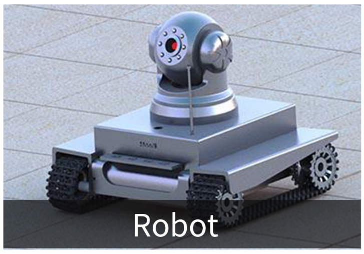
ATO

9-Axis Digital Compass Sensor

Product Manual

V2.0



Introduction

The 9-axis Digital Magnetic Compass designed by by Jobrey is mainly composed of three-axis magnetometer, three-axis accelerometer, three-axis gyroscope and other devices, which can measure the angle information of the object in three axial directions: pitch angle (X-axis), roll Angle (Y axis), heading angle (Z axis). Because the product has built-in hard magnetic interference and soft magnetic interference compensation, and the accelerometer and gyroscope are used for compensation when calculating the heading angle, it is very suitable for full attitude angle measurement in a dynamic environment.

Among them, the specific models of the DCS306 series 9-axis electronic compass navigation can be divided into two types according to the agreement: DCS306C (hexadecimal protocol) and DCS306M (Modbus RTU protocol). The product is a real industrial-grade product with good scalability and a variety of output interfaces to choose from: RS485, RS232, TTL, which can be easily integrated into various control systems.

Application

- Satellite tracking
- Petroleum geological exploration
- Optical range finder
- GPS-assisted navigation
- Individual combat equipment
- Ocean test
- Underwater navigation
- Mechanical control

Parameters

Main Features

- Three-axis gyro three-axis accelerometer three-axis magnetometer
- Dynamic and static measurements
- Temperature offset tracking algorithm eliminates drift
- Heading accuracy: 2°
- Operating temperature: -40℃ ~ +85℃
- Product size: L55 × W37 × H24(MM)
- Hard magnetic, soft magnetic and tilt compensation
- High precision, low cost

Electrical Parameters

Power supply	+5V DC
Operating current	30mA (Max40mA)
Operating temperature	-40~85℃
Store temperature	-55~100℃

Performance Specifications

Compass heading parameter	Heading accuracy	2° (RMS, static, compass working mode)
	Heading accuracy	3° (RMS, dynamic, attitude working mode)
	Repeatability	0.1°
Compass tilt parameter	Rolling pitch accuracy	2° (RMS , Dynamic) 0.5° (RMS , Static)
	Rolling pitch accuracy	2° (RMS , Dynamic) 0.5° (RMS , Static)
	Resolution	0.01°
	Tilt range	Pitch ±90°; Roll ±180°
Calibration	Hard magnetic calibration	Yes
	Soft magnetic calibration	Yes
	Limited tilt user calibration	Yes
Physical specifications	Size	L55 x W37 x H24 (mm)
	Weight	80g
	Output form	RS232/485/TTL Optional
Interface specifications	Start delay	<3s
	Maximum sampling rate	100/s
	RS-232Communication rate	2400-19200 Baud rate
Environment	Anti-vibration performance	3000g

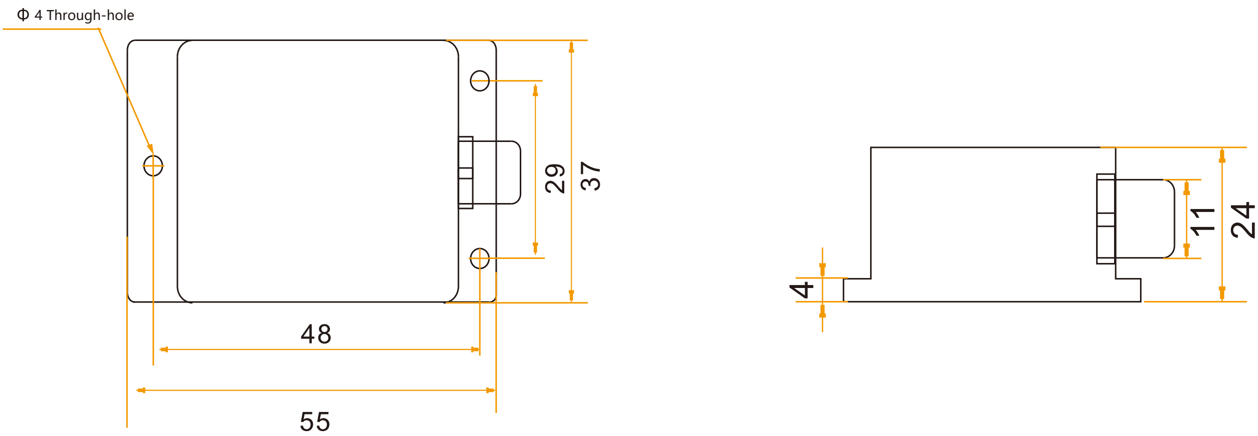
Resolution: The measured minimum change value that the sensor can detect and resolve within the measurement range.
Accuracy: The error between the actual angle and the Root mean square(RMS) of the measured angle of the sensor (≥16 times).

