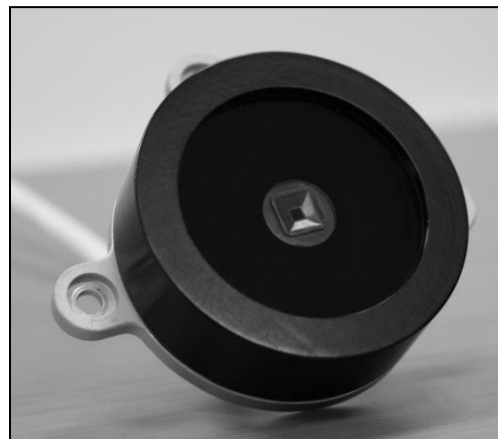


*Solar MEMS Technologies S.L.*

## Sun Sensor ISS-DX

*Digital sensor  
MODBUS RTU communication*

### Technical Specifications



#### Features

- Two orthogonal axes sun sensor*
- Wide or narrow field of view*
- High accuracy*
- MODBUS over RS-485*
- Low power consumption: 33 mA*
- Wide operating voltage range: 5÷12 V*
- Industrial temperature range: - 40° to 85°*
- Reduced size*
- Low weight*
- IP65 protection*
- Reverse polarity protection*

***ISS-DX sun sensor measures the incident angle of a sun ray in both orthogonal axes and the solar radiation. The high sensitivity reached is based on the geometrical dimensions of the design.***

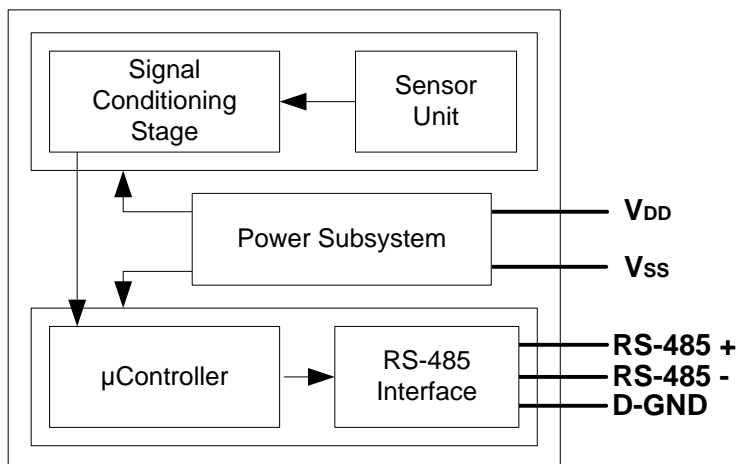
***Its characteristics make it a suitable tool for high accurate sun-tracking and positioning systems, with low power consumption and high reliability.***

#### Applications

- Sun tracking/pointing systems*
- Heliostats*
- Attitude control using light sources*
- Aircraft attitude control*
- Satellite attitude control*
- Determination of sun radiation*

***ISS-DX sun sensor has been designed with a unique and novel own technology based on MEMS fabrication processes to achieve high integrated sensing structures at low cost.***

**ISS DX**



*Fig 1. Block Diagram*

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Solar MEMS is not liable for the correct operation of the system if the user does not follow the instructions of this document or use replacement parts that are not covered by this guarantee.

## Figures

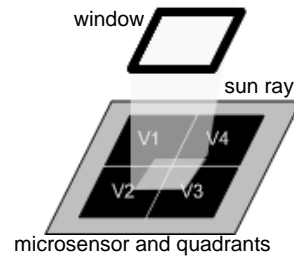
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## 1. Sun Sensor ISS-DX

ISS-DX measures the incidence angle of a sun ray in both azimuth and elevation based on a quadrant photodetector device. The sunlight is guided to the detector through a window above the sensor. Dependent of the angle of incidence, the sunlight induces photocurrents in the four quadrants of the detector.



*Fig 2. Microsensor of ISS-DX*

Different models of the ISS-DX are offered, differing in the field of view (FOV) of the sensor. The accuracy of the sensor is inversely proportional to this field of view.

