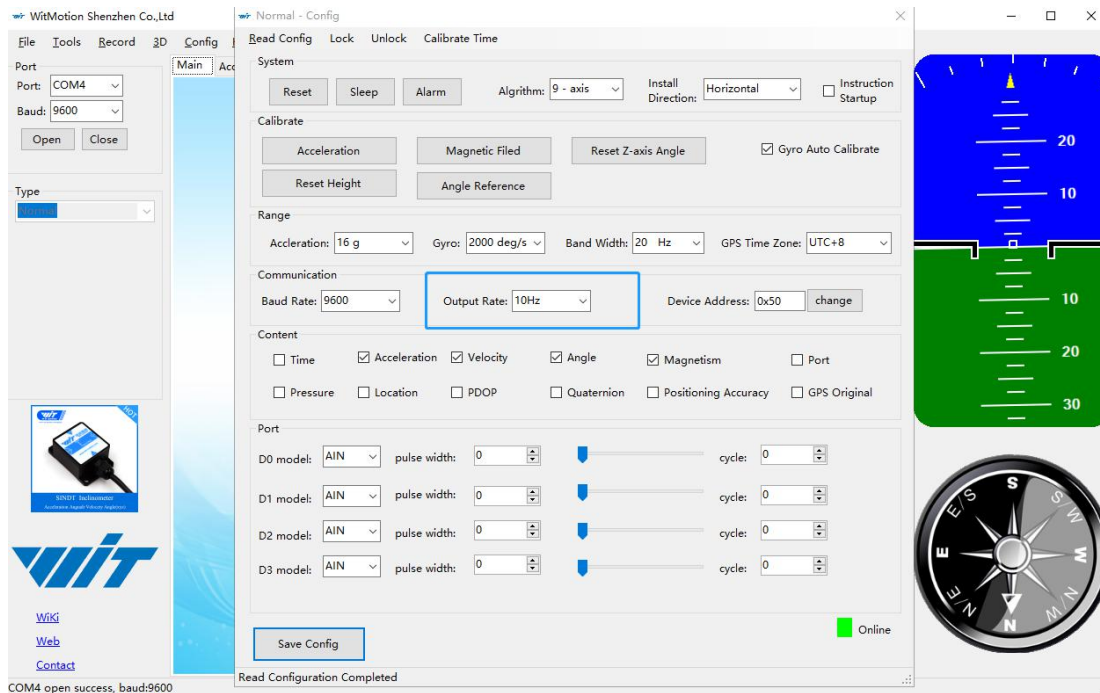
Setting method: The content of the data return can be set according to user needs, click the configuration option bar, and check the data content to be output.

Taking WT931 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. Under normal circumstances, do not directly check ""GPS original".



## 2.4.2 Output Rate



The default return rate of the module is 500Hz, that is, the return rate of the PC software is selected as "single 单次", the baud rate is 921600, it is 500Hz, and the return rate supports up to 500Hz.

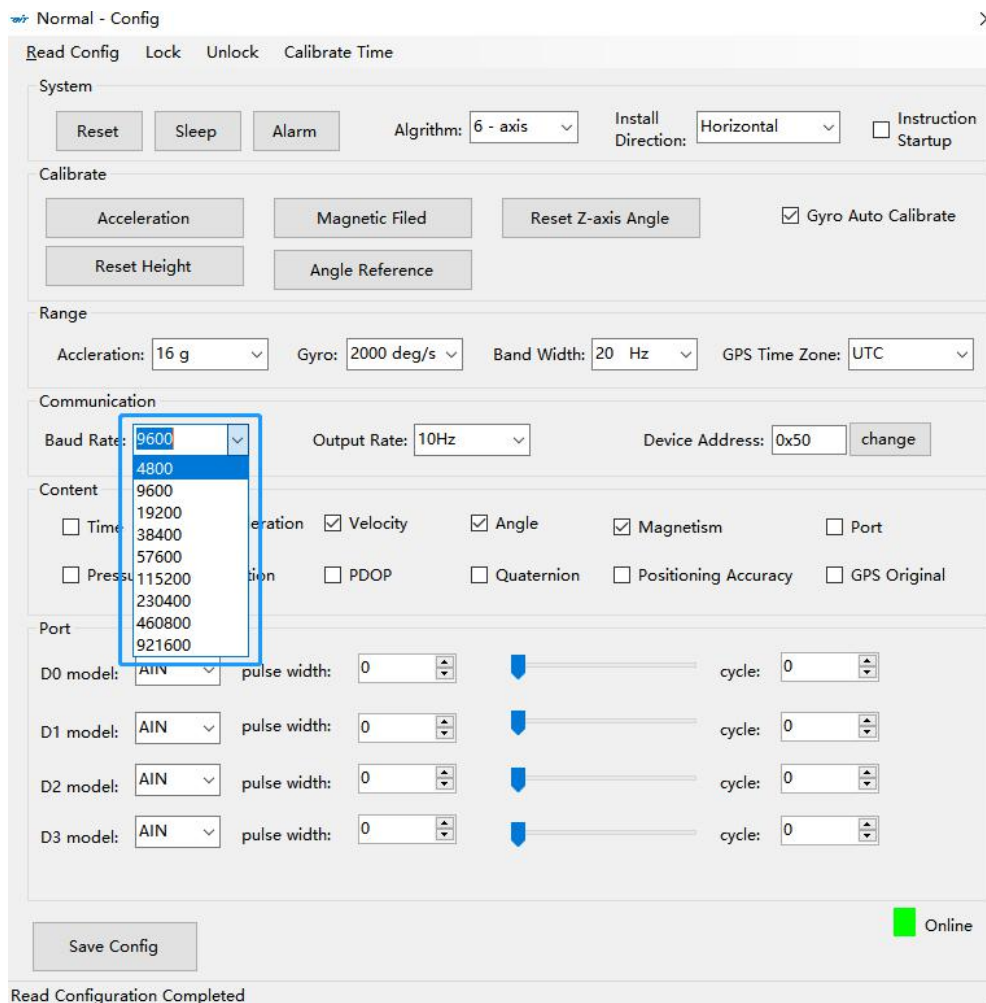
500HZ refers to the return of 500 data packets in 1S. By default, 1 data packet is 44 bytes.

