

Solar MEMS Technologies S.L.

Sun Sensor ISS-TX

*Digital sensor for Tracking Systems
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-TX 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, 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-TX 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.

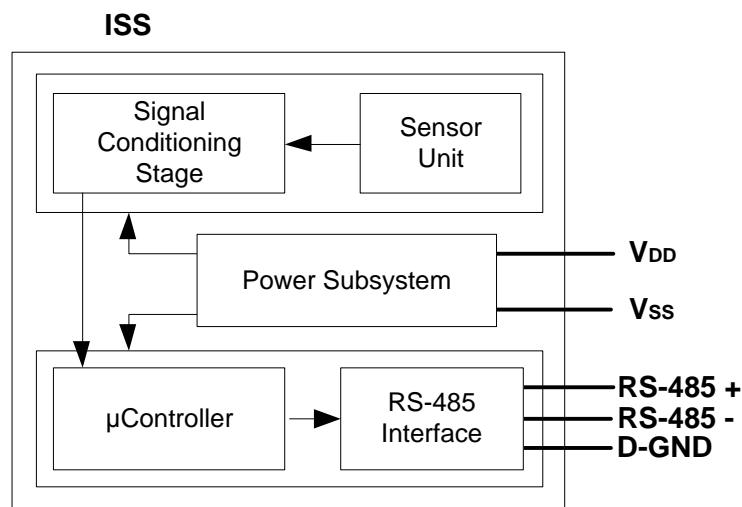


Fig 1. Block Diagram

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Responsibility exemption:

Solar MEMS has checked the concordance of this document with the described software and hardware. However, as it is impossible to exclude deviations, Solar MEMS is not liable for full concordance. Solar MEMS reviews this document periodically. If necessary, possible corrections will be included in the next version.

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.

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1. Sun Sensor ISS-TX

ISS-TX measures the incidence angle of a sun ray in both azimuth and elevation based on a quadrant photo-detector 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.

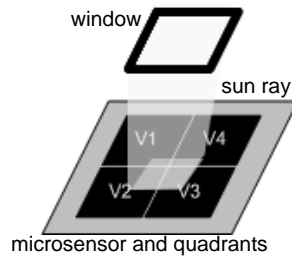


Fig 2. Microsensor of ISS-TX

Different models of the ISS-TX are offered, depending on 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	T60	T25	T15	T5	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	< 10	< 10	< 10	< 10	%	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 of ISS-TX models

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 _r	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 _{DD}	Feed current	-	33	-	mA
RS-485					
V _{IH}	Voltage <i>input high</i>	2			V
V _{IL}	Voltage <i>input low</i>			0.8	V
V _{OH}	Voltage <i>output high</i>	3.5			V
V _{OL}	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-TX

Parameter	T60	T25	T15	T5	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	< 10	< 10	< 10	< 10	%	3σ
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 ²	
Max. radiation	1200	1200	1200	1200	W/m ²	
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 ^a 25°C, V _{DD} 5V, Radiation 900 W/m ²						
Expected life time: 10 years +						

Table 5. Characteristics of the sensor

Sun sensor ISS-TX is specifically designed and made for Tracking Systems, as CPV trackers, Weather Stations, PV trackers, Dish-stirling trackers, etc, any system using a tracking controller, for Sun or other light sources.

Different models of the ISS-TX are offered, differing in the field of view (FOV) of the sensor. The accuracy of the sensor is inversely proportional to the field of view. All these models have been tested on solar trackers with Solar MEMS Helios Controller in our facilities.

Depending on the application of the Sun Sensor ISS-TX, we recommend the use of the following models:

- Solar Tracker with Photovoltaic:
The accuracy requirements are not demanding, so it's recommended to **use the ISS-T25 model, to get a wide field of view.**
- Solar Tracker with CPV or similar:
The accuracy requirements are very demanding, so it's recommended to **use the ISS-T5 model, to get high accuracy and narrow field of view**, because a wide field of view increases the effects of the **environmental conditions** on the accuracy of the sun sensor: clouds effect and seeing of the ground.
- Other applications:
It depends on the demanding of the field of view and the accuracy.