## 2. General Specifications

| Parameter           | D60                          | D25    | D15    | D5      | Unit | Comments                     |
|---------------------|------------------------------|--------|--------|---------|------|------------------------------|
| Sensor type         | 2 axes                       | 2 axes | 2 axes | 2 axes  | -    | Orthogonal                   |
| Field of view (FOV) | 120                          | 50     | 30     | 10      | °    | Aperture of the cone of view |
| Accuracy            | < 0,4                        | < 0,3  | < 0,2  | < 0,1   | °    | 3σ                           |
| Precision           | < 0,06                       | < 0,04 | < 0,02 | < 0,005 | °    | Sensitivity                  |
| Average consumption | 33                           | 33     | 33     | 33      | mA   |                              |
| Dimensions          |                              |        |        |         |      |                              |
| Diameter            | 80                           | 80     | 80     | 80      | mm   |                              |
| Height              | 27                           | 27     | 27     | 27      | mm   |                              |
| Weight              | 100                          | 100    | 100    | 100     | g    |                              |
| Level of protection | IP65                         | IP65   | IP65   | IP65    |      | CEI 60529 Standard           |
| Pressure            | Tested at 0,05 mbar and 25°C |        |        |         |      |                              |

*Table 1. General Specifications*

### 3. Absolute maximum ratings

| Symbol | Parameter             | Minimum value | Maximum value | Unit |
|--------|-----------------------|---------------|---------------|------|
| VDD    | Supply voltage        | 0             | 16            | V    |
| TOP    | Operating temperature | -40           | 85            | °C   |
| VRS485 | RS-485 input voltage  | -10           | 10            | V    |

*Table 2. Absolute maximum ratings*

### 4. Recommended operating conditions

| Symbol         | Parameter             | Minimum value | Maximum value | Unit |
|----------------|-----------------------|---------------|---------------|------|
| VDD            | Supply voltage        | 5             | 12            | V    |
| V <sub>r</sub> | Supply voltage ripple | 0             | 100           | mVpp |
| TOP            | Operating temperature | -40           | 85            | °C   |
| VRS485         | RS-485 input voltage  | -10           | 10            | V    |

*Table 3. Recommended operation conditions*

### 5. Electrical characteristics

| Symbol          | Parameter                  | Min | Typical | Max | Unit |
|-----------------|----------------------------|-----|---------|-----|------|
| VDD             | Supply voltage             | 5   | 5       | 12  | V    |
| I <sub>DD</sub> | Feed current               | -   | 33      | -   | mA   |
| RS-485          |                            |     |         |     |      |
| V <sub>IH</sub> | Voltage <i>input high</i>  | 2   |         |     | V    |
| V <sub>IL</sub> | Voltage <i>input low</i>   |     |         | 0.8 | V    |
| V <sub>OH</sub> | Voltage <i>output high</i> | 3.5 |         |     | V    |
| V <sub>OL</sub> | Voltage <i>output low</i>  |     |         | 0.4 | V    |

*Table 4. Electrical characteristics*

Reverse polarity protection.

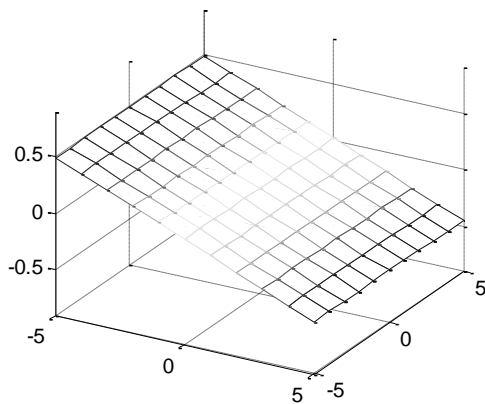
120Ω RS-485 termination resistors included (see figs. 10 to 12):

