RUICOM

HTS6 High-Precision Digital Output Tilt Sensor

Product manual

V1.9-20230918

Technical Highlights

- ❖ Measuring range ±1~±90° selectable;
- ❖ Small measuring range accuracy 0.005°;
- ❖ Resolution 0.001°;
- ❖ DC 9~36V wide voltage input;
- ❖ RS485, RS232, RS422, and TTL output interfaces selectable.

Product Introduction

The HTS6 series high-performance single/dual-axis tilt sensors, while maintaining stable and reliable characteristics, further improve measurement accuracy and optimize temperature drift performance. This product integrates a high-precision 16-bit differential A/D converter, combined with a 5th-order digital filtering algorithm, to accurately measure the roll and pitch angles of the sensor relative to the horizontal plane.

Multi-protocol digital output: Supports RS485, RS232, RS422, and TTL interfaces to adapt to different industrial communication needs.

Intelligent temperature drift compensation: Built-in high-precision digital temperature sensor, real-time correction of temperature drift error (optional temperature output), ensuring excellent repeatability in a wide temperature range.

Industrial-grade reliability: Utilizing a reinforced design, this product is suitable for harsh industrial environments due to its excellent expandability and environmental adaptability, possessing superior anti-interference capabilities and long-term stability.

Application Scope

Typical applications of this product series include: industrial automation, engineering machinery platform leveling systems, photovoltaic tracking bracket control systems, aerospace attitude reference systems, precision instrument leveling devices, and high-precision tilt measurement fields such as platform leveling.

Performance Parameters

HTS6	Condition	Parameter			
Measurement Range	-	±10°	±30°	±60°	±90°
Measurement Axis	-	Single-axis / Dual-axis			
Resolution[1)]	-	0.001°			
Measurement Accuracy[2)]	@25℃	0.005°	0.01°	0.01°	0.02°
Long-Term Stability		0.01°	0.02°	0.05°	0.08°
Zero-Point Temp Coefficient[3)]	-40~85℃	0.0005°/℃			
Sensitivity Temp Coefficient[4)]	-40~85℃	≤50ppm/℃	≤50ppm/℃	≤50ppm/℃	≤100ppm/℃
Power-On Startup Time	0.5S				
Response Frequency	20Hz				
Output Rate	5Hz / 15Hz / 35Hz / 50Hz/ 100Hz optional				
Output Signal	RS232 / RS485 / RS422 / TTL / MODBUS				
EMC	According to EN61000 and GBT17626				
Insulation Resistance	≥100 MΩ				
Shock Resistance	100g@11ms, 3 Axial Direction (Half Sinusoid)				
Vibration Resistance	10grms/10~1000Hz				
Protection Class	IP67				
Cables	Standard 2m cable, wire diameter 6.0~6.5mm, wire weight ＜ 155g				
Weight	≤200g (excluding cable)				

*The maximum range for a single axis is ±90°, and the maximum range for a dual axis is ±89.5°.

1) Resolution: The smallest angular change that can be detected within the effective measurement range, reflecting its ability to monitor minute tilt fluctuations.
2) Measurement Accuracy: A comprehensive evaluation of the sensor's performance indicators under standard ambient temperature, including the overall performance of linearity error, repeatability error, hysteresis error, zero-point offset error, and cross-axis sensitivity error.
3) Zero-Point Temperature Coefficient: The ratio of the sensor's output value to temperature when the sensor is in a zero-input state, defined as the ratio of the zero-point offset within the rated operating temperature range to the room temperature reference value.
4) Sensitivity Temperature Coefficient: A stability index of the sensor's full-scale output value with temperature changes, characterizing the drift rate of sensitivity relative to the room temperature reference value within the rated temperature range.

