

## YOI726S MOD BAS INCLINOMETER DATA SHEET



CAT NO: YOI726S-15-M485-MB

Description: callous Inclinometer (MODBUS RTU Protocol )

**Application:** Solar photovoltaic power generation angle tracking system,  
Military applications, Marine applications, Railway applications, whenever required accurate angle  
measurements & accurate electronic spirit leveling sys.

### Standard reference

- Enterprise quality system standards: ISO9001: 2015 standard,  
(Certification number: 89210)
- CE certification: AT011611741E FCC certification: AT011611742E
- Tilt sensor production standards: GB / T 191 SJ 20873-2003 inclinometer general  
specification of Level
- Ronar metrology and quality inspection Calibrated in accordance to:  
JJF1119-2004 Electronic Level calibration.



**יוסי עובדיה**  
הנדסה ואחזקות חשמל בע"מ



### Specification

- Product environmental testing standards: GJB150
- Electromagnetic anti-interference test standards: GB / T 17626
- Version: Ver.101

### General Description

YOI726S-15-M485-MB is a small volume high- accuracy gradient inclinometer that was converted to work in difficult areas by hardening the electromechanical mechanisms,  
Performed by, "Yosi Ovadia" electrical marine Engineering Ltd company  
The inclinometer was adapted for military and other industries field control, using RS485/RS232 Serial interface, MODBUS RTU standard protocol format. Built-in high-precision 24bit A /D differential converter, by 5 filtering algorithms, which can measure the angle of sensor output relative to the horizontal tilt and pitch tilt. The product integration of the latest technology to the main MEMS tilt unit, measuring a range of  $\pm 180$  degrees with full-range accuracy of 0.01 degrees, can easily achieve biaxial and uniaxial inclination measurement. The products are truly industrial-grade products, with reliable performance, scalability, and a variety of output options. The utility model is suitable for the control of the angle of the photovoltaic cell board, the orientation of the photovoltaic cell board, the measurement of the angle of various thermal power generation mirrors, and the large range of high precision measurements of industrial sites.

### Features:

- Single/Dual Axis Inclinometer
- Accuracy: Refer to the technical data
- Wide temperature working:  $-40 \sim +85^{\circ}\text{C}$
- IP67 protection class
- Direct lead cable interface
- Output mode: MODBUS
- Measuring Range :  $\pm 1 \sim \pm 90^{\circ}$  optional
- Wide voltage input:  $9 \sim 36\text{V}$
- Resolution:  $0.001^{\circ}$
- Highly anti-vibration performance  $> 100\text{g}$
- Small size :  $54 \times 44 \times 18\text{mm}$  (customized)



**יוסי עובדיה**

הנדסה ואחזקות חשמל בע"מ



### Application:

- Satellite positioning Search
- engineering mechanical measurement of dip angle
- Radar detection of vehicle platform
- Gun Barrel angle measurement in early shooting
- Satellite communications vehicle posture detection
- Ship's navigation posture measurement
- Rail-mobile monitoring
- oil-well drilling equipment
- Underground drill posture navigation
- Based on the angle direction measurement
- Shield pip jacking application
- Geological equipment inclined monitoring



### Ordering information :

YOI7  6 —  —   — M

|     |     |             |             |
|-----|-----|-------------|-------------|
| ■ 1 | ■ S | ■ 10:±10°   | ■ 23:RS232  |
| ■ 2 | ■ V | ■ 15:±15°   | ■ 48: RS485 |
|     |     | ■ 30:±30°   | ■ 485-MB    |
|     |     | ■ 45:±45°   |             |
|     |     | ■ 60:±60°   |             |
|     |     | ■ 90:±90°   |             |
|     |     | ■ 180:±180° |             |

E.g : YOI726S-15-M485-MB : x-y Double axis /Standard /±15° Measuring range /MODBUS/485 digital signal output type