Mechanical Characteristic

Connector	Aviation joint（standard cable is 1.5m）
Protection level	IP67
Shell material	Magnesium alloy anodizing
Installation	Wkuhh M4 screws

Package Size

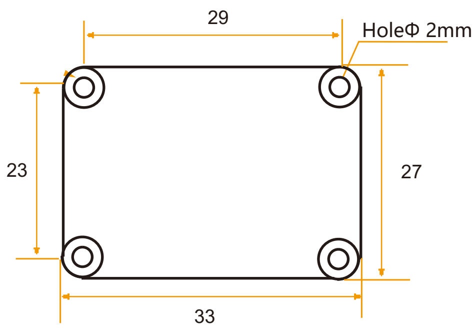
Size：L55*W37*H24（mm）



PCB Board Size

Size: L33*W27*H6(mm)

Note: ±1mm error for length and width dimensions, please refer to actual size.



Installation Notes

Although this product can compensate for magnetic interference, users should choose an environment with the least magnetic interference to install and use, as far away as possible from iron, nickel, magnets, motors and other magnetic materials. Otherwise, it may cause an irreversible decrease in measurement accuracy. The method we recommend is: install the sensor on a vertically erected aluminum pole (or other non-magnetic material) for heading angle measurement (the rotating pole is perpendicular to the rotating platform, try to avoid large external magnetic field interference).

Calibration

Method 1 - Plane calibration:

1.Connect the product to the system and place the product in a horizontal state;
2.Open the serial port debugging assistant and send 77 04 00 11 15;
3.Rotate the product in the horizontal plane (with the pitch and roll angles within ±5°) around the z-axis (z-axis is vertical) and rotate 2-3 turns. The rotation process is as slow as possible and rotates at a constant speed. The time of one rotation is controlled between 10 seconds and 15 seconds;
4.Rotating the compass around the X-axis or the Y-axis, the rotation process is as slow as possible and rotates at a constant speed, rotating 2-3 turns around each axis, and the time of one rotation is about 15 seconds;
5.Complete calibration, send 77 04 00 12 16 to save calibration.

Method 2 - Multi-face calibration:

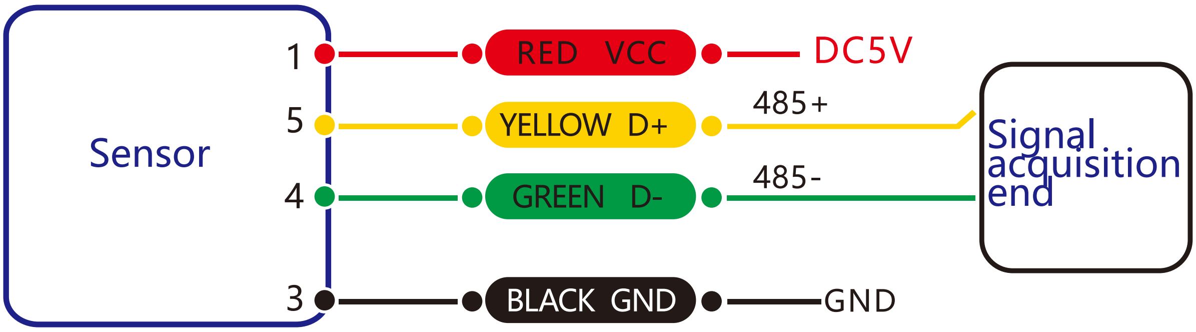
1.Fix the electronic compass in the use environment, and try not to carry magnetic items such as keys and mobile phones during calibration;
2.Place the compass in a horizontal state (within ±5°);
3.Send the following calibration command in hexadecimal format: 77 04 00 08 0C, return value 77 05 00 88 00 8D;
4.The product is placed horizontally, face up (pitch and roll are within ±5°), rotate one revolution at a constant speed approximately and use for more than 10 seconds.
5.The product is placed horizontally, with the mounting surface facing up (pitch and roll are within ±5°), rotate one revolution at a constant speed approximately and use for more than 10 seconds.