Electrical Parameters

Parameter	Condition	Min	Typ		Max	Unit
Power supply voltage	Standard	9	12	24	36	V
	Customized		Other voltages			
Operating current	No load		50			mA
Operating temperature		-40			+85	℃
Storage temperature		-40			+85	℃

Ordering Selection

Model	Axis	Range		Signal Output	Communication Protocol		Installation Direction
HTS6	X: X-axis	10: ±10°	-	232: RS232	SP. Serial Protocol	-	H:Horizontal installation
	Y: Y-axis	15: ±15°		TTL: TTL	MB: MODBUS Protocol		HD:Horizontal downwards
	D: Dual axis	30: ±30°		485: RS485			V:Vertical installation
		45: ±45°		422: RS422			VL:Vertical leftwards
		60: ±60°					VR:Vertical rightwards
		90: ±90°					

Example: HTS6X10-232SP-H: Single-axis X-axis / Measurement range ±10° / RS232 output / Serial communication protocol / Horizontal installation.

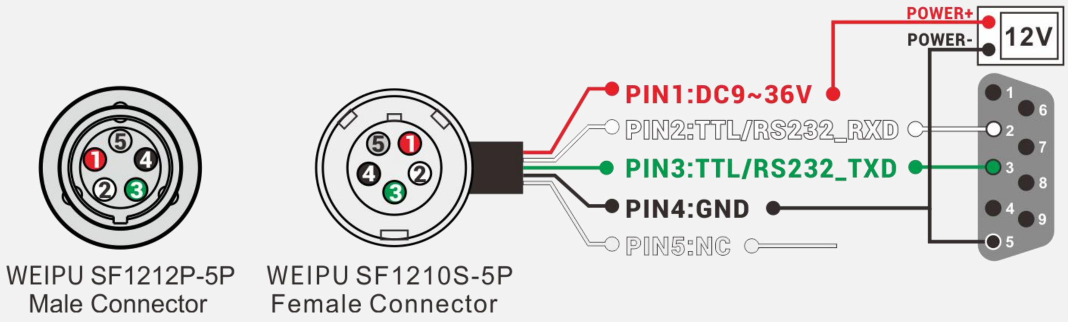
Indicator light operation instructions

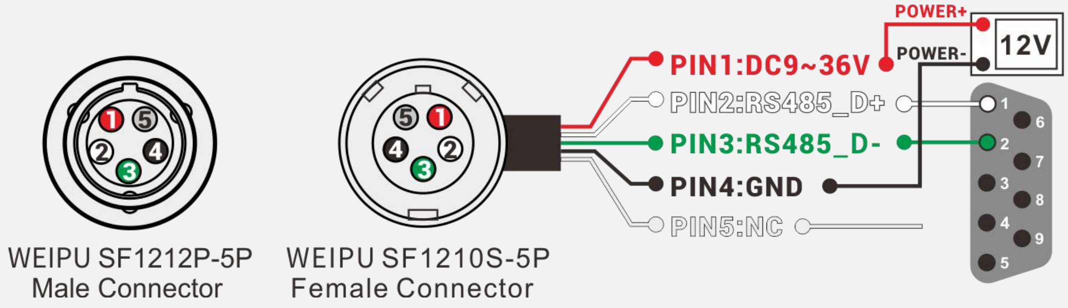
The red indicator light remains constantly on after the product is powered on. It will begin flashing when a connection is successfully established and data is being transferred. If the red light remains constantly on during the connection process, it indicates a connection failure, and a reconnection operation is required.

Interface Definition

TTL/RS232/RS485 Pin definition

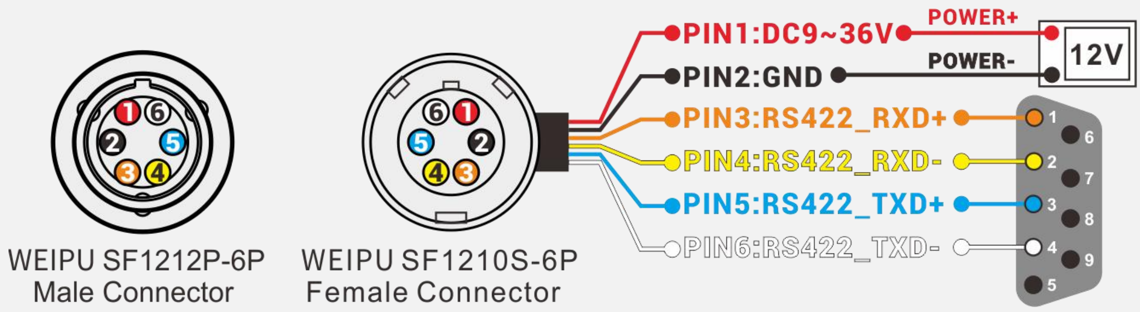
Pin/Thread Color	Definition	Description
PIN1 / Red	DC9~36V	Positive power supply
PIN2 / White	TTL/RS232_RXD / RS485_D+	Receive data
PIN3 / Green	TTL/RS232_TXD / RS485_D-	Transmit data
PIN4 / Black	GND	Negative power supply
PIN5 / - -	NC	No connection
PIN6 / - -	NC	No connection
PIN7 / - -	NC	No connection