Note: If there is more backhaul content and the communication baud rate is lower, it may not be possible to transmit so much data. At this time, 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 be set higher, generally 921600.

### 2.4.3 Baud Rate

The module supports multiple baud rates, and the default baud rate is 921600. Set the baud rate of the module based on the correct connection between the software and the module, select the baud rate to be changed in the communication rate drop-down box in the configuration bar (Normal-Config), and wait a few seconds after the setting is completed. The module will complete the change of the baud rate. If the data cannot be displayed, power on the module again.

Note: After the change, the module will output at the original baud rate, but it is incorrect.



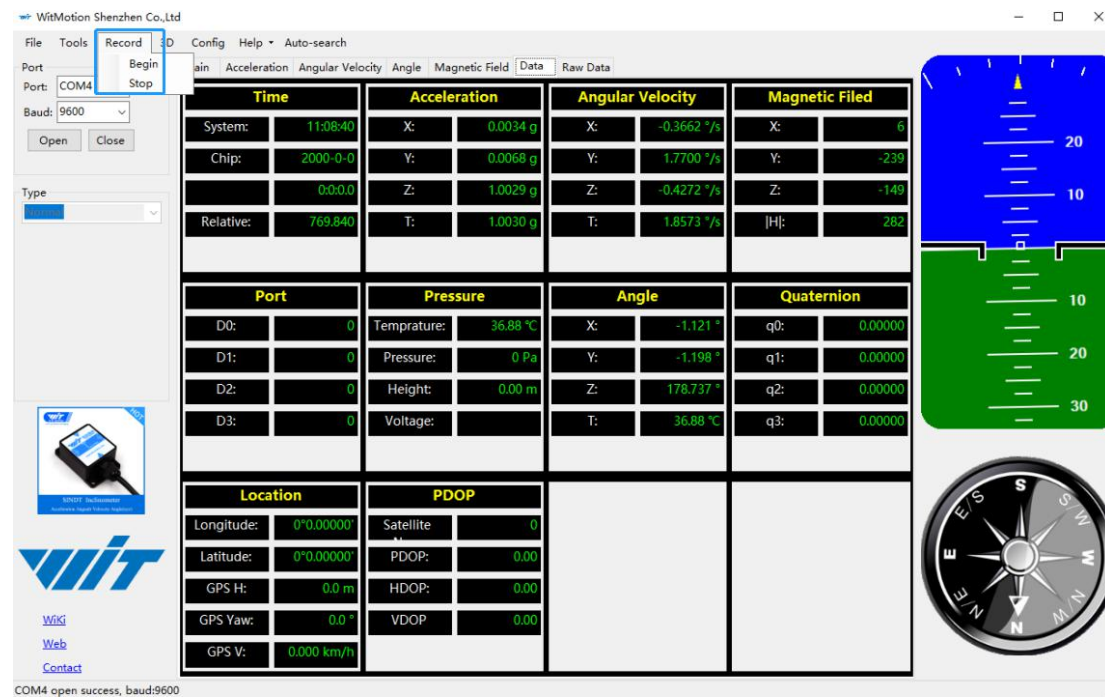
The screenshot shows the 'Normal - Config' window with the 'Communication' section selected. The 'Baud Rate' dropdown menu is open, showing a list of available rates: 9600, 4800, 19200, 38400, 57600, 115200, 230400, 460800, and 921600. The '9600' option is currently selected. Other settings visible include 'Algorithm: 6 - axis', 'Install Direction: Horizontal', 'Gyro Auto Calibrate' checked, 'Acceleration: 16 g', 'Gyro: 2000 deg/s', 'Band Width: 20 Hz', 'GPS Time Zone: UTC', 'Output Rate: 10Hz', and 'Device Address: 0x50'. The 'Port' section at the bottom shows four models (D0, D1, D2, D3) all set to 'AIN' with pulse width and cycle controls. A 'Save Config' button is at the bottom left, and an 'Online' status indicator is at the bottom right.