*Please, refer to the manufacturer for any other particular configuration.*

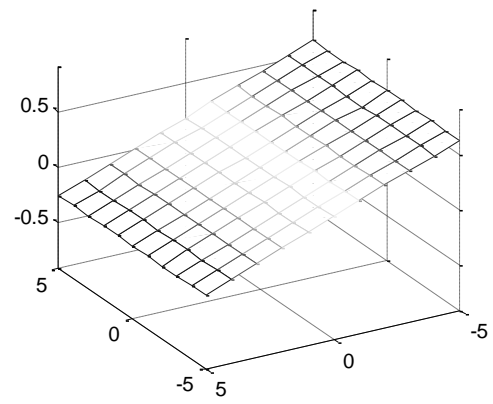
## 6. Characteristics of the ISS-DX

| Parameter   | D60    | D25    | D15    | D5      | Unit             | Comments                              |
|---|--------|--------|--------|---------|------------------|---------------------------------------|
| Sensor type   | 2 axes | 2 axes | 2 axes | 2 axes  | -                | Orthogonal                            |
| Field of view (FOV)   | 120    | 50     | 30     | 10      | °                | Aperture of the cone of view          |
| Accuracy  | < 0,4  | < 0,3  | < 0,2  | < 0,1   | °                | 3 $\sigma$                            |
| Precision   | < 0,06 | < 0,04 | < 0,02 | < 0,005 | °                | Sensitivity                           |
| Angle resolution  | 0.01   | 0.001  | 0.001  | 0.001   | °                |                                       |
| Radiation accuracy  | < 10   | < 10   | < 10   | < 10    | %                | As accurate as close to normal vector |
| Radiation resolution  | 1      | 1      | 1      | 1       | W/m <sup>2</sup> |                                       |
| Max. radiation  | 1200   | 1200   | 1200   | 1200    | W/m <sup>2</sup> |                                       |
| Temperature accuracy  | 2      | 2      | 2      | 2       | °C               |                                       |
| Temperature resolution  | 1      | 1      | 1      | 1       | °C               |                                       |
| Sampling frequency  | 50     | 50     | 50     | 50      | Hz               |                                       |
| Bandwidth   | 0,4    | 0,4    | 0,4    | 0,4     | Hz               |                                       |
| T <sup>a</sup> 25°C, V <sub>DD</sub> 5V, Radiation 900 W/m <sup>2</sup> |        |        |        |         |                  |                                       |
| Expected life time: 10 years +  |        |        |        |         |                  |                                       |

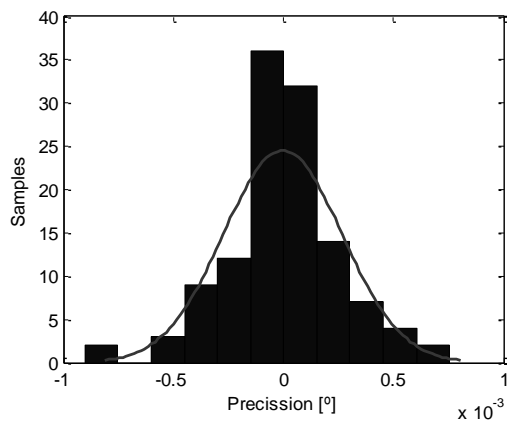
*Table 5. Characteristics of the sensor*