6.The product is placed in a vertical state, the smooth side of the casing is facing downward (the pitch and the roll are both within ±5°), rotate one revolution at a constant speed approximately and use for more than 10 seconds.
7.The product is placed in a vertical state, and the other smooth side of the casing faces downward (the pitch and the roll are both within ±5°), rotate one revolution at a constant speed approximately and use for more than 10 seconds.
Where step 4.5.6.7 can be exchanged;
8.After the four faces have been rotated, send the hexadecimal command 77 04 00 09 0D to save the calibration and return to 77 05 00 89 XX YY. (XX represents the calibration error coefficient, the smaller the value, the better, less than 1 is ideal, FF indicates calibration failure, and YY is the checksum of the command);
9.Calibration completed

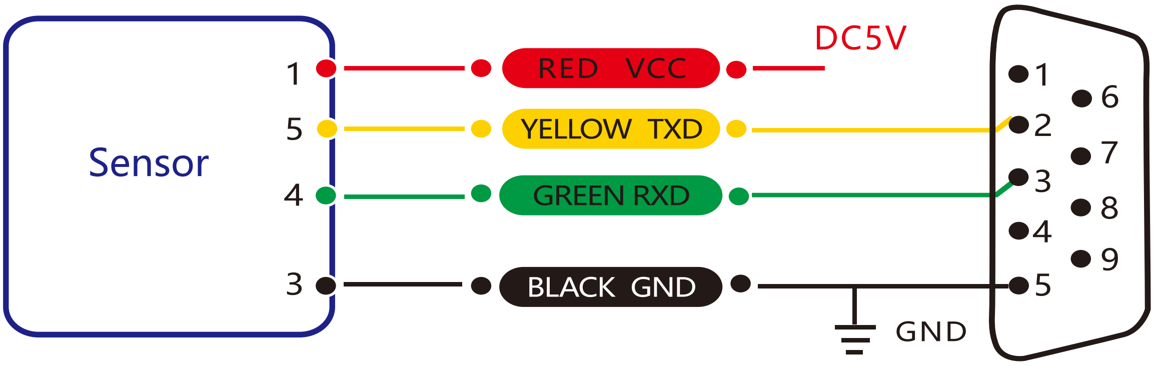
Wiring Instructions

Electrical interfaces

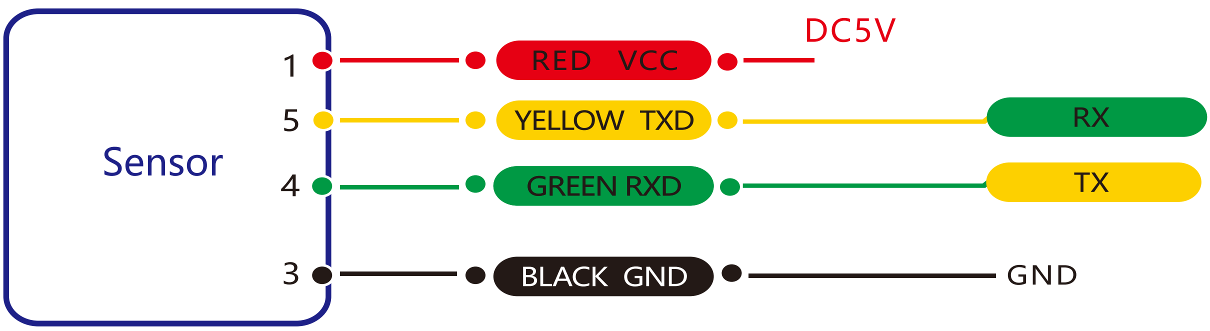
Wire color & Function	RED	BLUE	BLACK	GREEN	YELLOW
	1	2	3	4	5
	VCC DC 5V	NC	GND	RXD (B、D-)	TXD (A、D+)



RS 485 wiring diagram



RS 232 wiring diagram



TTL wiring diagram

Hexadecimal Protocol

1Data Frame Format: （8 data bits，1 stop bit，No parity check，default baud rate 9600）

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77					

Data Format: Hexadecimal
Identifier: Fixed to 77
Frame Length: Length from Frame Length to Checksum (included)
Address Code: Address of acquiring module, default 0x00
Data: Content and length variable according to Command
Checksum: Sum of Frame Length, Address Code, Command and Data. (Please pay attention that when the command or data changes, the checksum will change.)