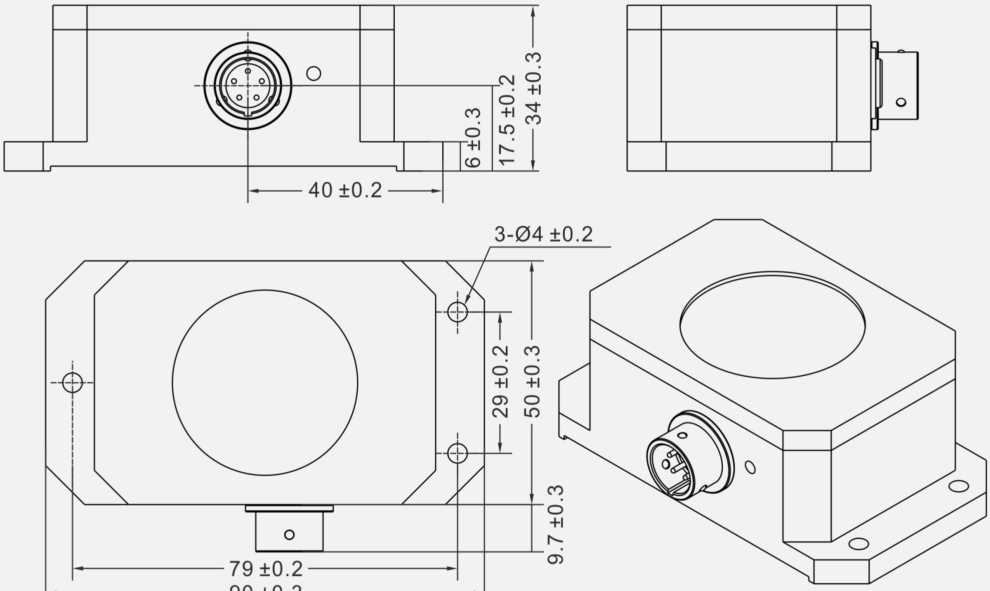


RS422 PIN Definition

Pin/Thread Color	Definition	Description
PIN1 / Red	DC9~36V	Power supply positive terminal
PIN2 / Black	GND	Power supply negative terminal
PIN3 / Orange	RS422_RXD+	Receiver's positive signal line
PIN4 / Yellow	RS422_RXD-	Receiver's negative signal line
PIN5 / Blue	RS422_TXD+	Transmitter's positive signal line
PIN6 / White	RS422_TXD-	Transmitter's negative signal line
PIN7 / - -	NC	No connection



