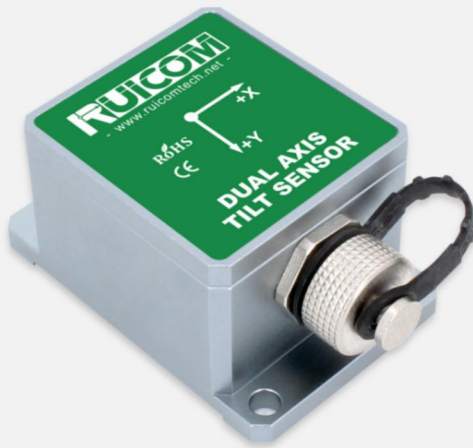




NTS6 Digital Output Tilt Sensor

Product manual

V2.7-20240412



✓ Technical Highlights

- ❖ Single/dual axis tilt measurement;
- ❖ Measurement range $\pm 10^{\circ}$ ~ $\pm 90^{\circ}$ selectable;
- ❖ Resolution 0.02°;
- ❖ Standard DC 5V power supply;
- ❖ IP67 protection rating.

✓ Product Introduction

The NTS6 series inclinometer is a compact digital output MEMS inclinometer from Ruicom Technology. This product integrates a dual-channel gravity tilt unit, measuring static gravitational acceleration and converting it into tilt angle changes, thus determining the sensor's output roll and pitch angles relative to the horizontal plane. Users can choose RS232, RS485, or TTL level interfaces as the output method according to their needs. The product has a built-in MCU control system that performs secondary correction on the sensor output linearity, compensating for the accuracy loss caused by insufficient correction in analog sensors.

This product uses a non-contact measurement principle, providing real-time output of the current attitude tilt angle. It is easy to operate and does not require relocating two opposing surfaces for installation. This sensor is mainly suitable for angle measurement in static and slowly changing dynamic scenarios, possesses good resistance to external electromagnetic interference, and can operate stably for extended periods in harsh industrial environments.

✓ Application Scope

This series of inclinometers offers mature solutions for industrial applications thanks to its high-precision inertial measurement capabilities.:

- ❖ Angle control for various engineering machinery
- ❖ Four-wheel alignment and control for automobiles
- ❖ Chassis measurement for automobiles
- ❖ Monitoring of gimbal operation
- ❖ Leveling of medical beds
- ❖ Satellite antenna positioning



Performance Parameters

NTS6	Condition	Parameter				Unit
Measurement Range		±10	±30	±60	±90	°
Measurement Axis		X Y	X Y	X Y	X Y	Axis
Resolution		0.02	0.02	0.02	0.02	°
Accuracy	@25℃	0.1	0.1	0.1	0.1	°
Zero-Point Temp Coefficient	-40~85℃	±0.02	±0.02	±0.02	±0.02	°/℃
Sensitivity Temp Coefficient	-40~85℃	≤150	≤150	≤150	≤150	ppm/℃
Power-On Startup Time		0.5	0.5	0.5	0.5	S
Response Frequency		20	20	20	20	Hz
Output Rate	5Hz、15Hz、35Hz、50Hz Configurable					
Output Signal	RS232/RS485/TTL Customized					
Electromagnetic Compatibility	According to EN61000 and GBT17626					
Insulation Resistance	≥100 megohms					
Shock Resistance	100g@11ms, triaxial (half-sine wave)					
Vibration Resistance	10grms, 10~1000Hz					
Waterproof Rating	IP67					
Cable	Standard config: 2m shielded cable, weight ≤123g					
Weight	≤112g					