## 2.4.4 Data Recording

Method are as follows:

Step 1: Click "Record" and "Begin"

Step 2: Click "Stop"



The screenshot shows the WitMotion software interface. The 'Record' menu is open, showing 'Begin' and 'Stop' options. The 'Data' tab is selected, displaying various sensor data readouts.

Time		Acceleration		Angular Velocity		Magnetic Field	
System:	11:08:40	X:	0.0034 g	X:	-0.3662 °/s	X:	6
Chip:	2000-0-0	Y:	0.0068 g	Y:	1.7700 °/s	Y:	-239
	0:0:0.0	Z:	1.0029 g	Z:	-0.4272 °/s	Z:	-149
Relative:	769.840	T:	1.0030 g	T:	1.8573 °/s	H :	282

Port		Pressure		Angle		Quaternion	
D0:	0	Temperature:	36.88 °C	X:	-1.121 °	q0:	0.00000
D1:	0	Pressure:	0 Pa	Y:	-1.198 °	q1:	0.00000
D2:	0	Height:	0.00 m	Z:	178.737 °	q2:	0.00000
D3:	0	Voltage:		T:	36.88 °C	q3:	0.00000

Location		PDOP	
Longitude:	0°0.00000'	Satellite:	0
Latitude:	0°0.00000'	PDOP:	0.00
GPS H:	0.0 m	HDOP:	0.00
GPS Yaw:	0.0 °	VDOP:	0.00
GPS V:	0.000 km/h		

COM4 open success, baud:9600





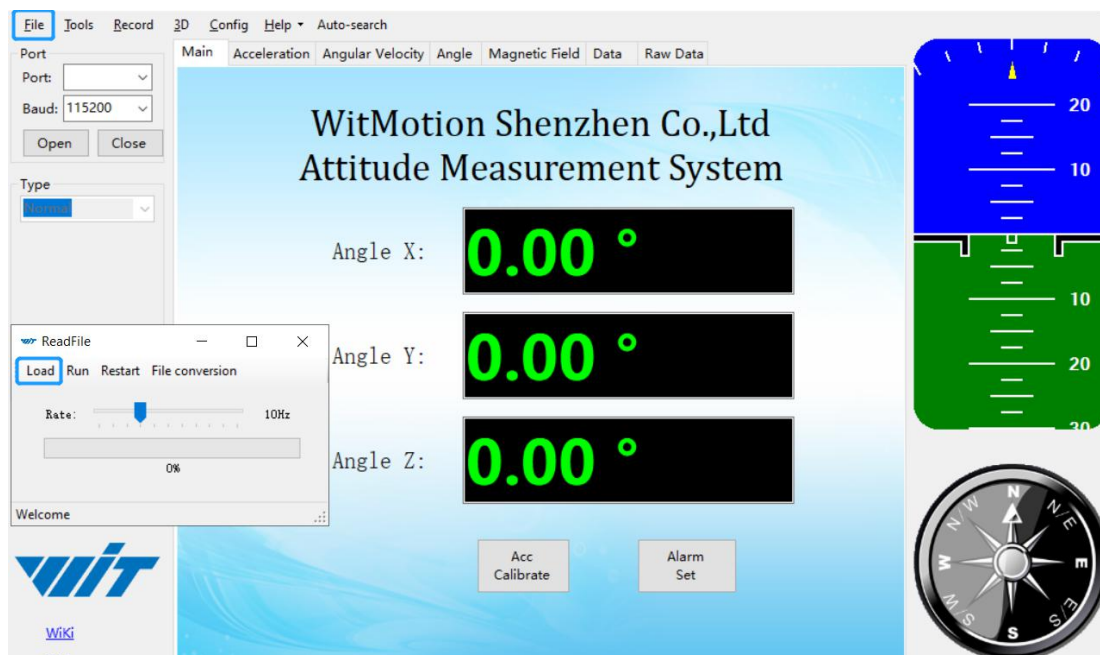
## 2.4.5 Data Playback

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.