2 Command Format:

2.1 Read PITCH angle Command：77 04 00 01 05

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77	0x04		0x01		0x05

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (3byte)	Checksum (1byte)
0x77	0x07		0x81	SXXX.YY	

Note: Data represents 4 byte angle value in format of compressed BCD code. S is the sign bit (0 means positive, 1 means negative), XXX is the three digit integer part, YY is the fractional part. The Data of other axis is the same format. For example, 10 26 87 means -026.87 °.

2.2 Read ROLL angle Command: 77 04 00 02 06

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77	0x04		0x02		0x06

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (3byte)	Checksum (1byte)
0x77	0x07		0x82	SXXX.YY	

2.3 Read Heading azimuth angle Command: 77 04 00 03 07

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77	0x04		0x03		

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (3byte)	Checksum (1byte)
0x77	0x07		0x83	SXXX.YY	

2.4 Read PITCH,ROLL,HEADING axis angle Command: 77 04 00 04 08

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77	0x04		0x04		0x06

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (9byte)	Checksum (1byte)
0x77	0x07		0x84	SXXX.YY	

Note: The data field contains 9 bytes of Pitch, Roll and Heading angle values, which are compressed BCD codes, each of which is a group of three bytes. For example, the return command is 77 0D 00. 84 10 26 80 00 33 65 03 13 71 66, where Pitch is 10 26 80, Roll is 00 33 65, Heading is 03 13 71. For the three bytes of the return value for each angle, the format is SX XX YY, S is the sign bit (0 positive, 1 negative) XXX is a three-digit integer value, and YY is a decimal value. The corresponding three angle readings for this example are: -26.8°, 33.65°, 313.71°.

77 0D 00 84 10 26 80 00 33 65 03 13 71 66

Identifier; fixed as 77

Frame Length The length of all bytes exclude identifier

00 device address; 00 by default

Command code，0X84 means return simultaneously Pitch，Roll，heading

Angle of Pitch, format is SXXX.YY. S is the sign bit (0 means positive, 1 means negative), XX are the digit integer part, YY are the fractional part . The data of other axis is the same format. For example, 10 27 70 means -26.70 ° .

Angel of Roll，33.65°

Angel of Heading，313.71°

Checksum

Hexadecimal Protocol

2.5 Set baud rate   Command: 77 05 00 0B 02 12

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x0B		

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05			0x00: success 0xFF: failure	

Note: 00:2400,01:4800,02:9600,03:19200,04:115200,05:38400,6:57600. If the baud rate is set to 19200, the command is 77 05 00 0B 03 13, where 13 = 05+ 00+ 0B+ 03, and so on when setting other baud rates.
Note: After setting the baud rate, the device will return the response command at the original baud rate. After that, the baud rate setting will take effect and the host computer needs to make the corresponding baud rate change to re-communicate with the device.

2.6 Set the magnetic declination   Command: 77 06 00 06 02 08 16

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (2byte)	Checksum (1byte)
0x77	0x06		0x06	SXXX.YY	0x06

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x86	0x00: success 0xFF: failure	

Note: S indicates a symbol, 0 is positive 1 is negative, XX is a two-digit integer, and Y is 1 decimal. For example, 02 08 is +20.8°. The checksum of the command is 16 (hex).16 = 06+00+06+02+08. If the declination is set to -3.2°, the command is 77 06 00 06 10 32 4E, where 4E = 06+00+06+10+32. Other magnetic declinations are analogous.