7. Main operations

ISS-TX 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-TX parameters

7.1.1. Reference Axes

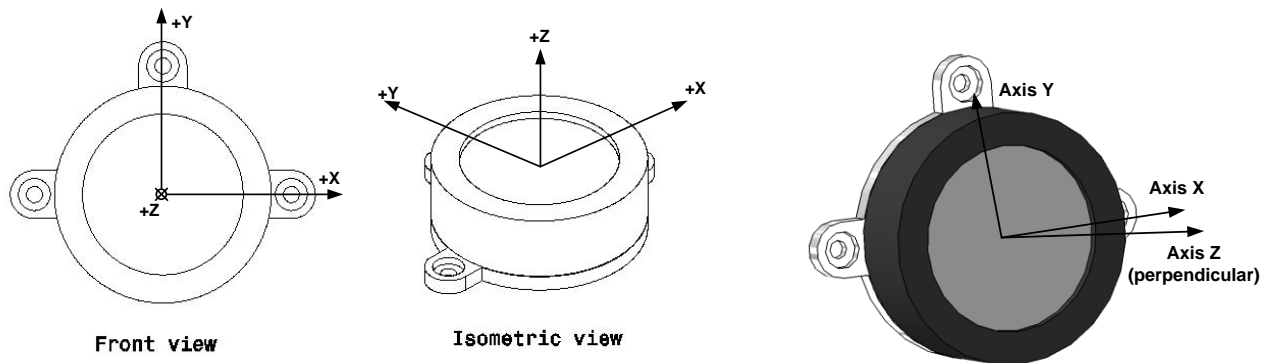


Fig 3. ISS-TX reference system

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-TX sensor. The accuracy of the sensor increases close to zero degrees (perpendicular). Both angles are provided in degrees.

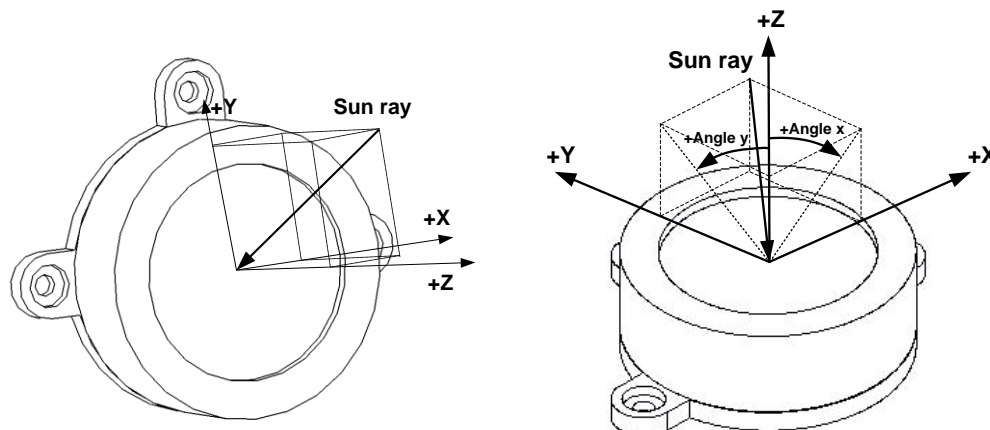


Fig 4. Reference for measured angles

The ISS-TX does an internal filtering processing to the angle measurements with the following features: third-order Butterworth filter with sampling frequency of 50 Hz and cut-off 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 use 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-TX 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:

Value (hexadecimal)	Information	Comments
0x00	No information	
0xFF	Zero radiation	Angles values set to 0° 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° Sun is to X positive reference
0x02	Sun is out of FOV	Angles values set to 0° Sun is to X negative reference
0x10	Sun is out of FOV	Angles values set to 0° Sun is to Y positive reference
0x20	Sun is out of FOV	Angles values set to 0° Sun is to Y negative reference
0x11	Sun is out of FOV	Angles values set to 0° Sun is to X positive and Y positive reference
0x12	Sun is out of FOV	Angles values set to 0° Sun is to X negative and Y positive reference
0x21	Sun is out of FOV	Angles values set to 0° Sun is to X positive and Y negative reference
0x22	Sun is out of FOV	Angles values set to 0° Sun is to X negative and Y negative reference

Table 6. Additional information

8. ISS-TX Modbus Communication

ISS-TX communication protocol is based on MODBUS RTU over RS-485 master/slave configuration. ISS-TX 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 38400 19200 (default) 9600	bps	Bit rate is modifiable by MODBUS <i>Please, refer to the manufacturer for any other particular configuration.</i>
Data Bits	8	bits	
Stop Bits	1 (default) 2	bit	Bit rate is modifiable by MODBUS <i>Please, refer to the manufacturer for any other particular configuration.</i>
Parity	No (default) Even Odd	-	Bit rate is modifiable by MODBUS <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-TX. Recommended maximum sampling frequency is 10 Hz.