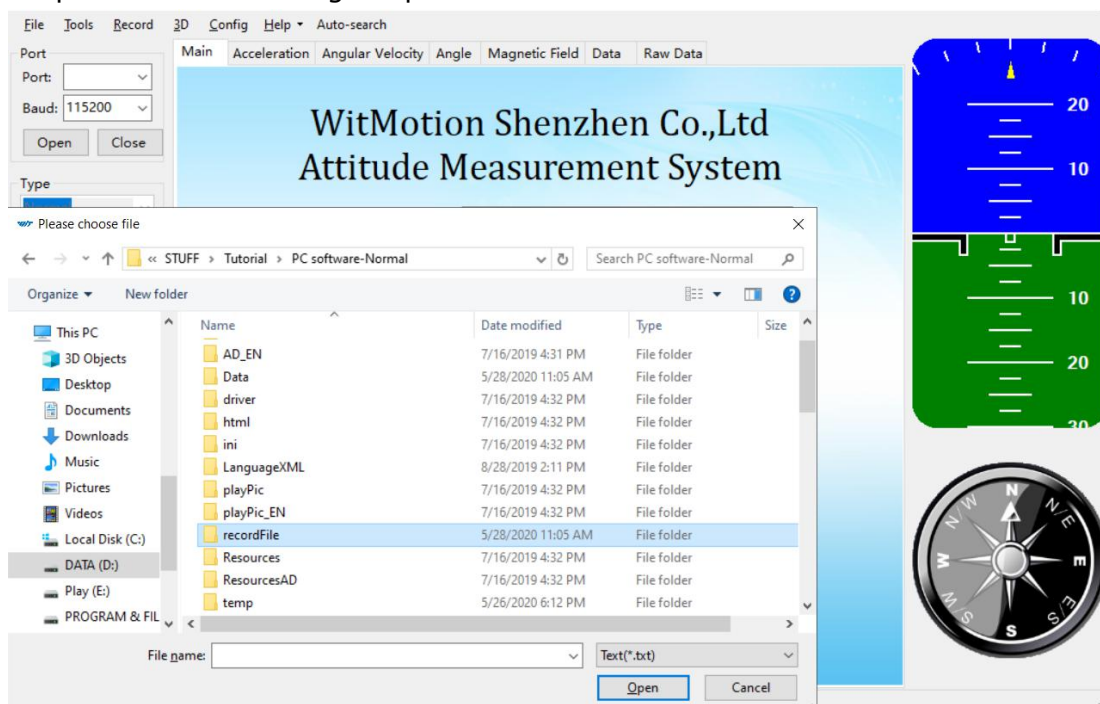
Recorded data playback method:

Step 1: Disconnect the sensor

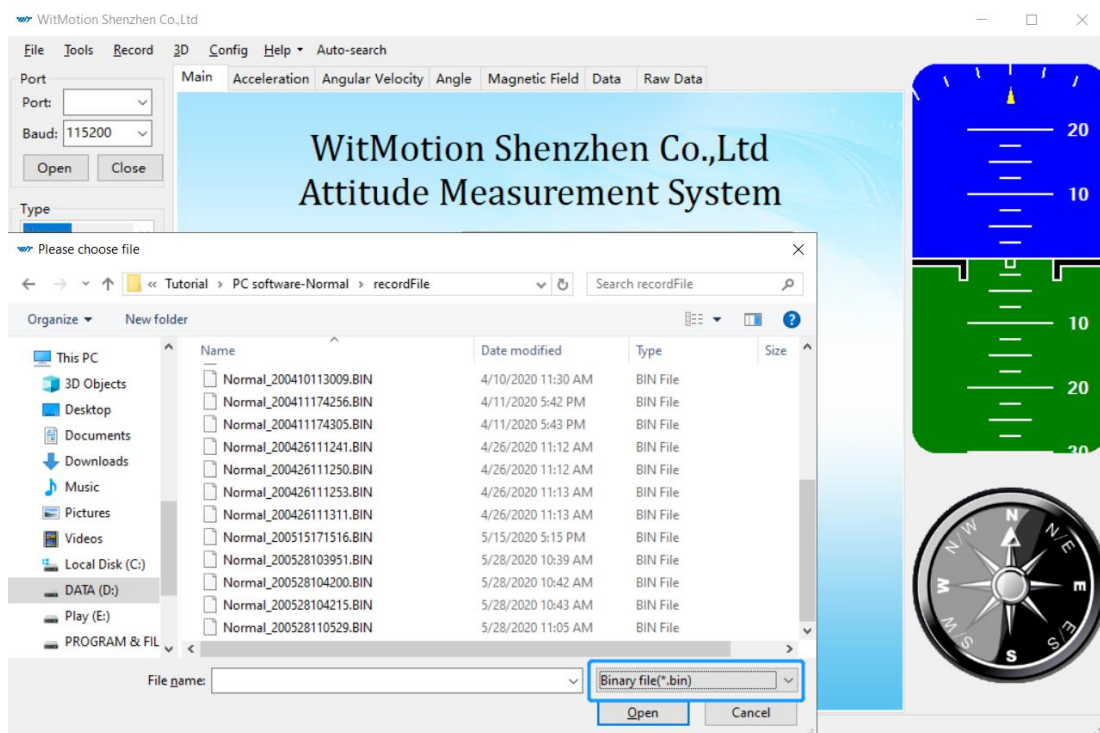
Step 2: Click "File" Button and then click "Load"