יוסי עובדיה

הנדסה ואחזקות חשמל בע"מ



## Technical Data

| Parameters                          | Conditions | HCA726S-15                                                                             | HCA726S-45 | HCA726S-60 | HCA716V-180     | Unit |
|-------------------------------------|------------|----------------------------------------------------------------------------------------|------------|------------|-----------------|------|
| Measuring range                     |            | ±15                                                                                    | ±45        | ±60        | ±180            | °    |
| Measuring axis                      |            | X,Y                                                                                    | X,Y        | X,Y        | Vertical X axis |      |
| Resolution                          |            | 0.001                                                                                  | 0.001      | 0.003      | 0.005           | °    |
| Absolute accuracy                   | @25°C      | ±0.008                                                                                 | ±0.01      | ±0.01      | ±0.01           | RMS  |
| Long term stability                 |            | <0.02                                                                                  | <0.02      | <0.02      | <0.02           | °    |
| Zero temperature coefficient        | -40~85°    | ±0.0005                                                                                | ±0.0005    | ±0.0005    | ±0.0005         | °/°C |
| Sensitivity temperature coefficient | -40~85°    | ≤0.01                                                                                  | ≤0.01      | ≤0.01      | ≤0.01           | %/°C |
| Power on time                       |            | 0.5                                                                                    | 0.5        | 0.5        | 0.5             | S    |
| Response time                       |            | 0.02                                                                                   | 0.02       | 0.02       | 0.02            | s    |
| Response frequency                  |            | >20HZ                                                                                  |            |            |                 |      |
| Output signal                       |            | RS232 or RS485 (MODBUS RTU)                                                            |            |            |                 |      |
| EMC                                 |            | According to EN61000 and GBT17626                                                      |            |            |                 |      |
| MTBF                                |            | ≥50000 Hours/times                                                                     |            |            |                 |      |
| Insulation Resistance               |            | ≥100M                                                                                  |            |            |                 |      |
| Shockproof                          |            | 100g@11ms、3Times/Axis(half sinusoid))                                                  |            |            |                 |      |
| Anti-vibration                      |            | 10grms、10~1000Hz                                                                       |            |            |                 |      |
| Protection glass                    |            | IP67                                                                                   |            |            |                 |      |
| Cables                              |            | Standard 1M length、wearproof、grease proofing、wide temperature、Shielded cables 4*0.2mm2 |            |            |                 |      |
| Weight                              |            | 120g( without cable)                                                                   |            |            |                 |      |

\*This Technical data only list ± 15 °, ± 45°, ± 60 °, ± 180 ° series for reference, other measuring range

## Electronic Characteristics

| Parameters          | Conditions | Min | Standard | Max | Unit |
|---------------------|------------|-----|----------|-----|------|
| Power supply        | Standard   | 9   | 12, 24   | 36  | V    |
| Working current     | Non-loaded |     | 40       |     | mA   |
| Working temperature |            | -40 |          | +85 | °C   |
| Storage temperature |            | -40 |          | +85 | °C   |

## Keywords :

**Resolution :** Refers to the sensor in the measuring range to detect and identify the smallest changed value.

**Absolute accuracy :** Refers to the normal temperature circumstances, the sensor absolute linearity,

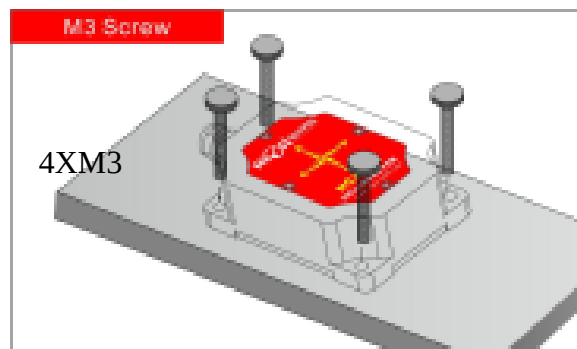
repeatability, hysteresis, zero deviation, and transverse error comprehensive error.

**Long term stability:** Refers to the sensors in normal temperature conditions, the deviation between the maximum and minimum values after a year's long-time work.

**Response time :** Refers to the sensor in an angle change, the sensor output value reached the standard time required.

## Mechanical Parameters

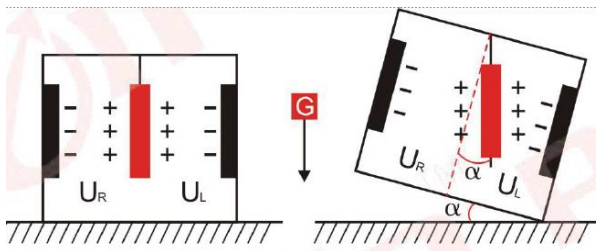
- Connectors : 1m lead cable customized)
- Protection glass : IP67
- Enclosure material : Aluminum Oxide
- Installation : 4\*M3 screws



## Working Principle

Adopt the European import of core control unit, using the capacitive micro pendulum principle and the earth gravity principle, when the inclination unit is tilted, the Earth's gravity on the corresponding pendulum will produce a component of gravity, corresponding to the electric capacity will change, by enlarge the amount of electric capacity, filtering and after conversion then get the inclination.