Ordering and Selecting

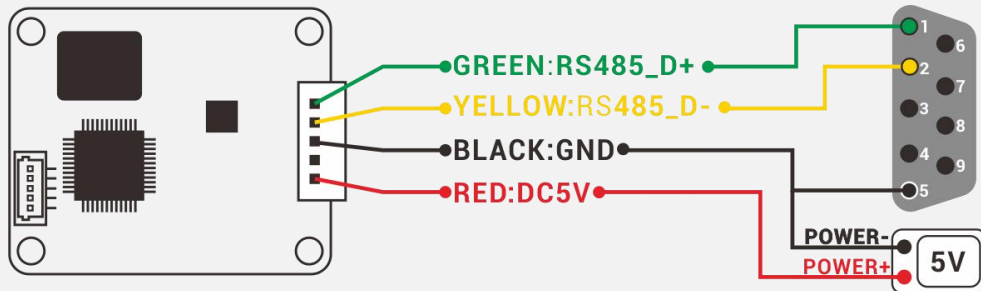
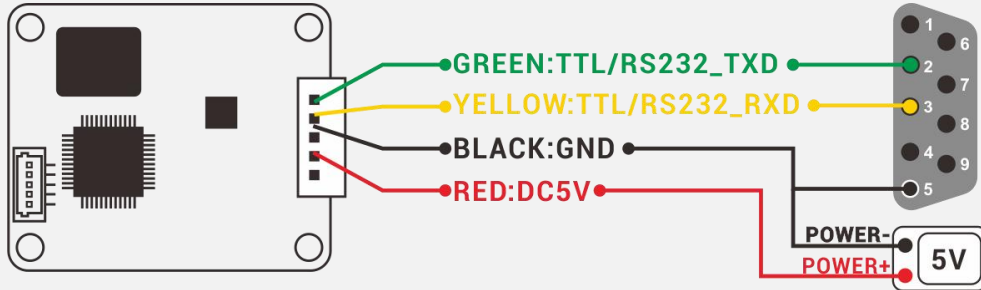
Model	Housing	Axis	Range	Signal Output	Protocol	Installation Method
NTS	3: PCBA	X: X Axis	10: ±10°	232: RS232	SP: Serial Protocol	H: Horizontal installation
	6: Shell	Y: Y Axis	15: ±15°	485: RS485	MB: MODBUS Protocol	HD: Horizontal downwards
		D: Dual Axis	30: ±30°	TTL: UART TTL		V: Vertical installation
			45: ±45°			VD: Vertical downwards
			60: ±60°			VL: Vertical leftwards
			90: ±90°			VR: Vertical rightwards
			180: ±180°(only X axis)			

E.g: NTS3X10-C1-H: PCBA, X axis, ±10° measurement range, CANopen signal output, horizontal installation.

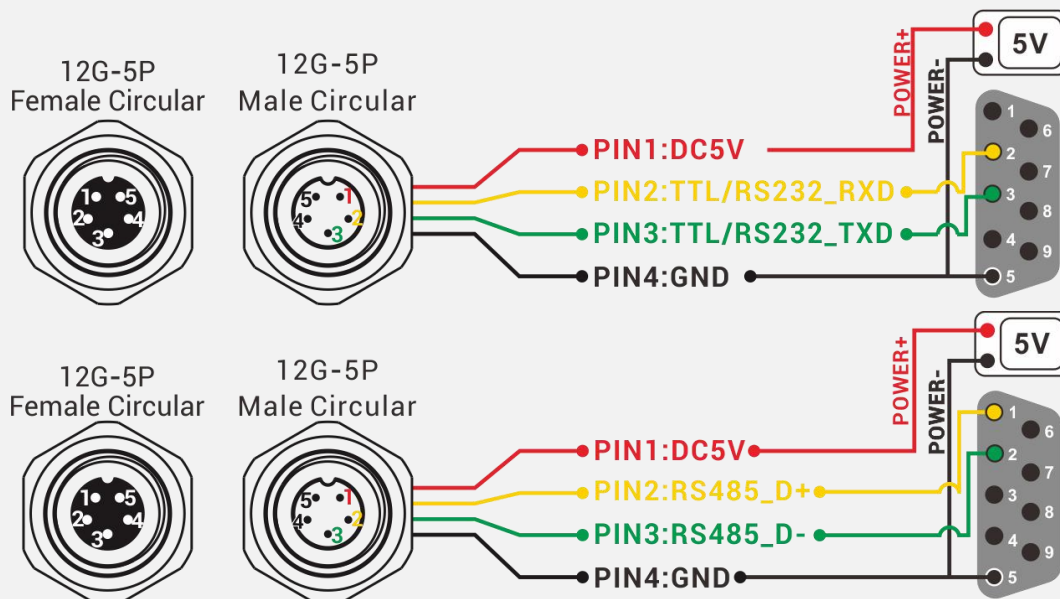
Note: Measurement range ±180° is limited to single-axis X-axis only.