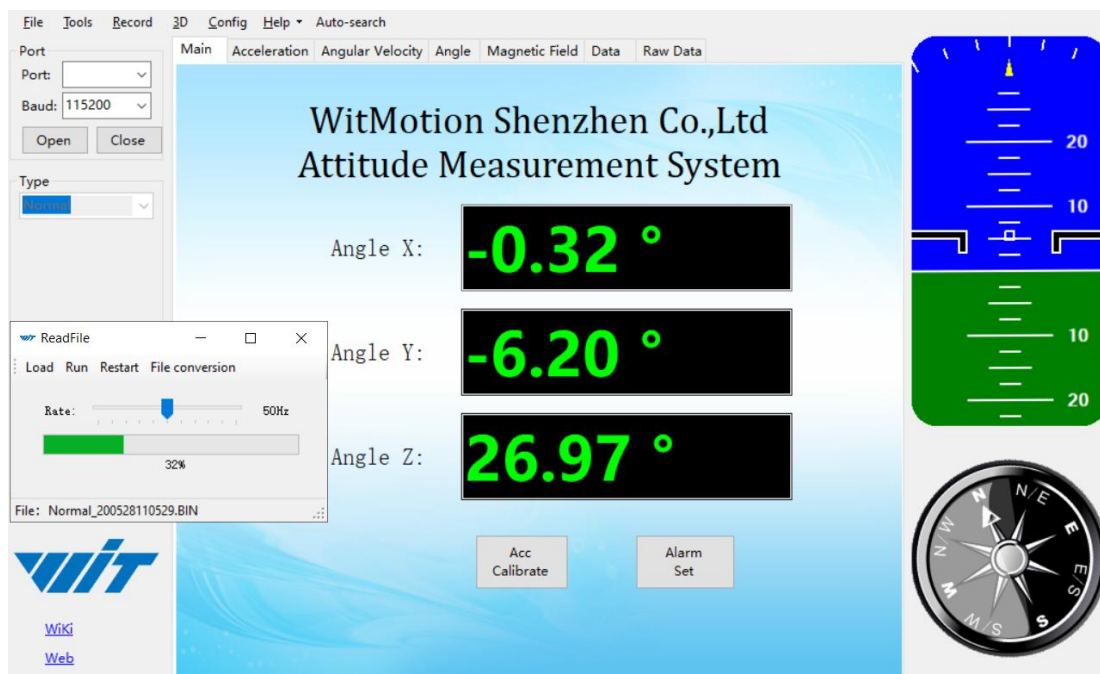
Step 3: Choose the original path of software installation and load the Bin file