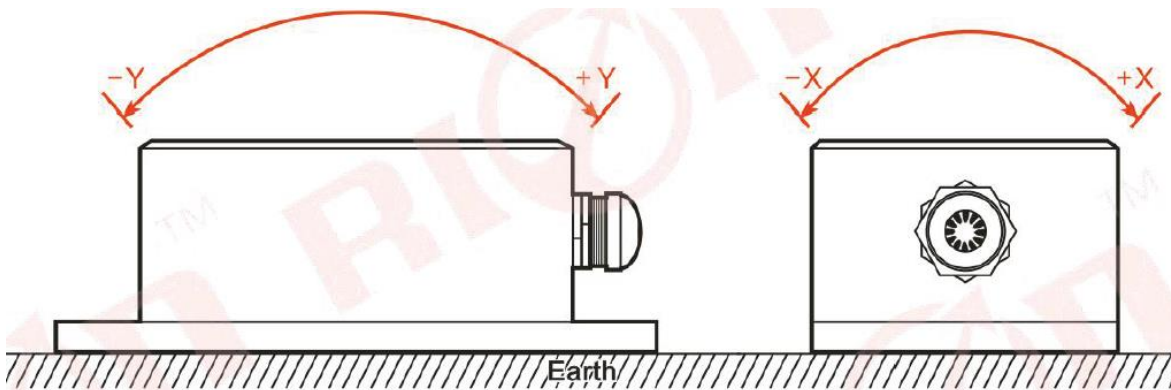


$U_R, U_L$  respectively is the pendulum left plate and the right plate corresponding to their respective voltage between the electrodes, when the tilt sensor is tilted,  $U_R, U_L$  will change according to certain rules, so  $f(U_R, U_L)$ . On the inclination of  $\alpha$  function:

$$\alpha = (U_R, U_L)$$

### Measuring Directions & Fix

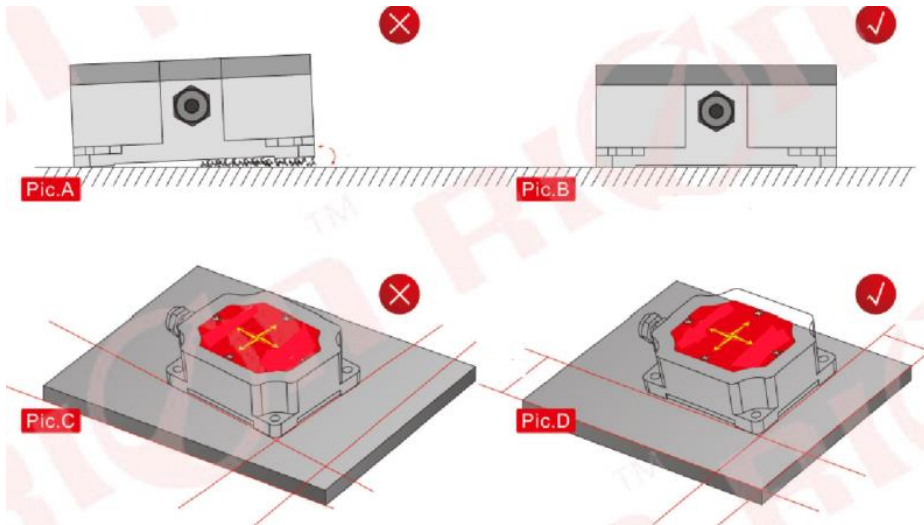
The installation must guarantee the product bottom is parallel to the measured face, and reduce the influence of dynamic and acceleration on the sensor. This product can be installed horizontally or mounted vertically (mounted vertically selection is only applicable to the single axis), for installation please refer to the following scheme.