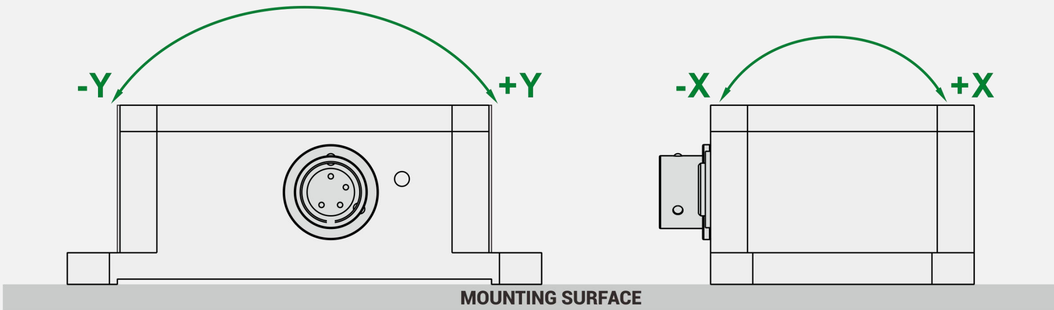
Product dimensions



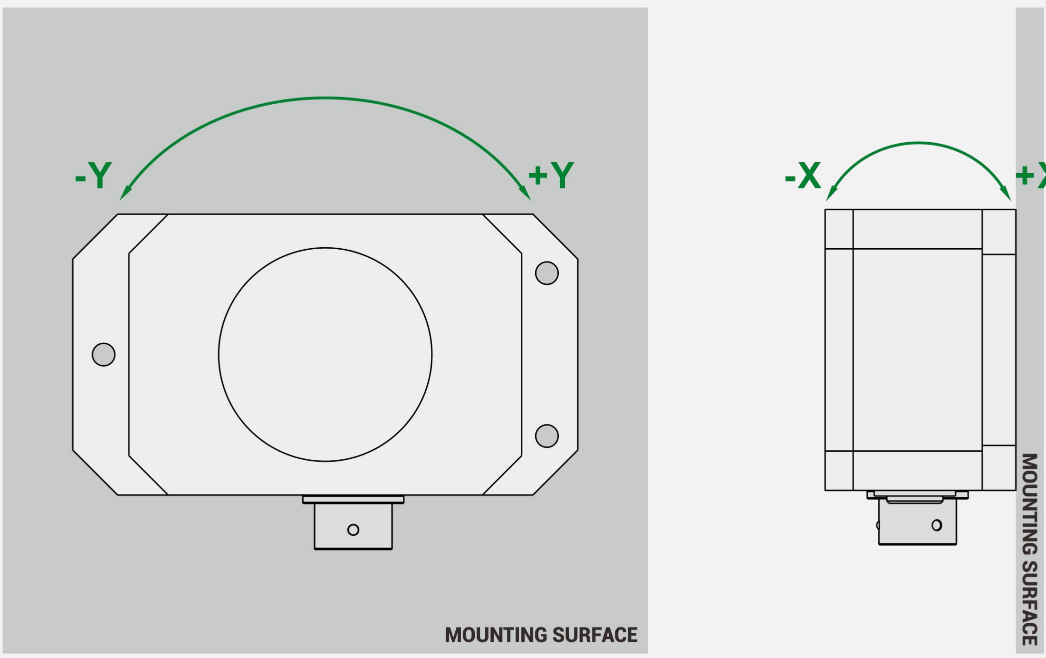
Case dimensions: L90×W59.1×H34mm

Recommended screws: 3 M4 screws

Measurement direction



Horizontal installation



Vertical installation

Serial communication protocol

One. 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 (inclusive)
Address Code: Address of the acquisition module, default is 00
The data field varies depending on the content and length of the command word.
Checksum: The sum of the data length, address code, command word, and data field, without considering carry-over.

Two. Command Word Parsing

CMD	Meaning/Example	Description
0X04	**Simultaneous angle reading command** Example: **68 04 00 04 08**	Data Field (0 bytes) No Data Field Command
0X84	Sensor response Example: **68 0D 00 84 00 20 10 10 40 00 05 05 00 1B**	Data Field (9 bytes) AA AB BB CC CD DD EE EF FF AA AB BB: 3 characters representing the X-axis CC CD DD: 3 characters representing the Y-axis EE EF FF: 3 characters representing temperature data Angle format and parsing method are the same as X-axis or Y-axis In the example on the left, the angle is: X-axis 02.010°, Y-axis 00.000°, temperature: +50.50 **00 20 10** The three red bytes are the X-axis angle value, which is compressed BCD code. The high bit of the first byte is 0 for the sign bit (0 for positive, 1 for negative). 02 represents a two-digit integer value, and 010 represents a three-digit decimal value. The parsing method for other axis data is the same. This angle is parsed as +02.010°. **10 40 00** The three blue bytes represent the Y-axis angle value, parsed using the same method as the X-axis. **05 05 00** The three green bytes represent the product's internal temperature value, parsed using the same method as the X-axis angle. CB: Checksum, the hexadecimal sum of all data, excluding the prefix 68
0X05	**Set Relative/Absolute Zero Point:** You can set the current angle to 0° for relative measurement, or reset it to	Data Field (1 byte) 00: Absolute Zero 01: Relative Zero