Interface Definition

Wire color	PIN Definition	Description
Red	DC4.5~5.5V	Positive power supply terminal
Black	GND	Negative power supply terminal
Yellow	RS232_RXD/RS485_D-	Receive data
Green	RS232_TXD/RS485_D+	Transmit data



Connector pin/wire colors	PIN Definition	Description
PIN1/Red	DC4.5~5.5V	Positive power supply
PIN2/Yellow	RS232_RXD/RS485_D+	Receive data
PIN3/Green	RS232_TXD/RS485_D-	Transmit data
PIN4/Black	GND	Negative power supply
PIN5/--	NC	No connection

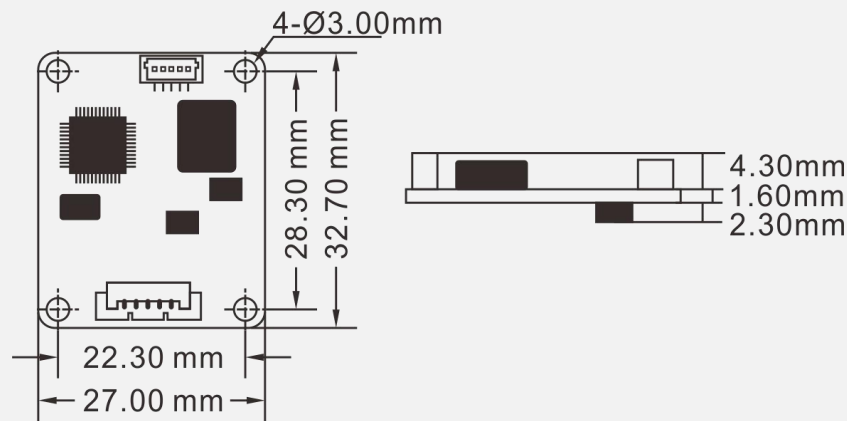


✓ Electrical Parameters

Parameter	Condition	MIN	TYP		MAX	Unit
Power supply voltage	Standard	4.5	5		5.5	V
	Customizable	9	12	24	36	V
Operating current	5V		35			mA
	12V		21			mA
	24V		11			mA
Operating temp		-40			+85	°C
Storage temp		-40			+85	°C