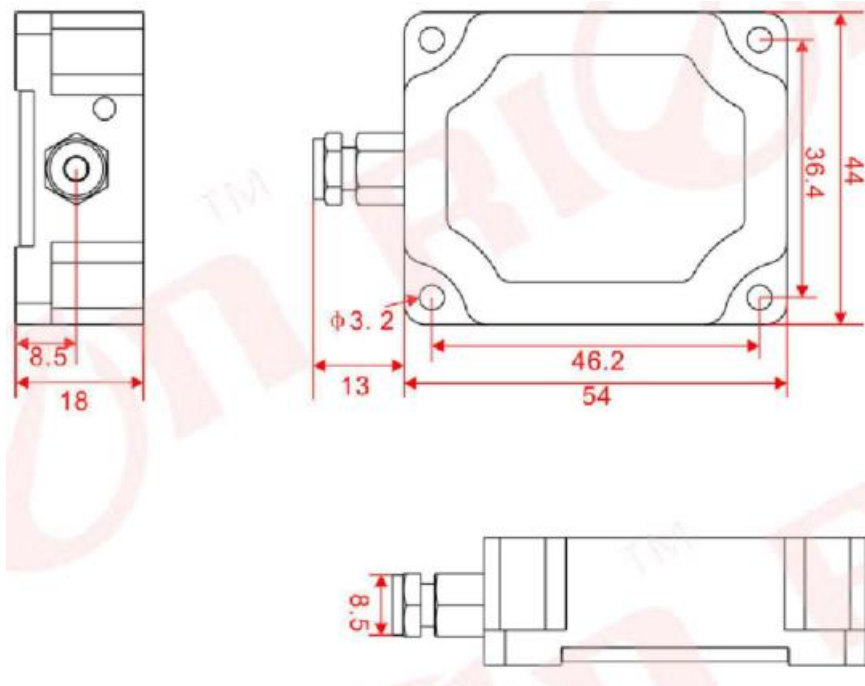
### Production installation notes:

Please follow the correct way to install the tilt sensor, incorrect installation can cause measurement errors, with particular attention to the "surface", "line":

- 1) The Sensor mounting surface and the measured surface must be fixed closely, smoothly, stability, if the mounting surface is uneven likely to cause the sensor to measure the angle error. See Figure Pic. AB
- 2) The sensor axis and the measured axis must be parallel; the two axes do not produce the angle as much as possible. See Figure Pic. CD



## Dimension



## Electrical Connection

| RED                         | GREEN                   | WHITE                   | BLACK                 | Line color |
|-----------------------------|-------------------------|-------------------------|-----------------------|------------|
| Vcc 9~36V<br>Power Positive | RS485(D-)<br>RS232(TXD) | RS485(D+)<br>RS232(RXD) | GND<br>Power Negative | function   |

## Product MODBUS Protocol

Please read the following items carefully before use:

1) Because the MODBUS protocol stipulates between the two data frames should be at least more than 3.5 bytes of time (such as the baud rate of 9600, the time is  $3.5 \times (1/9600) \times 11 = 0.004s$ ). However, in order to leave enough margin, the sensor will be increased this time to 10ms, so please leave at least the time interval between each data frame.

The master computer sends commands — 10ms idle — slave computer reply command  
— 10ms idle - The master computer sends commands.....

2) MODBUS protocol stipulates the broadcast address ---0 relevant content, the sensor can also accept the broadcast address content, but will not reply. Therefore, the broadcast address 0 can be used for the following purposes, for reference only.

- 1 All the sensors mounted on BUS are all set to an address.
- 2 All the sensors mounted on BUS are all set to relative / absolute zero.

3 Test all sensors mounted on BUS, that is, the master computer sends 0 address to BUS for query angle command, communication lights can flicker that means the communication is normal.

3) In order to improve the reliability of the system, set the address command and set the absolute/relative command, set the baud rate, these three commands must be sent two consecutive times will be valid. "Two consecutive send" refers to two times sent successfully (the slave machine replies every time), must be consecutive two times, which means the master computer can not insert other frames in the middle of two replies, otherwise, the command will be locked until the power off, setting process refer to below :

Send set address command — waiting for the slave computer to send command of successful commands - (no other commands) to send the set address command again -waiting for the successful settings from the slave computer to send the command - modify the success

4) After power-up, the above two sets of commands can be set only once, if necessary, again need to repower.

5) when the normal communication accumulated to a certain number of times, the communication indicator will flash once.