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

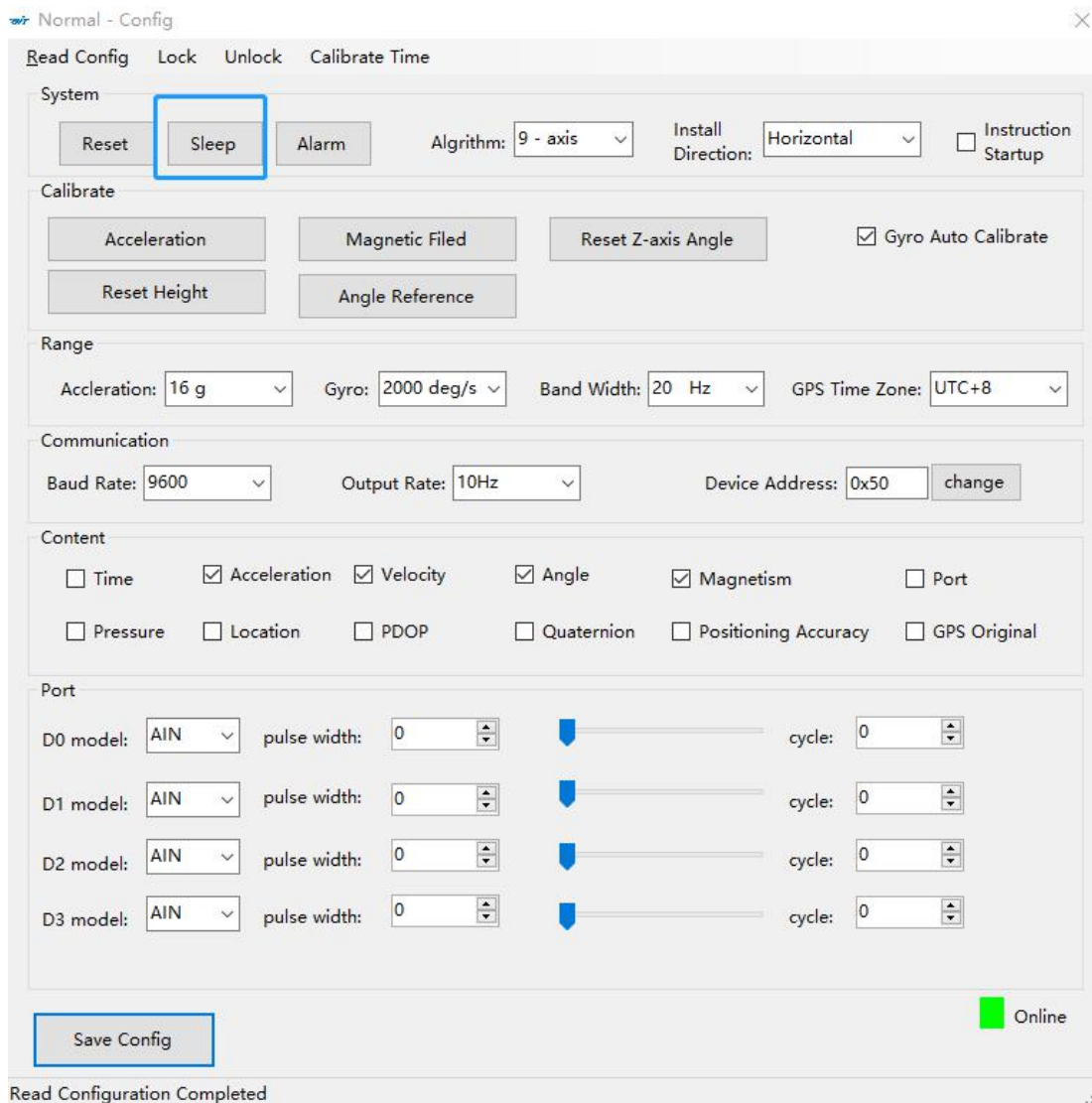


## 2.4.6 Standby and Wake Up

**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.



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+8

**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

Save Config Online

Read Configuration Completed

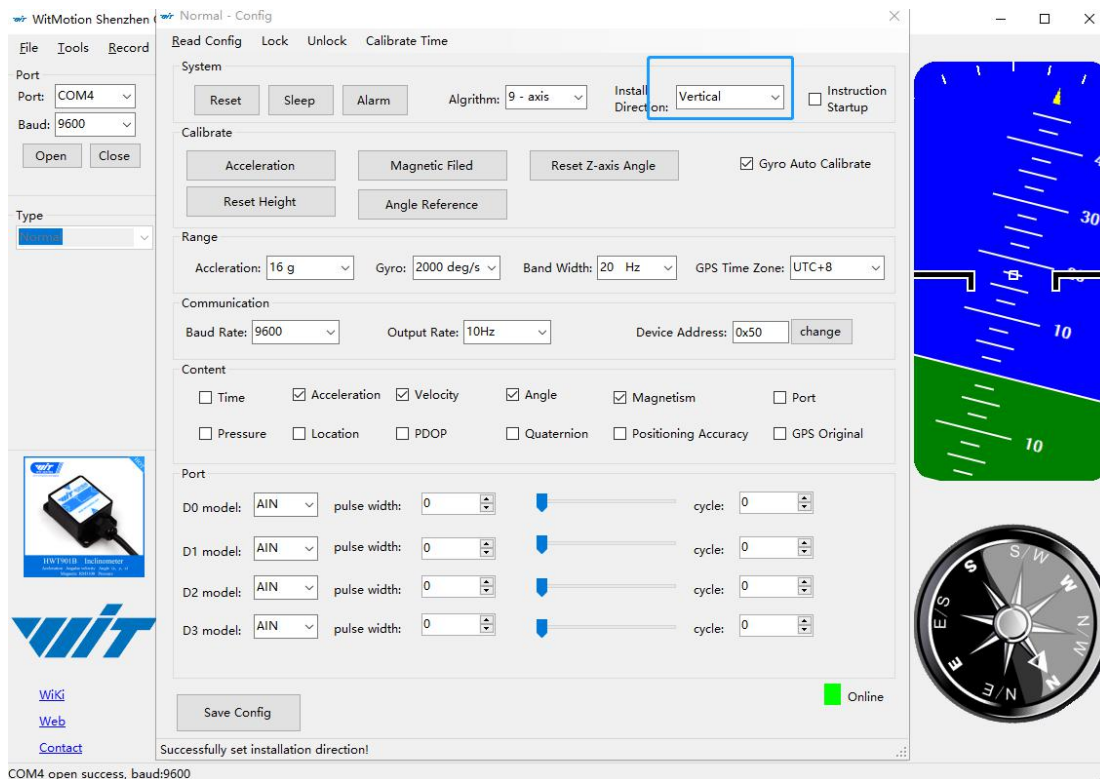
## 2.4.7 Placement Direction

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

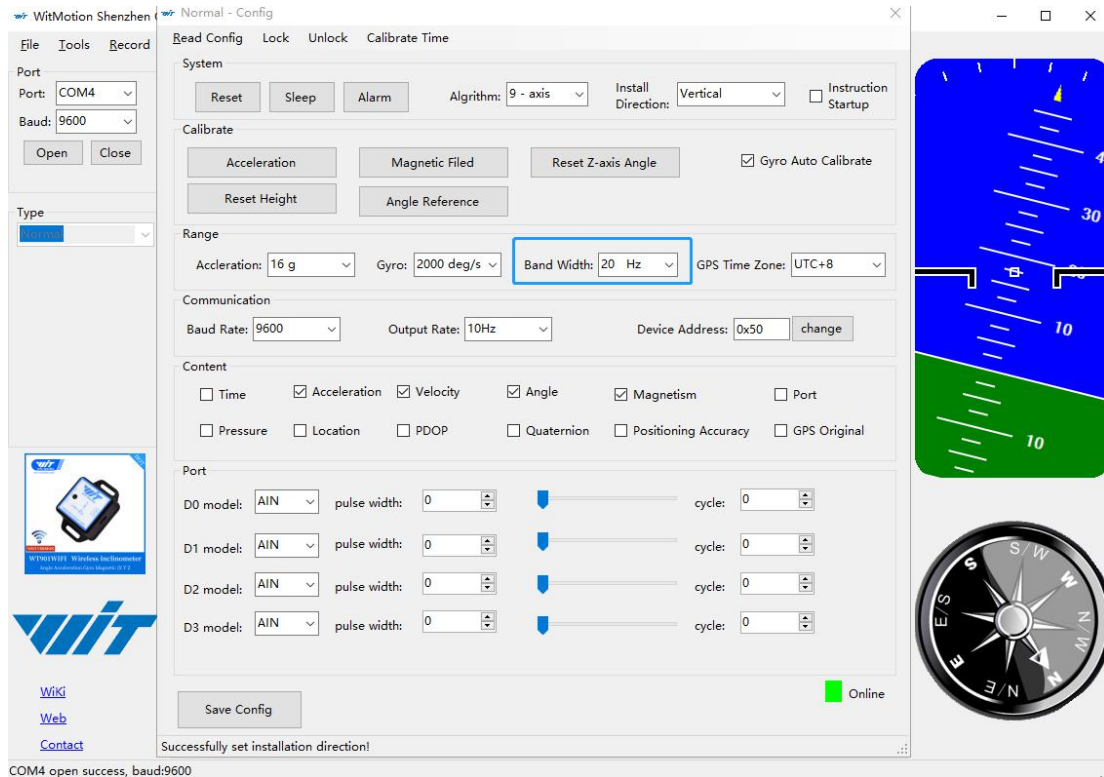
Step 2: Place the sensor 90 degrees vertically