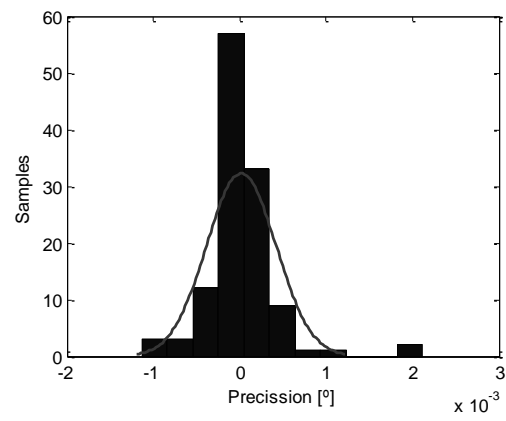
*Fig 3. Sensor response ISSD5: axis x*



*Fig 4. Sensor response ISSD5: axis y*



*Fig 5. Statistics of accuracy ISSD5: axis x*



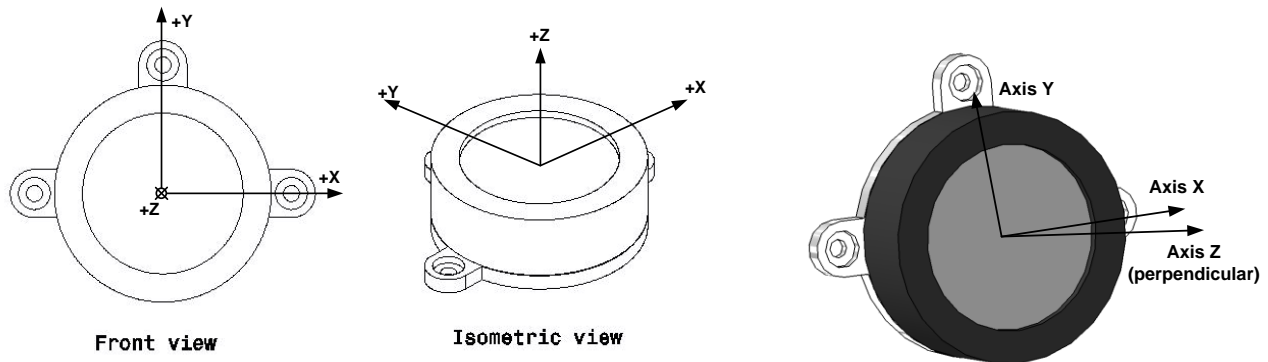
*Fig 6. Statistics of accuracy ISSD5: axis y*

## 7. Main operations

ISS-DX sensor measures the incidence angles of a solar radiation respect to its perpendicular. This information is provided through a RS485 UART channel (master-slave configuration).

### 7.1. ISS-DX parameters

#### 7.1.1. Reference Axes

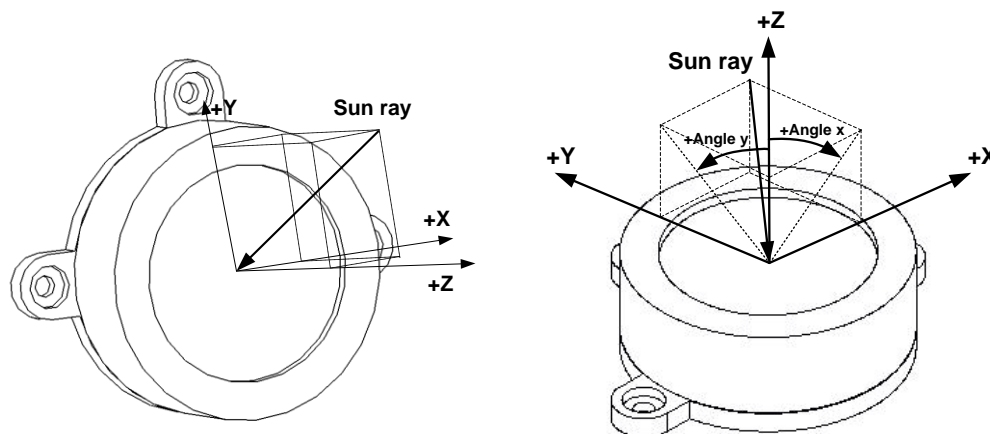


*Fig 7. ISS-DX reference system*

Z axis is perpendicular to the sensor base plane.

#### 7.1.2. Angles

The *angle x* and *angle y* specify the angular position of the incident sun ray inside the field of view of the ISS DX sensor. The accuracy of the sensor increases close to zero degrees (perpendicular). Both angles are provided in degrees.



*Fig 8. Reference for measured angles*

The ISS-DX does an internal filtering processing to the angle measurements with the following features: third-order Butterworth filter with sampling frequency of 50 Hz and cutoff frequency of 0.4 Hz.

### 7.1.3. Solar Radiation DNI

*Radiation* is an estimation value of the atmospheric solar radiation, according to the measurements inside FOV. In sunny day conditions, this radiation is equivalent to the direct solar radiation. Radiation is provided in  $W/m^2$ .

The user can utilize this information, in addition to the sensor data, to estimate the atmospheric conditions at the time of measurement, i.e. clouds, fog, dust, etc.

### 7.1.4. Temperature

This parameter is an estimation of the internal ISS-DX sun sensor temperature. Thermal data is provided in °C.

### 7.1.5. Additional information

This information is a data packet for validating the measurements: indicates if the sun sensor receives enough radiation, or if it detects the Sun out of its field of view (FOV).