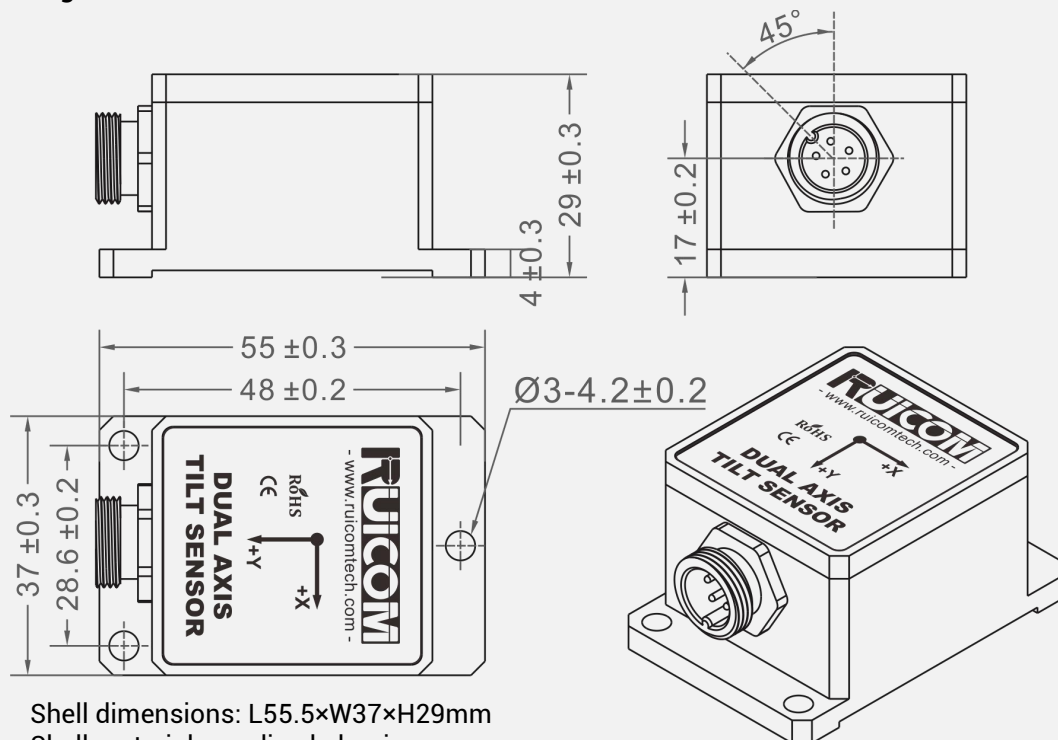
✓ Product Dimensions

PCBA Board Dimensions



PCBA board dimensions: L32.7×W27×H8.2mm
Recommended screws: 4 -M3 screws

Package dimensions



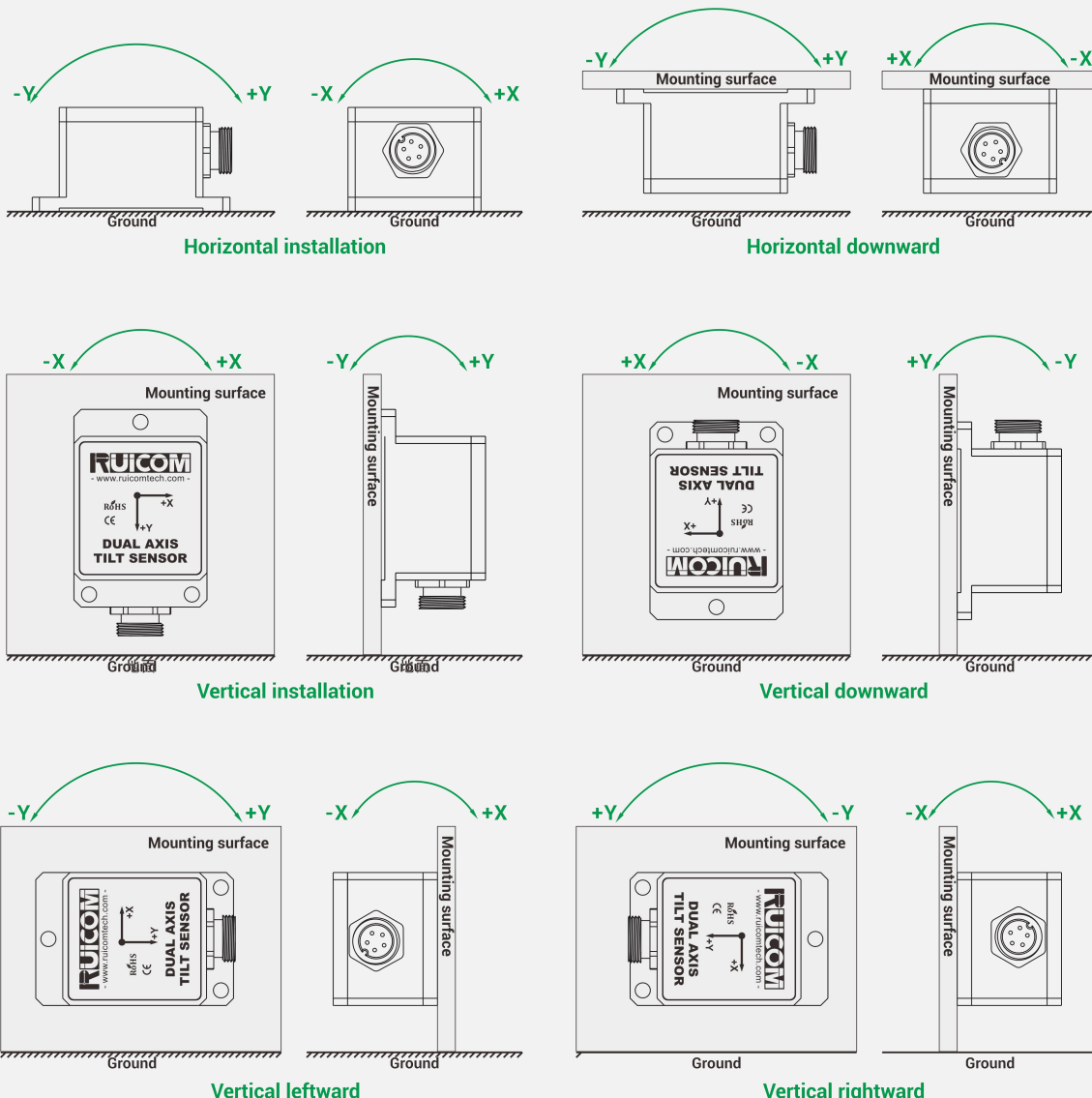
Shell dimensions: L55.5×W37×H29mm
Shell material: anodized aluminum
Connector: aviation plug 12G-5P
Suggested screws: 3 M4 screws