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



## 2.4.8 Bandwidth

Default bandwidth is 20Hz.

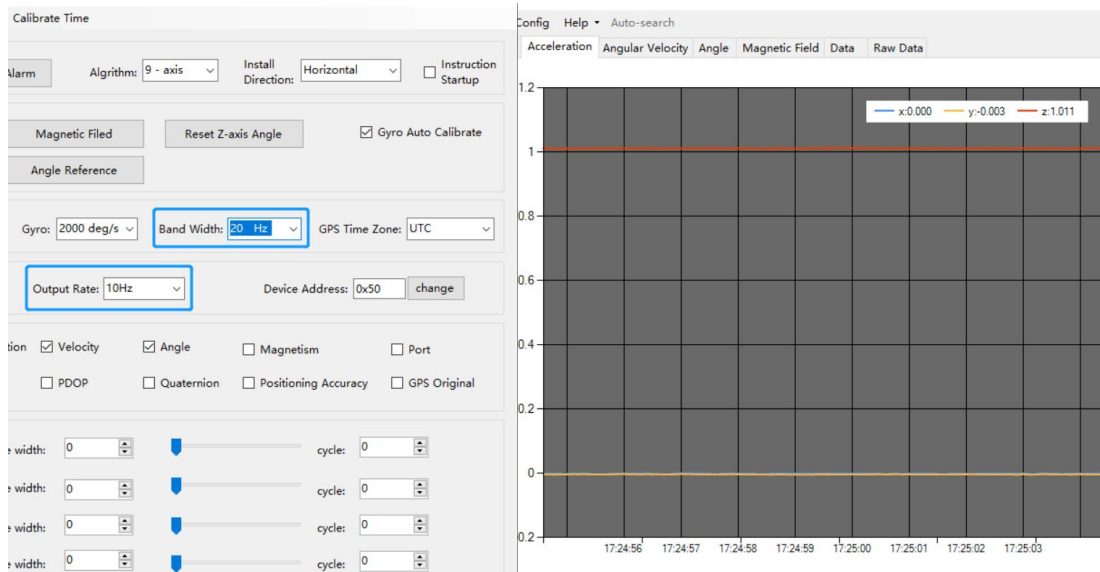


Function:

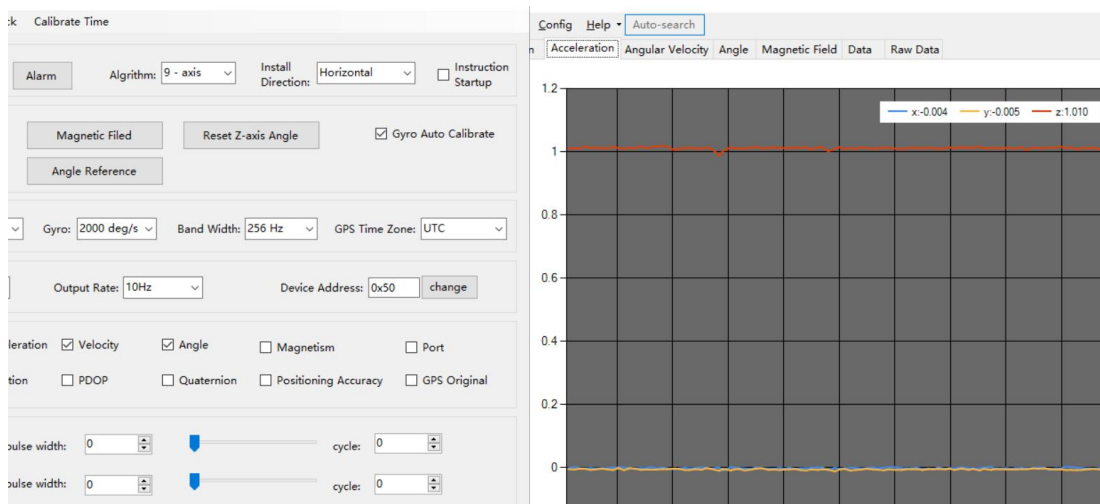
1. The higher rate of bandwidth setting will lead to the higher fluctuation in data waveform. Conversely, the lower rate of bandwidth, data will become more fluent.