	the factory absolute zero point, which is saved after power failure. Example: **68 05 00 05 00 0A**	
0X85	Sensor Response Command Example: **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) 00 represents 2400 01 represents 4800 **02 represents 9600 (default)** 03 represents 19200 04 represents 38400 05 represents 115200
0X8B	Sensor Response Command Example: **68 05 00 8B 00 90**	Data Field (1 byte) The number in the data field represents the sensor's response result. 00: Success FF: Failure
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 the X and Y angles after power-on, and the output frequency depends on the set value. For high-frequency output, please set the baud rate to 115200. (This function can be remembered even after power failure) Example: **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 Auto Output Mode 04 35Hz Auto Output Mode 05 50Hz Auto Output Mode
0X8C	Sensor response command Example: **68 05 00 8C 00 91**	Data Data Field (1 byte) The number in the data field represents the sensor's response result. 00: Success FF: Failure
0X0F	**Module address setting command** The default address of the sensor is 00. 1) If multiple sensors are connected to a single bus, such as RS485, each sensor needs to be set to a different	Data Field (1 byte) Module address, ranging from 00 to EF; Note: All products share a common address: **FF,** **If you forget the set address during operation, you can use the FF address to operate the product, and it will still respond normally.**

	address to achieve separate control and response angles. 2) After successfully changing the address, the address code in all subsequent command 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 for power-off preservation. Example: ***68 05 00 0F 01 15*** Sets the address to 01 ***68 05 FF 0F 00 13*** Resets the address to 00 using a general address	
0X8F	Sensor Response Command Example: **68 05 00 8F 94**	Data Field (1 byte) The number in the data field represents the sensor's response result. 00: Success FF: Failure
0X0D	**Query Relative/Absolute Zero Point** Used to query whether the sensor's current zero-degree mode is relative or absolute zero. Example: **68 04 00 0D 11**	Data Field (0 byte) No data field command
0X8D	Sensor Response Command Example: **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 01: Relative zero

MODBUS Communication Protocol

Please carefully read the following items before use:

1) The MODBUS protocol stipulates that there should be more than 3.5 bytes of time between two data frames (e.g., at a baud rate of 9600, this time is 3.5 × (1/9600) × 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 (except for the address code reading function). 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 master sends an address 0 query angle command to the bus; if the communication indicator light flashes, communication is normal.

3) To improve system reliability, the address setting command, absolute/relative setting command, and baud rate setting command must be sent twice consecutively to be effective. "Two consecutive sendings" means both sends are successful (the slave responds each time), and the two responses must be consecutive. The master cannot insert other data frames between the two responses; otherwise, the command will be locked. The setting process is as follows:

Send address setting command → Wait for slave to send a success command → Send address setting command again → Wait for slave to send a success command → Modification successful.

4) 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 (factory default)

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 Start Address	00H	Data length 8 bytes	0AH	
	02H	Data word 1 lower 8 bits	50H	X-axis data
Data Length 4 words	00H	Data word 1 higher 8 bits	46H	
	05H	Data word 2 lower 8 bits	00H	
CRC	2409H	Data word 2 higher 8 bits	00H	
		Data word 3 lower 8 bits	23H	Y-axis data
		Data word 3 higher 8 bits	20H	
		Data word 4 lower 8 bits	00H	
		Data word 4 higher 8 bits	00H	
		Data word 5 higher 8 bits	03	Temperat

		Data word 5 lower 8 bits	57	ure
		CRC	FA0EH	

Example 1 of using the command to read measurement data:								
Host sends	01H	03H	00H	02H	00H	05H	24H	09H
Slave Response	01H	03H	0AH	50H	46H	00H	00H	23H
		20H	00H	00H	03H	57H	FAH	0EH