✓ Instructions for use

1. This tilt sensor measures the tilt angle of an object by sensing the Earth's gravity. During installation, ensure the sensor's sensing axis is parallel to the tilt axis of the object being measured for optimal accuracy. The sensor and the surface being measured must be tightly fitted, flat, and stable. Uneven mounting surfaces can cause measurement angular errors.
2. This tilt sensor can be installed on any of its six sides. After installation, use the sensor's relative zero-point setting command to zero it. (This also sets the current installation method; the setting is stored in the product's internal memory. After zeroing, the product will operate with the current position as zero degrees.)
3. This sensor has an IP67 protection rating. Rain or strong water jets will not affect the operation of the internal components. Do not use it for extended periods of immersion in water to avoid damaging the internal circuitry. The manufacturer will provide paid repair services for any damage caused by immersion in water.
4. After the product is installed, please be careful not to short-circuit the signal line with the positive terminal of the power supply line when wiring, so as not to burn out the output circuit. Since the negative terminal of the signal and the negative terminal of the power supply are shared by this product, please connect the negative terminal of the signal at the acquisition end to the negative terminal of the power supply of this product.

✓ Installation Orientation

During installation, the sensor mounting surface should be kept parallel to the target surface, and the effects of dynamics and acceleration on the sensor should be minimized. This product can be installed horizontally or vertically; please refer to the diagram below for installation instructions:



SP.Serial Communication Protocol

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

Identifier (1byte)	Data Length (1byte)	Address Code(1byte)	Command Word(1byte)	Data Field	Checksum (1byte)
68					

Data format: Hexadecimal,

Identifier: Fixed at 68,

Data length: Length from the data length to the checksum (including the checksum),

Address code: Address of the acquisition module, default is 00,

Data field: Varies according to the different content and length of the command word,

Checksum: The sum of the data length, address code, command word, and data field, without considering carry.

