# AHRS IMU Sensor | SINDT

*The Robust Acceleration, Angular velocity & Angle Detector*

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*The SINDT is a IMU 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]
[SINDT 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

# Contents

# 1 Overview

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

SINDT is employed where the highest measurement accuracy is required. SINDT 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, PC software, 51 serial, STM32, Arduino, and Matlab sample code, communication protocol

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

# 2 Features

- The default baud rate of this device is 9600 and could be changed.
- The interface of this product only leads to a serial port
- The module consists of a high precision gyroscope, 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.

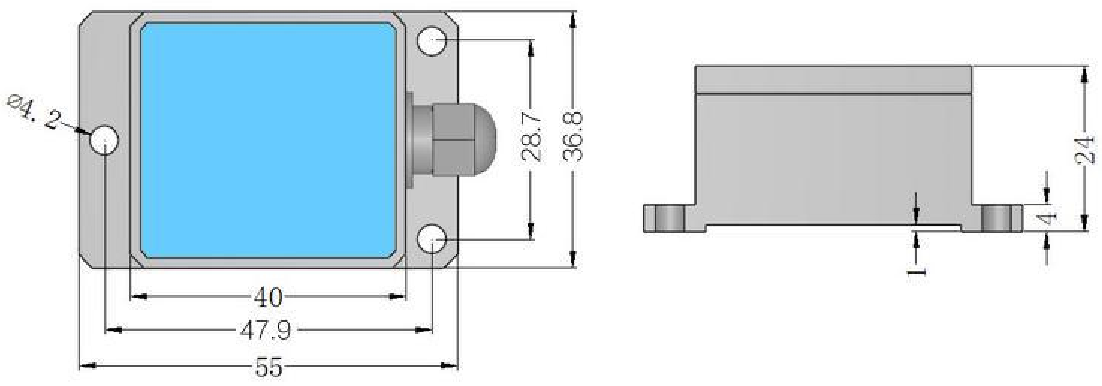
# 3 Specification

## 3.1 Parameter

| Parameter | Specification |
|---|---|
| ➢ Working Voltage | RS485:9-36V |
| ➢ Current | <40mA |
| ➢ Size | 55mm x 36.8mm X 24mm |
| ➢ Data | Angle: X Y Z, 3-axis<br>Acceleration: X Y Z, 3-axis<br>Angular Velocity: X Y Z, 3-axis<br>Time, Quaternion |
| ➢ Interface | Serial RS485 level |
| ➢ Baud rate | (4800,9600(default),19200,38400,57600, 115200,230400,460800,921600) |

| Measurement Range & Accuracy | | |
|---|---|---|
| Sensor | Measurement Range | Accuracy/ Remark |
| ➢ Accelerometer | X, Y, Z, 3-axis<br>±16g | Accuracy: 0.01g<br>Resolution: 16bit<br>Stability: 0.005g |
| ➢ Gyroscope | X, Y, Z, 3-axis<br>-±2000°/s | Resolution: 16bit<br>Stability: 0.05°/s |
| ➢ Angle/ Inclinometer | X, Y, Z, 3-axis<br>X, Z-axis: ±180°<br>Y ±90°<br>(Y-axis 90° is singular point) | Accuracy:X, Y-axis: 0.05°<br>Z-axis: 1°<br>(Angle of Z-axis will have accumulated error) |

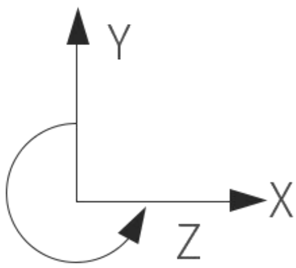
# 3.2 Size




| Parameter | Specification | Tolerance | Comment |
|---|---|---|---|
| Length | 55 | ±0.1 | Unit: millimeter. |
| Width | 36.8 | ±0.1 | |
| Height | 24 | ±0.1 | |
| Weight | 100 | ±1 | 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 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.