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.

### 2.4.9 Restore Factory Setting

There are two ways to restore the factory settings, the short circuit method and the command method.

Short-circuit method: short-circuit the D2 pin and VCC pin of the module with wires, and then power on the module. The LED of the module is on continuously for about 2 seconds. The LED is off, and the factory reset operation is completed.

Command method: connect the WT931 module and the computer through the USB-TTL module, click the setting tab, and click to restore the default. 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, please try to use the short circuit method to recover)

## 2.4.10 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.

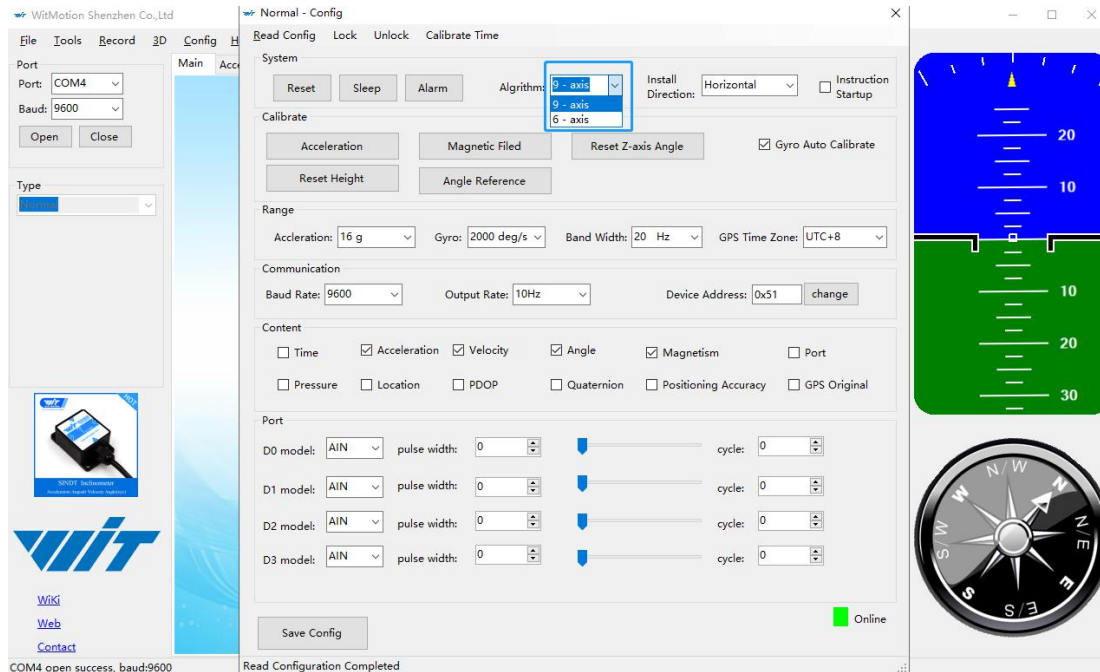
The default algorithm of WT931 is 9-axis. If there is magnetic field interference around installed environment, it is recommended to switch to 6-axis algorithm to detect the angle.

Method:

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

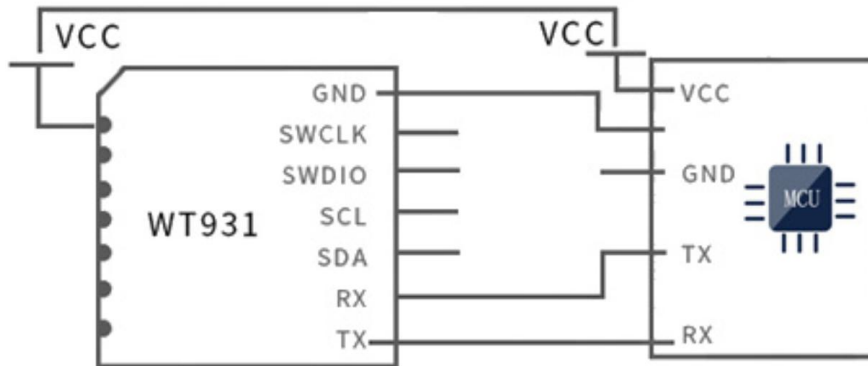
Step 2: Proceed the "Accelerometer calibration" and "Reset Z-axis angle" calibration.

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





## 3 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.

### 3.1 Arduino

[Download link](#)

[Arduino UNO3 Demo Link](#)

### 3.2 STM32

[Download link](#)

### 3.3 Raspberry pi

[Tutorial link](#)

### 3.4 C#

[DEMO link](#)



## 3.5 C++

[DEMO link](#)

## 3.6 Matlab

[Receive Sample Code](#)

[Dataplot DEMO](#)