ZC Sensor

# ZCT-CX300B-S2xx In-place Inclinometer Datasheet


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# In-place Inclinometer

# Datasheet

## I. Introduction

Developed and manufactured by Shanghai Zhichuan Electronic Tech Co., Ltd., ZCT-CX300B-S2xx in-place inclinometer (IPI) is a highly accurate (up to 0.005 degree) tilt sensing system with ±30 degree measurement range. The product is Modbus RTU compliant, so data can be conveniently collected via RS485 serial communication. The casings (tubes) to work with the product shall be of 65-85mm OD or 55-75mm ID.

## II. Advantages

* **Ultra-low power consumption**
* Wider range with high accuracy
* Modbus RTU compliant
* Solid and durable
* Maintenance friendly

## III. Application

To monitor tilt of foundation pits, slopes, embankments etc.

## IV. Technical parameters (typical values at 25℃ unless otherwise specified)

| Item | Test conditions | Min | Typical | Max | Unit |
|---|---|---|---|---|---|
| **Power supply** | DC | 8 | 24 | 30 | V |
| **Quiescent current** | VCC=12V; no on-going RS485 communication; without terminal resistor | | **0.85** | **1.2** | mA |

| | | | | | |
|---|---|---|---|---|---|
| **Working temperature** | | -30 | | +80 | ℃ |
| **Measurement range** | Dual-axis | | ±30 | | ° |
| **Resolution** (1 | | | 0.001 | | ° |
| **Accuracy** (2 | -15°~+15° | | ±0.005 | ±0.01 | ° |
| | -30°~+30° | | ±0.01 | ±0.02 | ° |
| **Zero temperature drift** (3 | -20~+60℃ | | ±0.002 | | °/ ℃ |
| | | | | ±0.1 | ° |
| **Storage temperature** | | -30 | | +80 | ℃ |
| **IP grade** | Water depth of 100m | | IP68 | | / |

Remarks:

1) Resolution is the smallest angle that can be detected by the inclinometer sensor.
2) Accuracy is the differences between the real angle value and the measured value in total range.
3) At room environment, with fixed zero angle output, zero temp drift is the angle deviation with changes of temp.

## V. Wire definition

Stripped terminal of the cable:

| | | | | |
|---|---|---|---|---|
| **Definition** | 8~30VDC | GND | 485B | 485A |
| **Wire color** | Red | Black | Yellow | Blue |

Connector definition:

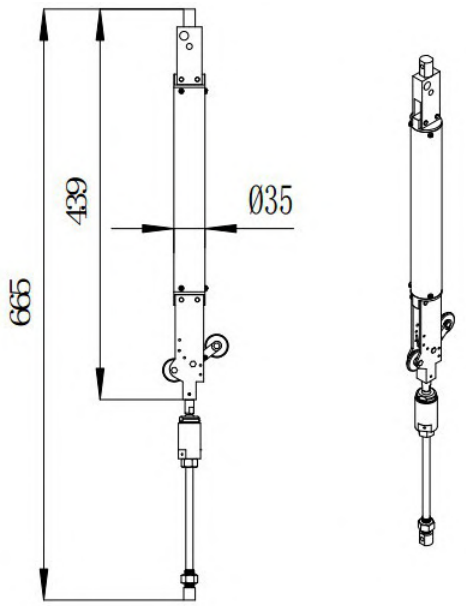
Top view of male plug


Top view of female plug

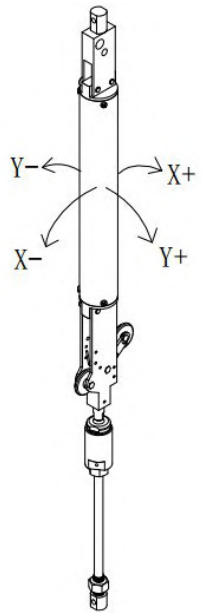

| | | | | |
|---|---|---|---|---|
| **PIN** | 1 | 2 | 3 | 4 |
| **Definition** | 8~30VDC | GND | 485B | 485A |
| **Color** | Red | Black | Yellow | Blue |