# 4 PIN Definition


| PIN | Color | Function |
|---|---|---|
| ➢ VCC | RED | Input Supply<br>RS485：powered by 9-36V |
| ➢ B | GREEN | RS485：B |
| ➢ A | YELLOW | RS485：A |
| ➢ GND | BLACK | Ground<br>GND |

# 5 MODBUS Communication Protocol

Level: RS485 level
Baud rate: 4800, 9600 (default), 19200 38400, 57600, 115200, 230400, 460800, 921600, stop bit and parity stop bit and parity bit 0
HWT901B RS485 module can be accessed entirely through RS485, the default address is 0x50, can be hanged by serial port instruction or MODBUS write address.

## 5.1 Register List

The data in each address of the module is 16 bits of data, which is 2 bytes. The address and meaning of the register are as follows:

| Address | Symbol | Meaning |
|---|---|---|
| 0x00 | SAVE | Save |
| 0x01 | CALSW | Calibration |
| 0x02 | RSV | Reserved |
| 0x03 | RSV | Reserved |
| 0x04 | BAUD | Baud rate |
| 0x05 | AXOFFSET | X axis Acceleration bias |
| 0x06 | AYOFFSET | Y axis Acceleration bias |
| 0x07 | AZOFFSET | Z axis Acceleration bias |
| 0x08 | GXOFFSET | X axis angular velocity bias |
| 0x09 | GYOFFSET | Y axis angular velocity bias |
| 0x0a | GZOFFSET | Z axis angular velocity bias |
| 0x0b~0x19 | RSV | Reserved |
| 0x1a | ADDR | Modbus address |
| 0x1b | RSV | Reserved |
| 0x1c | RSV | Reserved |
| 0x30 | MMYY | Month , Year |
| 0x31 | HHDD | Hour , Day |
| 0x32 | SSMM | Second , Minute |
| 0x33 | MS | Millisecond |
| 0x34 | AX | X axis Acceleration |
| 0x35 | AY | Y axis Acceleration |

| | | |
|---|---|---|
| 0x36 | AZ | Z axis Acceleration |
| 0x37 | GX | X axis angular velocity |
| 0x38 | GY | Y axis angular velocity |
| 0x39 | GZ | Z axis angular velocity |
| 0x3a | RSV | Reserved |
| 0x3b | RSV | Reserved |
| 0x3c | RSV | Reserved |
| 0x3d | Roll | X axis Angle |
| 0x3e | Pitch | Y axis Angle |
| 0x3f | Yaw | Z axis Angle |
| 0x40 | TEMP | Temperature |
| 0x41~0x50 | RSV | Reserved |
| 0x51 | Q0 | Quaternion Q0 |
| 0x52 | Q1 | Quaternion Q1 |
| 0x53 | Q2 | Quaternion Q2 |
| 0x54 | Q3 | Quaternion Q3 |

**Details:**

Save:

| Save | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:00H | Save[15:0] | | | | | | | | | | | | | | | |
| Mode | W | | | | | | | | | | | | | | | |
| Value | 0: Save all register<br>1: Restore to factory setting | | | | | | | | | | | | | | | |

Calibration:

| Calibration | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:01H | CALSW[15:0] | | | | | | | | | | | | | | | |
| Mode | W | | | | | | | | | | | | | | | |
| Value | 0: Finish calibration(quit calibration)<br>1: Acceleration calibration<br>3: Reset height to 0<br>7: Magnetic calibration | | | | | | | | | | | | | | | |

Baud rate:

| Baud rate | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:04H | BAUD[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | 1: 4800<br>2: 9600<br>3: 19200<br>4: 38400<br>5: 57600<br>6: 115200<br>7: 230400<br>8: 460800<br>9: 921600 | | | | | | | | | | | | | | | |

X axis Acceleration bias:

| AXOFFSET | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:05H | AXOFFSET[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | X axis Acceleration bias | | | | | | | | | | | | | | | |

Y axis Acceleration bias:

| AYOFFSET | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:06H | AYOFFSET[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Y axis Acceleration bias | | | | | | | | | | | | | | | |

Z axis Acceleration bias:

| AZOFFSET | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:07H | AZOFFSET[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Z axis Acceleration bias | | | | | | | | | | | | | | | |

X axis angular velocity bias:

| GXOFFSET | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:08H | GXOFFSET[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | X axis angular velocity bias | | | | | | | | | | | | | | | |