2. Command Word Parsing

Command words	Meaning / Examples	Explanations
0X04	Simultaneous angle reading command E.g: 68 04 00 04 08	Data Field (0 bytes) No Data Field Command
0X84	Sensor response E.g: 68 0D 00 84 00 20 10 10 05 25 00 50 50 9B	Data Field (9byte) SA AA BB SC CC DD SE EE FF SA AA BB : 3 characters representing the X-axis angle value, in compressed BCD code. S is the sign bit (0 for positive, 1 for negative), AAA is the three-digit integer value, and BB is the decimal value; SC CC DD : 3 characters representing the Y-axis; SE EE FF : 3 characters representing the product's internal temperature value, parsed in the same way as the X-axis angle. Angle format and parsing method are the same as X-axis or Y-axis. In the example on the left, the angles are: X-axis 20.10°, Y-axis -5.25°, temperature: +50.5°C
0X05	Set Relative/Absolute Zero Point: This allows you to set the current angle to zero for relative measurement, or reset it to the factory absolute zero point, which is saved after power failure. E.g: 68 05 00 05 00 0A	Data Field (1 byte) 00: Absolute Zero 01: Relative Zero
0X85	Sensor Response Command E.g: 68 05 00 85 00 8A	Data Field (1 byte) The number in the data field represents the sensor's response result. 00: Successful setting FF: Failed setting

0X0B	Set Communication Rate Example: 68 05 00 0B 03 13 This command setting requires a power failure and restart to take effect, and the setting is saved after power failure.	Data Field (1 byte) Baud Rate: 00 represents 2400 01 represents 4800 02 represents 9600 (default) 03 represents 19200 04 represents 38400 05 represents 115200
0X8B	Sensor Response Command E.g: 68 05 00 8B 00 90	Data Field (1 byte) The number in the data field represents the sensor's response result. 00: Successful setting FF: Failed setting
0X0C	Set Sensor Output Mode Response Mode: The sensor responds with a relative angle only after the host computer sends a read angle command. Automatic Output Mode: The sensor automatically outputs X and Y angles after power-on, with the output frequency set as shown in the table on the right. (This function is power-off memory saved) E.g: 68 05 00 0C 00 11	Data Field (1 byte) 00 Response Mode (default) 01 5Hz Auto Output Mode 02 15Hz Auto Output Mode 03 25Hz Automatic Output Mode 04 35Hz Automatic Output Mode 05 50Hz Automatic Output Mode Note: RS485 only has a response mode, not an automatic output mode.
0X8C	Sensor response/reply command E.g: 68 05 00 8C 00 91	Data Field (1 byte) The number in the data field represents the sensor's response result. 00: Setting successful FF: Setting failed
0X0F	Set module address command The default address of the sensor is 00. 1. If multiple sensors are connected to a bus, such as RS485, each sensor needs to be set to a different address to achieve separate control and response angles. 2. After successfully changing the address, the address code in all subsequent commands and response data packets must be replaced with the new address code to be effective; otherwise, the sensor will not respond to the command. This command is power-off memory saved. E.g: 68 05 00 0F 01 15 Set to address 01	Data Field (1 byte) XX module address, the address ranges from 00 to EF. Note: All products have a common address: FF. If you forget the address you set during operation, you can use the FF address to operate the product, and it will still respond normally.

	68 05 FF 0F 00 13 Reset address to 00 using a universal address.	
0X8F	Sensor Response Command E.g: 68 05 00 8F 00 94	Data Field (1 byte) The number in the data field represents the sensor's response result. 00: Setting successful FF: Setting failed
0X0D	Query Relative/Absolute Zero Point Used to query whether the sensor's current zero-degree mode is relative or absolute zero. E.g: 68 04 00 0D 11	Data Field (0 byte) No data field command
0X8D	Sensor Response Command E.g: 68 05 00 8D 00 92	Data Field (1 byte) The number in the data field represents the sensor's response result. 00: Absolute zero point 01: Relative zero point



MB:MODBUS Communication Protocol

Please carefully read the following items before use:

1) The MODBUS protocol stipulates that there should be at least 3.5 bytes of time between two data frames (e.g., at a baud rate of 9600, this time is $3.5 \times (1/9600) \times 11 = 0.004s$). However, to leave sufficient margin, this sensor increases this time to 10ms. Therefore, please leave at least a 10ms time interval between each data frame.

Master sends command -- 10ms idle -- Slave replies -- 10ms idle -- Master sends command...