## VI. Dimensions and directions

1. Housing size:




2. Working directions:



## VII. Communication protocol

**1) The communication protocol is in compliance with Modbus RTU protocol (baud rate =9600bps; parity bits = none; data bits = 8; stop bits = 1).**

| Register Address | Data Value Name | Data Type | Range | R/W | Default Value |
|---|---|---|---|---|---|
| **0000H** | X-axis angle value HI | Self-defined | Measurement range | R | - |
| **0001H** | X-axis angle value LO | Self-defined | Measurement range | R | - |
| **0002H** | Y-axis angle value HI | Self-defined | Measurement range | R | - |
| **0003H** | Y-axis angle value LO | Self-defined | Measurement range | R | - |
| **0006H** | Enable / disable relative angle measurement | int16U | 0000H/5A5AH | R/W | 0000H (absolute angle measuring mode) |
| **0007H** | Local address | int16U | 0101H~FFFFH | R/W | 0101H (address is 01H) |
| **0008H** | Baud rate | int16U | A0A0~A3A3 | R/W | A2A2H (baud rate is 9600bps) |
| **0009H** | Data format of angle and temperature output | int16U | B0B0~B3B3 | R/W | B0B0H (Zhichuan self-defined format) |
| **000CH** | Sensor temperature HI | Self-defined | Measurement range | R | - |
| **000DH** | Sensor temperature LO | Self-defined | Measurement range | R | - |

*R means read only, R/W means both readable and writable. Use 03H to read register, 06H to write register, and 42H to read local address.*

**a) 03H function code, to read register:**

Request:

| Device address | Function code | Register starting address HI | Register starting address LO | Number of register HI | Number of register LO | CRC check |
|---|---|---|---|---|---|---|
| 1 byte | 0x03 | 1 byte | 1 byte | 1 byte | 1 byte | 2 bytes |

Response:

| Device address | Function code | Number of bytes | Register value | CRC check |
|---|---|---|---|---|
| 1 byte | 0x03 | 1 byte | N*2 bytes | 2 bytes |

**b) 06H function code, to write a single register:**

Request :

| Device address | Function code | Register starting address HI | Register starting address LO | Register value HI | Register value LO | CRC check |
|---|---|---|---|---|---|---|
| 1 byte | 0x06 | 1 byte | 1 byte | 1 byte | 1 byte | 2 bytes |

Response：

| Device address | Function code | Register starting address HI | Register starting address LO | Register value HI | Register value LO | CRC check |
|---|---|---|---|---|---|---|
| 1 byte | 0x06 | 1 byte | 1 byte | 1 byte | 1 byte | 2 bytes |

**c) 42H function code (self-defined), to read local address register:**

Request:

| Broadcast address | Function code | Register starting address HI | Register starting address LO | Number of register HI | Number of register LO | CRC check |
|---|---|---|---|---|---|---|
| 0x00 | 0x42 | 1 byte | 1 byte | 1 byte | 1 byte | 2 bytes |

Response:

| Device address | Function code | Number of bytes | Register value | CRC check |
|---|---|---|---|---|
| 1 byte | 0x42 | 1 byte | N*2 bytes | 2 bytes |

**d) Abnormal response**

After correctly receiving the complete information frame (correct CRC, address and function code), when illegal register address, illegal number of registers or illegal parameter writing is detected, abnormal code A5H will be returned.

| Address code | Error code | Abnormal code | CRC check |
|---|---|---|---|
| 1 byte | 0x80 \| function code | 1 byte | N*2 bytes |

## 2) Commands and function details

### a) Read X-axis angle data:

Example,

Send command: 01 03 00 00 00 02 C4 0B

Response: 01 03 04 **00 0C 62 05** CRC low CRC high

The angle returned is 12.985°

(angle = [ (-1)^**0**]*[(**0*** 100) + (**0** * 16 + **12**) + (**6** * 16+**2**) / 100+ (**0** * 16+**5**) / 1000])

Note: 01 is the address of the sensor.

### b) Read Y-axis angle data:

Example,

Send command: 01 03 00 02 00 02 65 CB

Response: 01 03 04 **10 0C 62 05** CRC low CRC high

The angle returned is -12.985°

(angle = [ (-1)^**1**]*[(**0*** 100) + (**0** * 16 + **12**) + (**6** * 16+**2**) / 100+ (**0** * 16+**5**) / 1000])

Note: 01 is the address of the sensor.

**Function code 03 can be used to read value of more than two registers. If the register is not readable, 0x00 will be returned.**

Example,

to read X- and Y-axis angle at the same time

Send command: 01 03 00 00 00 04 44 09

Response: 01 03 08 **00 0C 62 05 10 0C 62 05** CRC low CRC high

The angles returned are 12.985° for X-axis and -12.985° for Y-axis. Command parsing is the same as that when X- and Y-axis angle are read separately.