Y axis angular velocity bias:

| GYOFFSET | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:09H | GYOFFSET[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Y axis angular velocity bias | | | | | | | | | | | | | | | |

Z axis angular velocity bias:

| GZOFFSET | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:0aH | GZOFFSET[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Z axis angular velocity bias | | | | | | | | | | | | | | | |

Modbus address:

| GZOFFSET | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:1aH | ADDR[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Modbus address | | | | | | | | | | | | | | | |

Month , Year:

| MMYY | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:30H | Month[7:0] | | | | | | | | Year[7:0] | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Month , Year | | | | | | | | | | | | | | | |

Hour , Day:

| HHDD | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:31H | Hour[7:0] | | | | | | | | Day[7:0] | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Hour , Day | | | | | | | | | | | | | | | |

Second , Minute:

| SSMM | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:33H | Second[7:0] | | | | | | | | Minute[7:0] | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Second , Minute | | | | | | | | | | | | | | | |

Millisecond:

| MS | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:33H | MS[15:0] | | | | | | | | | | | | | | | |
| Mode | R/W | | | | | | | | | | | | | | | |
| Value | Millisecond | | | | | | | | | | | | | | | |

X axis Acceleration:

| AX | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:34H | AX[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | X axis Acceleration | | | | | | | | | | | | | | | |

Y axis Acceleration:

| AY | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:35H | AY[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Y axis Acceleration | | | | | | | | | | | | | | | |

Z axis Acceleration:

| AZ | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:36H | AZ[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Z axis Acceleration | | | | | | | | | | | | | | | |

X axis angular velocity:

| GX | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:37H | GX[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | X axis angular velocity | | | | | | | | | | | | | | | |

Y axis angular velocity:

| GY | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:38H | GY[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Y axis angular velocity | | | | | | | | | | | | | | | |

Z axis angular velocity:

| GZ | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:39H | GZ[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Z axis angular velocity | | | | | | | | | | | | | | | |

X axis Angle:

| Roll | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:3dH | Roll[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | X axis Angle | | | | | | | | | | | | | | | |

Y axis Angle:

| Pitch | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:3eH | Pitch[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Y axis Angle | | | | | | | | | | | | | | | |

Z axis Angle:

| Yaw | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:3fH | Yaw[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Z axis Angle | | | | | | | | | | | | | | | |

Temperature:

| TEMP | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:40H | TEMP[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Temperature | | | | | | | | | | | | | | | |

Quaternion:

| Quaternion | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:51H | Quaternion Q0[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Quaternion Q0 | | | | | | | | | | | | | | | |

| Quaternion | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:52H | Quaternion Q1[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Quaternion Q1 | | | | | | | | | | | | | | | |

| Quaternion | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:53H | Quaternion Q2[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Quaternion Q2 | | | | | | | | | | | | | | | |

| Quaternion | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Addr:54H | Quaternion Q3[15:0] | | | | | | | | | | | | | | | |
| Mode | R | | | | | | | | | | | | | | | |
| Value | Quaternion Q3 | | | | | | | | | | | | | | | |

## 5.2 MODBUS Write Format

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Device address | 0x06 | Reg H | Reg L | Data H | Data L | CRCH | CRCL |
| 0x50 (default) | Write | Register high | Register low | Date high | Date low | CRC check high | CRC check low |

Note: device address(MODBUS address) can be changed according to 5.2, default is 0x50,it can changed according to their own needs, device address angle:0x00-0x7F.

According to this date format, the baud rate, return rate and other data can be changed.

## 5.2.1 Example1:Calibrate Acceleration

Assume the device is 0x50.

Step 1: Send "unlock" commands
0x50 06 00 69 B5 88 22 A1

Place the sensor on a plat interface firstly

Step 2: Set the CSW register to acceleration calibration mode
0x50 06 00 01 00 01 14 4B

After sending the command, please kindly wait for 3-5 seconds.

Step 3: Set the CSW register to normal mode
0x50 06 00 01 00 00 D5 8B

Step 4: Send "Save Configuration" command
0x50 06 00 00 00 00 84 4B

### 5.2.2 Example2:Set Baud Rate

Assume the device address is 0x50.