The data packet is one byte with the following meaning according to its value:

| <b>Value (hexadecimal)</b> | <b>Information</b> | <b>Comments</b>  |
|----------------------------|--------------------|--|
| 0x00                       | No information     |  |
| 0xFF                       | Zero radiation     | Angles values set to 0°<br>Radiation not enough: less than 300 $W/m^2$   |
| 0x33                       | Sun is out of FOV  | Angles values set to 0°  |
| 0x01                       | Sun is out of FOV  | Angles values set to 0°<br>Sun is to X positive reference                |
| 0x02                       | Sun is out of FOV  | Angles values set to 0°<br>Sun is to X negative reference                |
| 0x10                       | Sun is out of FOV  | Angles values set to 0°<br>Sun is to Y positive reference                |
| 0x20                       | Sun is out of FOV  | Angles values set to 0°<br>Sun is to Y negative reference                |
| 0x11                       | Sun is out of FOV  | Angles values set to 0°<br>Sun is to X positive and Y positive reference |
| 0x12                       | Sun is out of FOV  | Angles values set to 0°<br>Sun is to X negative and Y positive reference |
| 0x21                       | Sun is out of FOV  | Angles values set to 0°<br>Sun is to X positive and Y negative reference |
| 0x22                       | Sun is out of FOV  | Angles values set to 0°<br>Sun is to X negative and Y negative reference |

*Table 6. Additional information*



## 8. ISS-DX Modbus Communication

ISS-DX communication protocol is based on UART over MODBUS (RS-485) master/slave configuration. ISS-DX always acts as slave. Up to 247 sensors can be connected to the same communication bus.

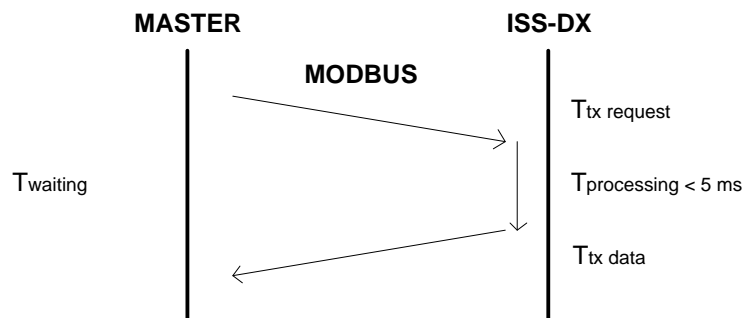
### 8.1. Communication channel parameters

| Parameter | Options                                    | Unit | Comments   |
|-----------|--|------|--|
| Bit rate  | 115200<br>38400<br>19200 (default)<br>9600 | bps  | Bit rate is modifiable by MODBUS<br><i>Please, refer to the manufacturer for any other particular configuration.</i> |
| Data Bits | 8  | Bits |  |
| Stop Bits | 1 (default)<br>2                           | Bit  | Bit rate is modifiable by MODBUS<br><i>Please, refer to the manufacturer for any other particular configuration.</i> |
| Parity    | No (default)<br>Even<br>Odd                | -    | Bit rate is modifiable by MODBUS<br><i>Please, refer to the manufacturer for any other particular configuration.</i> |

*Table 7. UART link parameters*

### 8.2. Master – Slave Operation

The master/slave operation allows the master of the system to request information to the ISS-DX. Recommended maximum sampling frequency is 10 Hz.

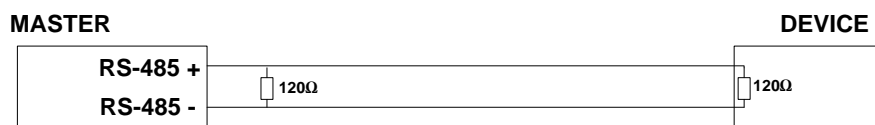


*Fig 9. Communication timeouts.*

### 8.3. RS-485 bus configurations

#### 8.3.1. Point to Point configuration

ISS-DX sun sensors include a 120 ohm terminator resistor for point to point configuration.



*Fig 10. Recommended point to point configuration*

### 8.3.2. Bus configuration

According to TIA/EIA-485 standard, the termination resistors are modifiable and depend on the bus configuration.