1. Data frames format :

RTU Mode

Communication Parameter : Baud rate 9600 bps

Data frames : 1 Start bit, 8 data, even parity check, 1 stop bit

2. Read angle data :

Modbus FUNC 03H

|                                             |                                  |
|---------------------------------------------|----------------------------------|
| <b>Master Computer Inquiry Command</b><br>: | <b>Slave Computer Response :</b> |
|---------------------------------------------|----------------------------------|



|                              |       |                          |       |
|------------------------------|-------|--------------------------|-------|
| Inclinometer Address         | 01H   | Inclinometer Address     | 01H   |
| FUNC                         | 03H   | FUNC                     | 03H   |
| Visit Register first Address | 00H   | Data Length 8 bytes      | 08H   |
|                              | 02H   | Data word 1 upper 8 bits | 50H   |
| Data Length                  | 00H   | Data word 1 Lower 8 bits | 46H   |
| 4 bytes                      | 04H   | Data word 2 upper 8 bits | 00H   |
| CRC                          | E5C9H | Data word 2 lower 8 bits | 00H   |
|                              |       | Data word 3 upper 8 bits | 23H   |
|                              |       | Data word 3 lower 8 bits | 20H   |
|                              |       | Data word 4 upper 8 bits | 00H   |
|                              |       | Data word 4 lower 8 bits | 00H   |
|                              |       | CRC                      | BD61H |

| Read the measured data command applicaton example 1 : |      |      |      |      |      |      |      |      |      |      |          |
|-------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|----------|
| Master computer sending                               |      |      |      | 01 H | 03 H | 00 H | 02 H | 00 H | 04 H | E5H  | C9H      |
| Slave computer response                               |      |      |      |      |      |      |      |      |      |      |          |
| 01H                                                   | 03 H | 08 H | 50 H | 46 H | 00 H | 00 H | 23H  | 20 H | 00 H | 00 H | BD H 61H |

Note : The master computer response data domain of the frames is 50H, 46H, 00H, 00H, 23H, 20H, 00H, 00H .

The X-Axis is the 1-4 bytes of the data domain, Y-Axis is the 5-8 bytes of the data domain, Low byte in front. Angle representation method for point representation, a point corresponding to 0.001°, 0.001 x ( points -offset) is the angle. If the measurement range is +-180°, the total point number is 360000. So the 0 corresponds to -180°, 360000 degrees corresponds to +180°, 180000 corresponds to 0 degree.

**Take the data frame as an example: the angle conversion process is as follows:**

- 1) get the current point of view, note, the low byte in the front, the X-axis is 4650H, Y-axis is 2023H.
- 2) convert to decimal, X axis: 4650H→18000, Y axis: 2023H→8227.
- 3) subtract the offset 180000 (Note: the value is related to the measurement range of a quantity), X axis: 18000-180000=-162000, Y axis: 8227-180000 = -171773.
- 4) Get the final angle, X axis :  $-162000 \times 0.001 = -162.000^\circ$  , Y axis  $-171773 \times 0.001 = -171.773^\circ$ .



יוסי עובדיה  
הנדסה ואחזקות חשמל בע"מ



#### Read the measured data command application example 2:

|                         |      |      |      |      |      |      |     |      |     |      |      |     |
|-------------------------|------|------|------|------|------|------|-----|------|-----|------|------|-----|
| Master computer sending | 01 H | 03 H | 00 H | 02 H | 00 H | 04 H | E5H | C9H  |     |      |      |     |
|                         |      |      |      |      |      |      |     |      |     |      |      |     |
| Slave computer response | 01H  | 03 H | 08 H | 00H  | 00 H | 00 H | 00H | 23 H | 00H | 00 H | 64 H | 1DH |

This example assumes that the sensor measurement range is  $\pm 45$  degrees, the total point number is 90000. So the 0 corresponds to  $-45^\circ$ , 90000 degrees corresponding to  $+45^\circ$ , 45000 corresponding to  $0^\circ$ , the conversion process is as follows:

- 1) get the current point of view, note, the low byte in the front, the 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 45000 (Note: the value is related to the measurement range of a quantity), X axis:  $0 - 45000 = -45000$ , Y axis:  $8960 - 45000 = -36040$ .
- 4) to get the final point of view, X axis:  $-45000 \times 0.001 = -45.00^\circ$ , Y axis:  $-36040 \times 0.001 = -36.040^\circ$ .