2.7 Read magnetic declination   Command: 77 04 00 07 0B

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77	0x04		0x07		

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (2byte)	Checksum (1byte)
0x77	0x06		0x87	SXXY	

Hexadecimal Protocol

2.8 Set address Command: 77 05 00 0F 01 15

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x0F	XX Address	

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x8F	0x00: success 0xFF: failure	

2.9 Query address Command: 77 04 00 1F 23

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77	0x04		0x1F		

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x1F		

Note: The default address of the sensor is 0x00. When the query address command is sent, the returned data field is the hexadecimal device address.

2.10 Set output mode Command: 77 05 00 0C 00 11

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x0C	0x00: question and answer Mode 0x01: 5Hz Data Rate 0x02: 10Hz Data Rate 0x03: 20Hz Data Rate 0x04: 25Hz Data Rate 0x05: 50Hz Data Rate 0x06: 100Hz Data Rate	

Note: The default output mode is 00(when setting 100HZ output frequency.
Set baud rate to 115200 in high speed mode.

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x8C	0x00: success 0xFF: failure	

Note: 5Hz Data Rate means that 5 sets of angle data are automatically output every second, and so on. When the product with the half-duplex RS485 interface is set to automatically outputs data to the outside, it may not be able to receive the input command effectively. At this point you may need to repeatedly send the command so that product can receive it. Therefore, if you need to send commands to interact with the product, it is recommended to set the product to work in Q&A mode. In addition, when the product is set to the automatic output mode, there will be no output within 10 seconds after the product is powered on, and the product can effectively receive the external setting command.

2.11 Save setting Command: 77 04 00 0A 0E

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (0 byte)	Checksum (1byte)
0x77	0x04		0x0A		

Command response:

Identifier (1byte	Frame Length (1byte)	Address Code (1byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x8A	0x00: success 0xFF: failure	

Note: If Save setting command is not executed, all setting will be invalid after power off.

Modbus (RTU) Protocol

1 Data frame format : (8data bits, 1 stop bit, no parity check, default baud rate 9600)

Address Code (1byte)	Function Code (1byte)	The first address of the read register (2 byte)	Number of read registers (2byte)	CRC check (2 byte)
0x77	03(read) 06(write)	XX XX	XX XX	XX XX

Data Format: Hexadecimal.
Address code: default 01 (note: address must not exceed FFF).
Function code: 03 for read register, 06 for prefabricated register.
Address of register: the starting address of the register that needs to be operated.
Number of registers: the number of registers to operate on.
CRC check: Through the calculation of the host computer. (suggested using CRC software)

2 Command format :

2.1 Read the PITCH angle Command : 01 03 00 01 00 01 D5 CA

Address Code (1byte)	Function Code (1byte)	The first address of the read register (2 byte)	Number of read registers (2byte)	CRC check (2 byte)
01	03	00 01	00 01	XX XX

Command response :

Address Code (1byte)	Function Code (1byte)	Number of bytes of data (1 byte)	Data (2byte)	CRC check (2 byte)
01	03	02	XX XX	ZZ ZZ

XX XX denotes pitch angle with an angle value of hexadecimal number. (PLC or configuration software read out the number is directly the decimal number). The angle is calculated as follows:
Actual angle = (data converted to decimal -20000 / 100).
For example: the return value of the angle value is 3D52, turning it into decimal is 15698,
The real data is (15698-20000) /100=-43.02°, and the other axes are the same.

2.2 Read the ROLL angle Command : 01 03 00 02 00 01 25 CA

Address Code (1byte)	Function Code (1byte)	The first address of the read register (2 byte)	Number of read registers (2byte)	CRC check (2 byte)
01	03	00 02	00 01	XX XX

Command response :

Address Code (1byte)	Function Code (1byte)	Number of bytes of data (1 byte)	Data (2byte)	CRC check (2 byte)
01	03	02	XX XX	ZZ ZZ

2.3 Read the HEADING angle Command : 01 03 00 03 00 01 74 0A

Address Code (1byte)	Function Code (1byte)	The first address of the read register (2 byte)	Number of read registers (2byte)	CRC check (2 byte)
01	03	00 03	00 01	XX XX

Command response :

Address Code (1byte)	Function Code (1byte)	Number of bytes of data (1 byte)	Data (2byte)	CRC check (2 byte)
01	03	02	XX XX	ZZ ZZ

2.4 Read the Heading, Pitch and Roll angle Command : 01 03 00 01 00 03 54 0B

Address Code (1byte)	Function Code (1byte)	The first address of the read register (2 byte)	Number of read registers (2byte)	CRC check (2 byte)
01	03	00 01	00 03	XX XX