2) The MODBUS protocol specifies the content related to broadcast address ---- 0. This sensor can also receive broadcast address content, but will not reply. Therefore, broadcast address 0 can be used for the following purposes, for reference only:

1. Set the address of all tilt sensors of this model connected to the bus to a certain address.

2. Set all tilt sensors of this model connected to the bus to relative/absolute zero point.

3. Test the sensors of this model on the entire bus. The host sends a command to the bus to query the angle at address 0. If the communication indicator light flashes, communication is normal.

3) To improve system reliability, both the address setting command and the absolute/relative setting command must be sent consecutively to be effective. "Sent consecutively" means both commands are successfully sent (the slave device responds each time), and the two responses must be consecutive. The host cannot insert other data frames between the two responses; otherwise, the command will be locked until power is cut off. The setting process is as follows: Send the address setting command – wait for the slave device to send a successful setting command – (no other commands can appear) Send the address setting command again – wait for the slave device to send a successful setting command – modification successful.

4) After power-on, each of the above two setting commands can only be set once. If resetting is required, power must be turned on again.

5) The communication indicator light will flash once after a certain number of successful communications.

1. Data Frame Format:

RTU Mode

Communication Parameters: Baud Rate 9600 bps

Data Frame: 1 start bit, 8 data bits, even parity, 1 stop bit

2. Read Angle Data:

Modbus Function Code 03H

Host query command:		Slave response:	
Sensor Address	01H	Sensor Address	01H
Function Code	03H	Function Code	03H
Access Register	00H	Data Length (8 bytes)	08H
Start Address	02H	Data Word 1 (High 8 bits)	50H
Data Length 4 words	00H	Data Word 1 (Low 8 bits)	46H
	04H	Data Word 2 (High 8 bits)	00H
CRC	E5C9H	Data Word 2 (Low 8 bits)	00H
		Data Word 3 (High 8 bits)	23H
		Data Word 3 (Low 8 bits)	20H
		Data Word 4 (High 8 bits)	00H
		Data Word 4 (Low 8 bits)	00H
		CRC	BD61H

Example of using the command to read measurement data 1:

Master sends	01H	03H	00H	02H	00H	04H	E5H	C9H
Slave replies	01H	03H	08H	50H	46H	00H	00H	23H
				20H	00H	00H	BDH	61H

1) Note: The data field of the slave device's reply frame is 50H, 46H, 00H, 00H, 23H, 20H, 00H, 00H. The X-axis represents bytes 1-4 of the data field, and the Y-axis represents bytes 5-8, with the least significant byte first. Angles are represented using a point-based notation, where one point corresponds to 0.01°. $0.01 \times (\text{number of points} - \text{offset})$ equals the angle. For example, if the measurement range is $\pm 90^\circ$, the total number of points is 18000. Therefore, 0 corresponds to -90° , 18000 corresponds to $+90^\circ$, and 9000 corresponds to 0° .

Taking the above data frame as an example: the angle conversion process is as follows:

1) Obtain the current angle point count. Note that the least significant byte comes first. The X-axis is 4650H, and the Y-axis is 2023H.

2) Convert to decimal: X-axis: 4650H $\rightarrow$ 18000, Y-axis: 2023H $\rightarrow$ 8227.

3) Subtract the offset of 9000 (Note: this value is related to the measurement range). X-axis: $18000 - 9000 = 9000$, Y-axis: $8227 - 9000 = -773$.

4) The final angle is obtained: X-axis: $9000 \times 0.01 = 90.00^\circ$, Y-axis: $-773 \times 0.01 = -7.73^\circ$.

Example of using the command to read measurement data 1:

Master sends	01H	03H	00H	02H	00H	04H	E5H	C9H
Slave replies	01H	03H	08H	00H	00H	00H	00H	00H
				23H	00H	00H	64H	1DH

Assuming the sensor's measurement range in this example is $\pm 45^\circ$, the total number of measurement points is 9000. Therefore, 0 corresponds to -45° , 9000 corresponds to $+45^\circ$, and 4500 corresponds to 0° . The angle conversion process is as follows:

1) Obtain the current angle measurement points. Note that the least significant byte comes first: X-axis is 0000H, Y-axis is 2300H.