Please refer to the manufacturer for ISS-DX sun sensors without terminator resistor, or any other value for this element.

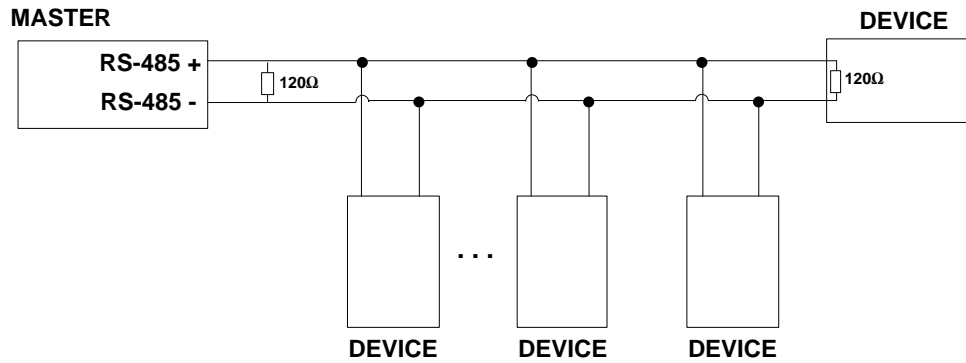


Fig 11. Optional bus configuration for more than one ISS-DX

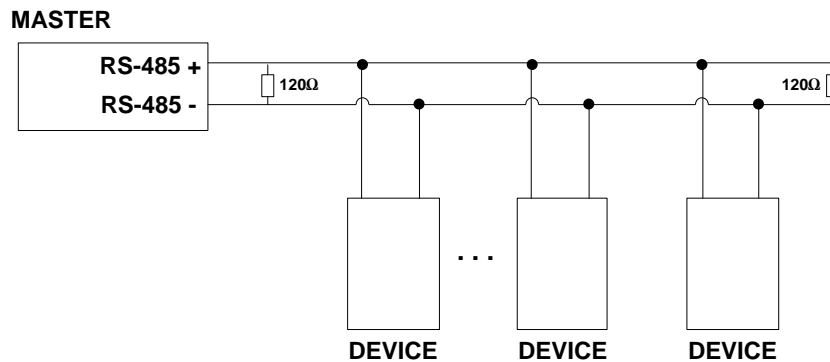


Fig 12. Optional bus configuration for more than one ISS-DX

## 8.4. Modbus operation

The ISS-DX sun sensor communicates by means of Modbus RTU framing:

- **Address:** ISS-DX detects unicast address. Every ISS-DX has address (=identifier) 1 by default.
- **Function code:** ISS-DX detects only “Read Register/s” (0x03) code and “Write Single Register” (0x06) code.
- **Exceptions:** ISS-DX runs the following exceptions: 01, 02, 03 and 04.
- **CRC16:** according to Modbus standard.
- **Registers:** each register has two bytes.

The ISS-DX sun sensor has the following stack of registers:

| Order | Name                   | Allowed operation | Default value | Units            | Comments  |
|-------|------------------------|-------------------|---------------|------------------|---|
| 1     | Identifier (address)   | Read/Write        | 1             | -                | Signed decimal: from 1 to 247   |
| 2     | Field of view          | R                 | -             | °                | Signed decimal: 5,15,25 or 60   |
| 3     | ISS-DX model           | R                 | -             | -                | Ascii code: A=0x41  |
| 4     | Reference code         | R                 | -             | -                | Signed decimal  |
| 5     | Bit rate               | R/W               | 19200         | Bps              | Values: 1=9600; 2=19200; 3=38400; 4=115200.   |
| 6     | Parity                 | R/W               | 3             | -                | Values: 1=even; 2=odd; 3=none   |
| 7     | Stop bits              | R/W               | 1             | Bits             | Values: 1=1bit; 2=2bits   |
| 8     | Additional information | R                 | -             | -                | Values according to table 6   |
| 9     | Radiation              | R                 | -             | W/m <sup>2</sup> | Signed decimal  |
| 10    | Temperature            | R                 | -             | °C               | Signed decimal, scale of 0.1°C.   |
| 11    | Angle X with filter    | R                 | -             | °                | Signed decimal, scale according to field of view:<br>60: scale of 0.01°<br>5,15,25: scale of 0.001°<br>With third-order Butterworth filter. |
| 12    | Angle Y with filter    | R                 | -             | °                |   |
| 13    | Angle X                | R                 | -             | °                | Signed decimal, scale according to field of view:<br>60: scale of 0.01°<br>5,15,25: scale of 0.001°   |
| 14    | Angle Y                | R                 | -             | °                |   |