5). Set sensor relative / absolute zero:  
Modbus FUNC 06H

| Set relative / absolute zero command :                                      |                                          | Slave computer response :                                                   |                                         |
|-----------------------------------------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------|
| Sensor address                                                              | 01H                                      | Sensor address                                                              | 01H                                     |
| FUNC                                                                        | 06H                                      | FUNC                                                                        | 06H                                     |
| Access register                                                             | 00H                                      | Register                                                                    | 00H                                     |
| First address                                                               | 10H                                      | address                                                                     | 10H                                     |
| If the word is nonzero, the relative zero is zero and zero is absolute zero | 00 H<br>FFH / 00H<br>Relative / Absolute | If the word is nonzero, the relative zero is zero and zero is absolute zero | 00H<br>FFH / 00H<br>Relative / Absolute |
| CRC                                                                         | C84FH/ 880FH                             | CRC                                                                         | C84FH/ 880FH                            |

#### Set ZERO command application example :

|                         |      |      |      |      |      |     |      |     |
|-------------------------|------|------|------|------|------|-----|------|-----|
| Master computer sending | 01 H | 06 H | 00 H | 10 H | 00 H | FFH | C8H  | 4FH |
| Slave computer response | 01 H | 06 H | 00 H | 10 H | 00 H | FFH | C8 H | 4FH |

Note: 0010 is the register address, the register control sensor output is relative zero, or absolute zero. If nonzero (as in the example above, is written to 00FFH), the output is relative zero. On the contrary, if zero (fifth, = 00H), is the absolute zero. The last two bytes are CRC checksum



**יוסי עובדיה**

הנדסה ואחזקות חשמל בע"מ



## 6. Set sensor address :

| Set sensor address code command : |      | Slave computer response : |      |
|-----------------------------------|------|---------------------------|------|
| Sensor add                        | 01H  | Sensor add                | 01H  |
| FUNC                              | 06H  | FUNC                      | 06H  |
| ADD                               | 00H  | Register address          | 00H  |
|                                   | 11H  |                           | 11H  |
| Sensor new address 04H            | 00 H | Sensor new address        | 00H  |
|                                   | 04H  |                           | 04H  |
| CRC                               | D80C | CRC                       | D80C |

Commands must be sent two times to be valid

| Set sensor address command example : |      |      |      |      |      |      |      |     |     |     |
|--------------------------------------|------|------|------|------|------|------|------|-----|-----|-----|
| Master computer sending              |      |      | 01 H | 06 H | 00 H | 11 H | 00 H | 04H | D8H | 0CH |
|                                      |      |      |      |      |      |      |      |     |     |     |
| Slave computer 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 address of the sensor is changed to 0004H, and the last two bytes are CRC checksum.

## 7. Set sensor baudrate: ( factory default 9600bps

| Sete sensor address code command : |      | Slave computer response : |     |
|------------------------------------|------|---------------------------|-----|
| Sensor address                     | 01H  | Sensor address            | 01H |
| FUNC                               | 06H  | FUNC                      | 06H |
| Add                                | 00H  | Register address          | 00H |
|                                    | 12H  |                           | 12H |
| Sensor                             | 00 H | Sensor baudrate           | 00H |
|                                    | XX   |                           | XX  |



**יוסי עובדיה**

הנדסה ואחזקות חשמל בע"מ



|          |        |     |        |
|----------|--------|-----|--------|
| baudrate |        |     |        |
| CRC      | CRC LH | CRC | CRC LH |

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

Commands must be sent two times to be valid

#### Set sensor address command example :

|                         |      |      |      |      |      |      |     |     |
|-------------------------|------|------|------|------|------|------|-----|-----|
| Master computer sending | 01 H | 06 H | 00 H | 12 H | 00 H | A2H  | A8H | 76H |
| Slave computer response |      |      |      |      |      |      |     |     |
| 01 H                    | 06 H | 00 H | 12 H | 00 H | A2H  | A8 H | 76H |     |

Note: 0012H is the register address, which controls the baud rate of the sensor. In the above example, the baud rate of the sensor is set to 19200, and the last two bytes are CRC checksum.

For more product information, please refer to the company's Website: [www.yosi.co.il](http://www.yosi.co.il)  
(product specifications are to upgrade or change, without prior notice)