Command response :

Address Code (1byte)	Function Code (1byte)	Number of bytes of data (2 byte)	Data (2byte)	CRC check (2 byte)
01	03	06	XX XX YY YY ZZ ZZ	ZZ ZZ

XX XX means PITCH angle YY YY means ROLL angle ZZ ZZ denotes HEADING angle

2.5 Set relative / absolute zero Command : 01 06 00 0A 00 00 A9 C8 / 01 06 00 0A 00 01 68 08

Address Code (1byte)	Function Code (1byte)	Function Code (1byte)	Zero Point Type (2byte)	CRC check (2 byte)
01	06	00 0A	00 00(Absolute) 00 01(Relative)	XX XX

Command response :

Address Code (1byte)	Function Code (1byte)	Function Code (1byte)	Zero Point Type (2byte)	CRC check (2 byte)
01	06	00 0A	00 00(Absolute) 00 01(Relative)	XX XX

Note: The measured angle is referred to the zero point calibrated in factory if absolute zero point is set. The measured angle is referred to the current angle if relative zero point is set. The zero point is the zero point of the dip Angle, and when installing, try to install it in the zero attachment. The Angle changes more, which will cause the change of azimuth.

Modbus (RTU) Protocol

2.6 Query the relative /Absolute zero point Command : 01 03 00 05 00 01 94 0B

Address Code (1byte)	Function Code (1byte)	The first address of the read register (2 byte)	Number of read registers (2byte)	CRC check (2 byte)
01	03	00 05	00 01	XX XX

Command response :

Address Code (1byte)	Function Code (1byte)	Number of bytes of data (1 byte)	Data (2byte)	CRC check (2 byte)
01	03	02	00 00(Absolute) 00 01(Relative)	ZZ ZZ

2.7 Set baud rate Command : 1 6 0 B 00 2 9 9

	Address Code (1byte)	Function Code (1byte)	Function Code (2byte)	Baud rate type (2byte)	CRC check (2 byte)
Send	01	06	00 0B	XX XX	XX XX
Response	01	06	00 0B	XX XX	XX XX

Note: if XX XX in the baud rate type is
0000, the baud rate is revised to 2400;
0001 indicates that the baud rate is revised to 4800;
0002 indicates that the baud rate is revised to 9600 (the default value);
0003 indicates that the baud rate is revised to 19200;
0004 indicates that the baud rate is revised to 115200;
If the baud rate is changed immediately after the command is sent, the return value is generally confusing.

2.8 Set address Command : 01 06 00 0D 00 02 99 CB

	Address Code (1byte)	Function Code (1byte)	Function Code (2byte)	Modified address (2byte)	CRC check (2 byte)
Send	01	06	00 0D	HH LL	XX XX
Response	LL	06	00 0D	HH LL	XX XX

Note: HH LL represents the address of the product to be changed, HH represents the high position of the address, and LL represents the status of the address, which is 00 00-00 FF. In the example, the address of the product is changed to 0002.

2.9 Query address Command : 77 04 00 2F 33

	Identifier (1byte)	Function Length (1byte)	Product custom protocol address (1byte)	Function Length (1byte)	MODBUS address (1byte)	Checksum (1byte)
Send	77	04	00	2F		33
Response	77	05	00	2F	XX	XX

Note: Because the MODBUS protocol specifies that the product can communicate only when it knows the address of the module, when the MODBUS protocol communication, the address is known in advance and can not be queried. This product uses custom protocols to query the address of the MODBUS protocol. You can see the product introduction of a custom protocol about related custom protocol. And the command is valid for 10 seconds before power.
The XX in the MODBUS address is the product address of the protocol.

2.10 Save setting Command : 01 6 0 F 00 0 8 9

Address Code (1byte)	Function Code (1byte)	Function Code (1byte)	(2byte)	CRC check (2 byte)
01	06	00 0F	00 00	XX XX

Command response :

Address Code (1byte)	Function Code (1byte)	Function Code (1byte)	(2byte)	CRC check (2 byte)
01	06	00 0F	00 00	XX XX

Note: command should be sent without a power outage after all previous settings that need to be changed are changed. Otherwise, there is no memory function.