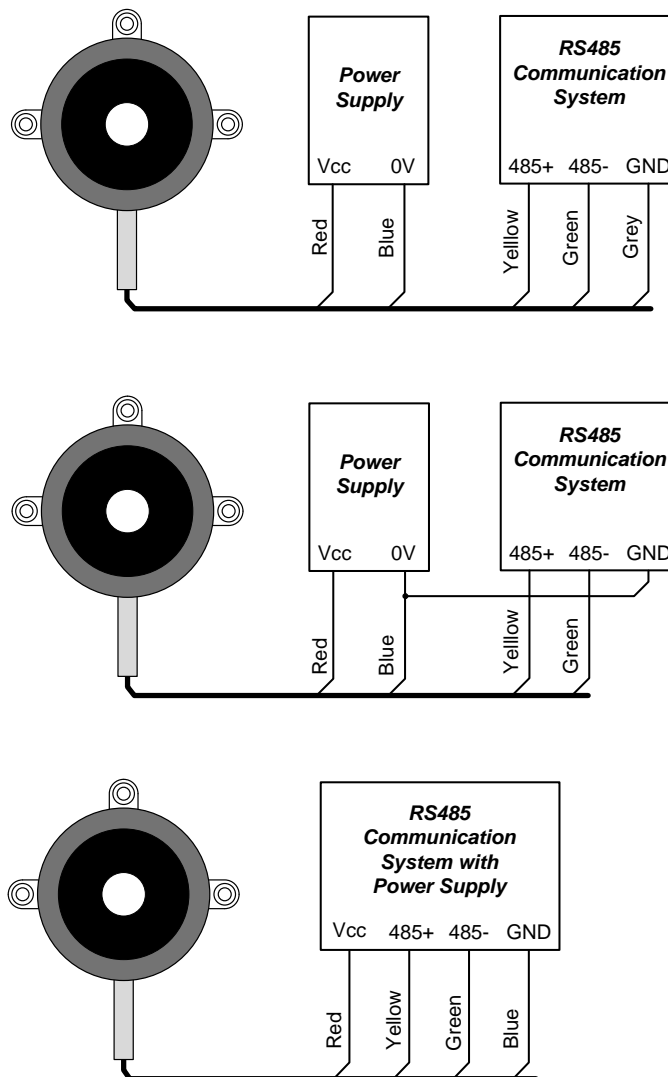
*Tabla 8. ISS-DX modbus registers*

*Please, refer to the manufacturer for a particular configuration.*

## 9. Electrical interface

| Colour | Terminal | Type           | Comments          |
|--------|----------|----------------|-------------------|
| Red    | VDD      | Power          | Power Supply      |
| Blue   | VSS      | Power          | Ground            |
| Yellow | RS-485 + | I/O            | Terminal + RS-485 |
| Green  | RS-485 - | I/O            | Terminal - RS-485 |
| Grey   | D-GND    | Communications | Digital Ground    |
| White  | -        | -              | Do Not connect    |
| Brown  | -        | -              | Do Not connect    |
| Pink   | -        | -              | Do Not connect    |
| Shield | -        | -              | See fig. 13       |