Note: The data field of the slave device's reply frame is 50H, 46H, 00H, 00H, 23H, 20H, 00H, 00H, 03H, 57H.
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 0.001°. 0.001 × (number of points - offset) equals the angle. For example, if the measurement range is ±10°, the total number of points is 10,000. Therefore, 0 corresponds to -10°, 20,000 corresponds to +10°, and 10,000 corresponds to 0°.
Taking the above data frame as an example, the angle conversion process is as follows:
1) Obtain the current angle point. 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 → 18000, Y-axis: 2023H → 8227.
3) Subtract the offset of 10000 (Note: This value is related to the measurement range. Multiply the measurement range value by 1000. If the offset for a measurement range of ±10° is 10 * 1000, and the offset for a measurement range of ±30° is 30 * 1000). X-axis: 18000 - 10000 = -8000, Y-axis: 8227 - 10000 = -1773. 4) Obtain the final angles: X-axis: -8000 × 0.001 = -8.000°, Y-axis: -1773 × 0.001 = -1.773°.
Temperature is represented by bytes 9-10 of the data field.
Explanation: The high four bits of the ninth byte are the sign bit: 1 for negative temperature, 0 for positive temperature.
The low four bits of the ninth byte are the tens digit, the high four bits of the tenth byte are the units digit, and the low four bits of the tenth byte are the tenths digit.
For example, if the slave device replies with 03H, 57H, the temperature is 35.7℃.

3. Set 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 Start Address	00H	Register Address	00H
	10H		10H
If this word is non-zero, it indicates a relative zero; if it is zero, it indicates an absolute zero	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
CRC	C84FH/ 880FH	CRC	C84FH/ 880FH

Commands must be sent twice consecutively to be effective.

Example of using the command to set relative/absolute zero point:								
Host sends	01 H	06 H	00 H	10 H	00 H	FFH	C8H	4FH
Slave Response	01 H	06 H	00 H	10 H	00 H	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. Set the sensor address (the sensor address is set to 1 by default at the factory).

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

Commands must be sent twice consecutively to be effective.

Example of using the command to set the sensor address:								
Host sends	01 H	06 H	00 H	11 H	00 H	04H	D8H	0CH
Slave Response	01 H	06 H	00 H	11 H	00 H	04H	D8 H	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	00H	Register Address	00H
	12H		12H
Sensor Baud Rate	00 H	Sensor Baud Rate	00 H
	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:								
Host sends	01 H	06 H	00 H	12 H	00 H	A2H	A8H	76H
Slave Response	01 H	06 H	00 H	12 H	00 H	A2H	A8 H	76H

Note: 0012H 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.

6. Read sensor address code

command to read sensor address code:		Slave Response:	
Sensor Address	00H	Sensor Address	01H
Function Code	42H	Function Code	42H
Address	00H	Returned data length	02H
	11H		
Data Length	00 H	Sensor address	01H
	01H		01H
CRC	CRC LH	CRC	CRC LH

Example of using the command to read sensor address code:								
Host sends	00 H	42 H	00 H	11 H	00 H	01H	E9H	D1H
Slave Response	01 H	42 H	02 H	01 H	01 H	6CH	28H	

7. Configure the sensor communication character format: (The factory default is even parity)

Command to set sensor communication character format:		Slave Response:	
Sensor Address	01H	Sensor Address	01H
Function Code	06H	Function Code	06H
Address	00H	Register Address	00H
	09H		09H
Sensor Communication Character Format Change	00H	New sensor format	00H
	01H		01H
CRC	9808	CRC	9808

Example of using the command to set the character format for sensor communication:								
Host sends	01 H	06 H	00 H	09 H	00 H	01H	98H	08H
Slave Response	01 H	06 H	00 H	09 H	00 H	01H	98 H	08H

The above example sets the byte format to: one start bit + 8 data bits, no parity, + 1 stop bit. This setting takes effect after a power cycle. The factory default is one start bit + 8 data bits, even parity, + 1 stop bit.

Note: 0009 is the register address; this register controls the sensor communication character format.

0000H: One start bit + 8 data bits, even parity, + 1 stop bit

0001H: One start bit + 8 data bits, no parity, + 1 stop bit