### c) Set sensor address:

Example,

Send command: 01 06 00 07 **05 05** CRC low CRC high

Response: 01 06 00 07 05 05 CRC low CRC high

Sensor address is set as 0x05 by the command, and it becomes effective after a restart.

**Notes:**

1. **The address becomes effective only after successful response and a restart.**
2. **The range of settable address is 01H~FFH. The address cannot be set as the broadcast address (00H).**

**d) Read sensor address:**

Example,

Send command: 00 42 00 07 00 01 CRC low CRC high

return data: 01 42 02 **01 01** CRC low CRC high

Sensor address 0x01 will be returned by this command.

**e) Set sensor baud rate:**

Example,

Send command: 01 06 00 08 **A1 A1** CRC low CRC high

Response: 01 06 00 08 A1 A1 CRC low CRC high

The baud rate will be set as 4800bps by this command, and it becomes effective after a restart.

**Notes:**

1. **The address becomes effective only after successful response and a restart.**
2. Baud rates supported: A0 = 2400, A1 = 4800, A2 = 9600, A3 = 19200.

**f) Read sensor temperature:**

Send command: 01 03 **00 0C** 00 02 CRC low CRC high

Response: 01 03 04 **10 10 00 00** CRC low CRC high

The temperature returned is -16℃.

(temperature = [ (-1)^ **1**]*[(**0*** 100) + (**1** * 16 +**0**) ])

Note: The lower two bytes of the register value are fixed as 0x00.

01 is sensor address.

**g) Enable/disable relative angle measurement:**

Send command: 01 06 00 06 **5A** **5A** CRC low CRC high

Response: 01 06 00 06 **5A** **5A** CRC low CRC high

In response to the above command, the sensor turns on the relative angle measurement mode, with the current angle set as the relative zero point. By sending 01 06 00 06 **00** **00** CRC low CRC high, relative angle measurement will be disabled.

**Note: It is suggested that the function of relative angle measurement (or zero setting) be realized through user's master computer software, so the raw data of the sensor can be kept at the same time. By this way, the continuity and comparability of the data over different test periods, before and after turning on relative angle measurement (or zero setting), can be ensured.**

**h) Select angle/voltage data output format:**

Send command: 01 06 00 09 **B0** **B0** CRC low CRC high

Return data: 01 06 00 09 B0 B0 CRC low CRC high

This is to set the angle output format to Zhichuan format. Supported data formats are:

B0 = Zhichuan format (default)

B1 = 32-bit int (large end)*10000

B2 = float large end

B3 = float small end

*Note: The data formats parsed in command a), b) and f) are Zhichuan format, which is the default data output format. Other optional formats are 32-bit int type 10,000 times magnified format (that is, 32-bit integer type data magnified by 10,000 times), float large end format and float small end format. For non-Zhichuan data formats, the only thing should be done is to parse the four bytes of x-axis angle or y-axis angle or temperature data according to int32_t (angle and temperature magnified by 10,000 times) or float type, with increasing direction of the data storage (byte) address the same as that of the register address (for example, the angle is - 5.0000 °, and the float large end format is 0xC0A00000).*

## VIII. Installation cautions:

When installing the sensor, improper methods may lead to large measurement error. Please follow below procedures:

1. Make sure that the fixed wheel faces the expected displacement direction of the measured borehole.

2. When installing the first probe, mount the rescue wire, so accidental falling of probes during installation can be avoided.

3. Make sure that the screw at each joint between a sensor probe and a connecting tube is tightened.

4. Tightly lock all the cable connectors between sensors to prevent water from entering the connectors.

5. Fix the cables to the probe bodies and connecting tubes with cable ties, to prevent the string of probes from jamming when it is lowered into the borehole.

6. During the installation, do not try to raise, lower or fix the probes by pulling the cables. Instead, please do it by holding the connecting tubes or the rescue wire.

7. The probe at the top of the string should be fixed, through a suspension kit, to a wellhead tool placed on top of the borehole opening.

## IX. Ordering information:

There are two methods of connection between sensor probes, one is by stainless steel tubes (rigid connection), and the other is by stainless steel ropes (flexible connection). The spacing, or interval, can be customized according to customer requirements.