2) Convert to decimal: X-axis: 0000H $\rightarrow$ 0, Y-axis: 2300H $\rightarrow$ 8960.

3) Subtract the offset 4500 (note: this value is related to the measurement range): X-axis: $0 - 4500 = -4500$, Y-axis: $8960 - 4500 = 4460$.

4) Obtain the final angle: X-axis: $-4500 \times 0.01 = -45.00^\circ$, Y-axis: $4460 \times 0.01 = 44.60^\circ$.

3. Setting the sensor's relative/absolute zero point: (Modbus function code 06H)

Command to set relative/absolute zero point:		Slave response:	
Sensor Address	01H	Sensor Address	01H
Function Code	06H	Function Code	06H
Access Register	00H	Register Address	00H
Start Address	10H		10H
If this word is non-zero, it indicates a relative zero; if it is zero, it indicates an absolute zero. CRC	00 H	If this word is non-zero, it indicates a relative zero; if it is zero, it indicates an absolute zero.	00H
	FFH / 00H Relative / Absolute		FFH / 00H Relative / Absolute
Sensor Address	C84FH/ 880FH	CRC	C84FH/ 880FH

Examples of using the command to set relative/absolute zero point:

Master sends	01H	06H	00H	10H	00H	FFH	C8H	4FH
Slave replies	01H	06H	00H	10H	00H	FFH	C8 H	4FH

Note: 0010 is the register address, which controls whether the sensor output is a relative zero or an absolute zero. If it is non-zero (as in the example above, it is written with 00FFH), the output is a relative zero. Conversely, if it is zero (by changing bytes 5 and 6 to 00H), it is an absolute zero. The last two bytes are the CRC checksum.

4. Setting the sensor address:

Command to set sensor address code:		Slave response:	
Sensor Address	01H	Sensor Address	01H
Function Code	06H	Function Code	06H
Address New Address of Sensor	00H	Register Address	00H
	11H		11H
CRC Sensor Address	00 H	New Address of Sensor	00H
	04H		04H
Function Code	D80C	CRC	D80C

Examples of using the command to set relative/absolute zero point:

Master sends	01H	06H	00H	11H	00 H	04H	D8H	0CH
Slave replies	01H	06H	00H	11H	00 H	04H	D8H	0CH

Note: 0011H is the register address, which controls the sensor address. In the example above, the sensor address has been changed to 0004H, and the last two bytes are the CRC checksum.

5. Set the sensor baud rate: (The factory default is 9600bps)

Command to set sensor baud rate:		Slave response:	
Sensor Address	01H	Sensor Address	01H
Function Code	06H	Function Code	06H
Address Sensor Baud Rate	00H	Register Address	00H
	08H		08H
Sensor Address	00H	Sensor Baud Rate	00H

	XX		XX
CRC	CRC LH	CRC	CRC LH

XX: A0H:4800 A1H: 9600 A2H: 19200 A3H: 38400

A4H: 115200

Commands must be sent twice consecutively to be effective.

Example of using the command to set the sensor baud rate:

Master sends	01H	06H	00H	08H	00H	A2H	A8H	76H
Slave replies	01H	06H	00H	08H	00H	A2H	A8H	76H

Note: 0008H is the register address, which controls the sensor baud rate. In the example above, the sensor baud rate is set to 19200, and the last two bytes are the CRC checksum.

Six. Set the sensor to output automatically: (Factory default is 0Hz)

Set the sensor to automatically output commands:		Slave response:	
Sensor Address	01H	Sensor Address	01H
Function Code	06H	Function Code	06H
Address Sensor Output Frequency	00H	Register Address	00H
	13H		13H
Sensor Address	00 H	Sensor Output Frequency	00H
	XX		XX
CRC	CRC LH	CRC	CRC LH

XX: 0 Inquiry mode, 1:10HZ 2:25HZ 3: 50HZ

Example of setting up automatic command output for sensors:

Master sends	01 H	06 H	00 H	13 H	00 H	00H	78H	0FH
Slave replies	01 H	06 H	00 H	13 H	00 H	00H	78H	0FH