Table 9. Electrical interface

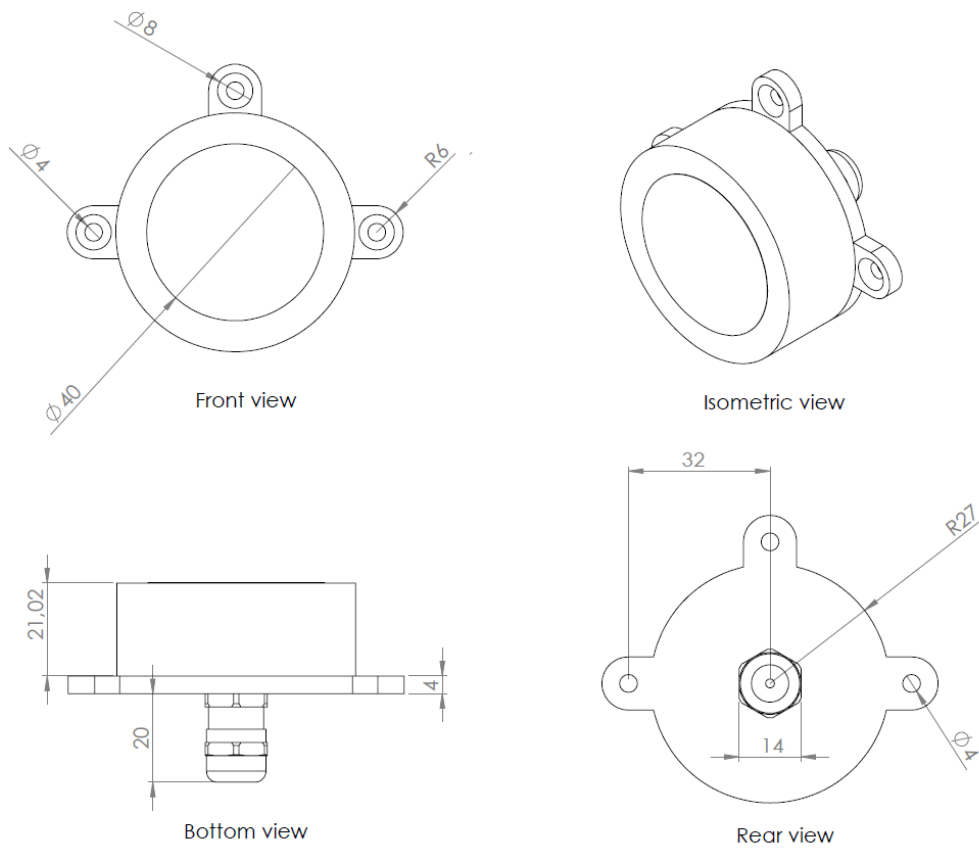


In any configuration we recommend connecting the shield to the blue wire

Fig 13. Recommended wiring diagram

The housing of the sun sensor ISSDX is isolated electrically.

## 10. Mechanical data



*Fig 14. ISS-DX dimensions*

The box of the ISS-DX sensor is composed of a top and bottom housing, both made of Aluminum 6082: it has good corrosion resistance. The top housing has a protective coating of anodizing and it is black lacquered, and the bottom housing has a protective coating of matt anodizing.

## 11. Warranty

Solar MEMS Technologies S.L. warrants the ISS-DX sun sensor to the original consumer purchaser any product that is determined to be defective for the following terms will be repaired, or replaced.

**The warranty is one year from date of purchase.**

The product in question must be sent to Solar MEMS Technologies S.L. (address is shown below) within the warranty period and the original consumer purchaser must comply with the following conditions, to be eligible for repair or replacement under this warranty:

- The product must not have been modified or altered in any way by an unauthorized source.
- The product must have been installed in accordance with the installation instructions and the technical specifications.

**This limited warranty does not cover:**

- Damage due to improper installation;
- Accidental or intentional damages;
- Misuse, abuse, corrosion, or neglect;
- Product impaired by severe conditions, such as excessive wind, ice, storms, lightning strikes or other natural occurrences;
- Damage due to improper packaging on return shipment.

Any and all labor charges for troubleshooting, removal or replacement of the product are not covered by this warranty and will not be honored by Solar MEMS Technologies S.L.

Return shipping to Solar MEMS Technologies S.L. must be pre-paid by the original consumer purchaser. Solar MEMS Technologies S.L. will pay the normal return shipping charges to original consumer purchaser within the European Union countries only.

**Address of Solar MEMS Technologies S.L.**

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C/ Leonardo da Vinci 18, Planta 1, Módulo 2.  
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Phone: (+34) 954 460 113

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