If you want to change the baud rate from 9600 to 115200.

Step 1.First you should send unlock command to your device use baud rate 9600.
the unlock command is write 0xB588 to register 0x69.
Send: 0x50 06 00 69 B5 88 22 A1

2. Send baud rate set command:
   Send: 0x50 0x06 0x00 0x04 0x00 0x06 0x45 0x88

3. Then change your master device's baud rate to 115200.

4. Send save config command:
   0x50 06 00 00 00 00 84 4B

## 5.2.3 Example3:Set Modbus address

Assume the device is 0x50. If you want to change address to 0x51, instructions as below.

Step 1: Send “unlock” commands
0x50 06 00 69 B5 88 22 A1

Step 2: Change the device address from 0x50 to 0x51
0x50 06 00 1a 00 51 64 70

Step 3: Send “Save Configuration” command
0x51 06 00 00 00 00 84 4B

Note: Sending frequency shall be 0.5s between each command.

## 5.3 MODBUS Read Format:

| Device address | Read | Reg H | Reg L | regNum H | regNum L | CRC H | CRCL |
|---|---|---|---|---|---|---|---|
| 0x50 (default) | 0x03 | RegH(First Reg) | RegL(First Reg) | Register number high | Register number low | 0x00 | 0x00 |

Example:

Read X Y Z angle

0x50 0x03 0x00 0x3d 0x00 0x03 0x99 0x86
(0x3d is the Modbus register address of X-axis angle. 0x99 0x86 needs to be calculated, refer to the CRC calculation part of the communication protocol)

Data Format:

| 0x50 | 0x03 | 0xN | Data H | Data L | … | CRCH | CRCL |
|---|---|---|---|---|---|---|---|
| Device address | Read function | Register Number =(0-0x7F) | First data high position | First data low position | …N data | CRC check high postion | CRC check low postion |

Example:

Read X Y Z angle:180° 90° 30°

0x50 0x03 0x06 0x80 0x00 0x40 0x00 0x15 0x55 0x14 0x49

## 5.3.1 Read Acceleration:

Send:
50 03 00 34 00 03 49 84

Tips: 50 is device address, 49 84 is the CRC.
**For CRC calculation method, please search CRC calculator on Google.**

Return:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MODADDR | 0X 03 | 0X 06 | AxH | AxL | AyH | Ay L | AzH | AzL | CRC H | CRC L |

Calculation:
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 )

CRCH:CRC Stop bit High
CRCL:CRC Stop bit Low

Note:
1、The data is transmitted in accordance with the 16 hexadecimal, notASCII code
2、Each data is transmitted in a low byte and a high byte, and the two is combined into a short type of symbol. Such as X axis acceleration data Ax, where AxL is the low byte,AxH is high byte.

The conversion method is as follows:
Assuming Data is the actual data, DataH for its high byte, DataL for its low byte part,then: Data= ((short) DataH<<8) |DataL. Here we must pay attention to that force the DataH to be converted into a symbol of the short type of data and then after shift 8 bit, and the type of Data is also a symbol of the short type, so it can show a negative.

## 5.3.2 Read Angular Velocity:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MODADDR | 0X03 | 0X06 | wxH | wxL | wyH | wyL | wzH | wzL | CRCH | CRCL |

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)
CRCH:CRC Stop bit High
CRCL:CRC Stop bit Low

## 5.3.3 Read Angle Output:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MODADDR | 0X03 | 0X06 | RollH | RollL | PitchH | PitchL | YawH | YawL | CRCH | CRCL |

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(°)
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

## 5.3.4 Quaternion output:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MODAD DR | 0X 03 | 0X 08 | Q0 H | Q0 L | Q1 H | Q 1L | Q2 H | Q2 L | Q3H | Q3L | CRC H | CR CL |

Calculation:

Q0=((Q0H<<8)|Q0L)/32768
Q1=((Q1H<<8)|Q1L)/32768
Q2=((Q2H<<8)|Q2L)/32768
Q3=((Q3H<<8)|Q3L)/32768

CRCH:CRC Stop bit high
CRCL:CRC stop bit low