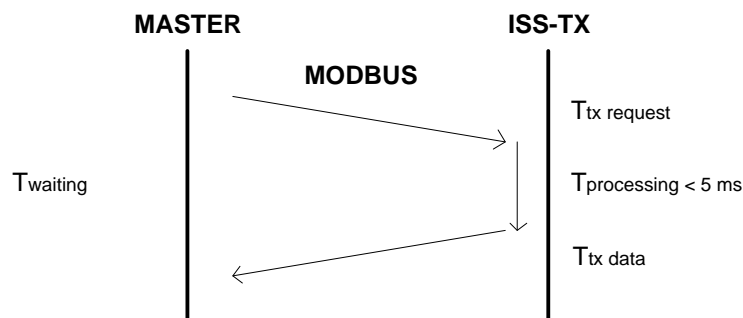


Fig 5. Communication timeouts.

8.3. RS-485 bus configurations

8.3.1. Point to Point configuration

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

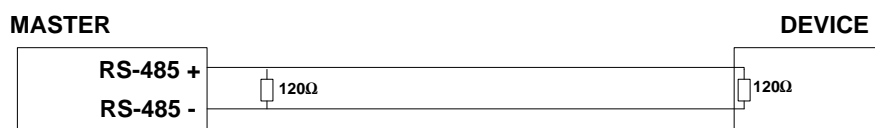


Fig 6. Recommended point to point configuration

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-TX sun sensors without terminator resistor, or any other value for this element.

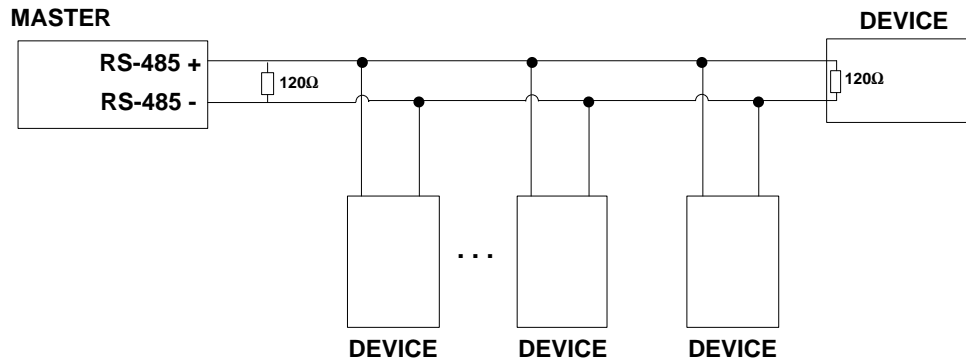


Fig 7. Optional bus configuration for more than one ISS-TX

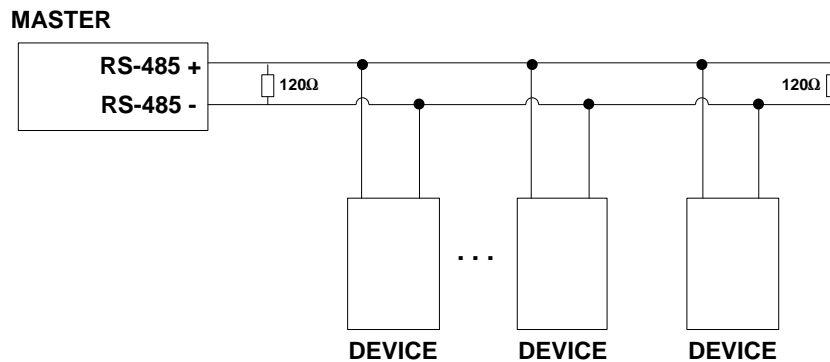


Fig 8. Optional bus configuration for more than one ISS-TX

8.4. Modbus operation

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

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

The ISS-TX 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 ²	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: 60: scale of 0.01° 5,15,25: scale of 0.001° With third-order Butterworth filter.
12	Angle Y with filter	R	-	°	
13	Angle X	R	-	°	Signed decimal, scale according to field of view: 60: scale of 0.01° 5,15,25: scale of 0.001°
14	Angle Y	R	-	°	

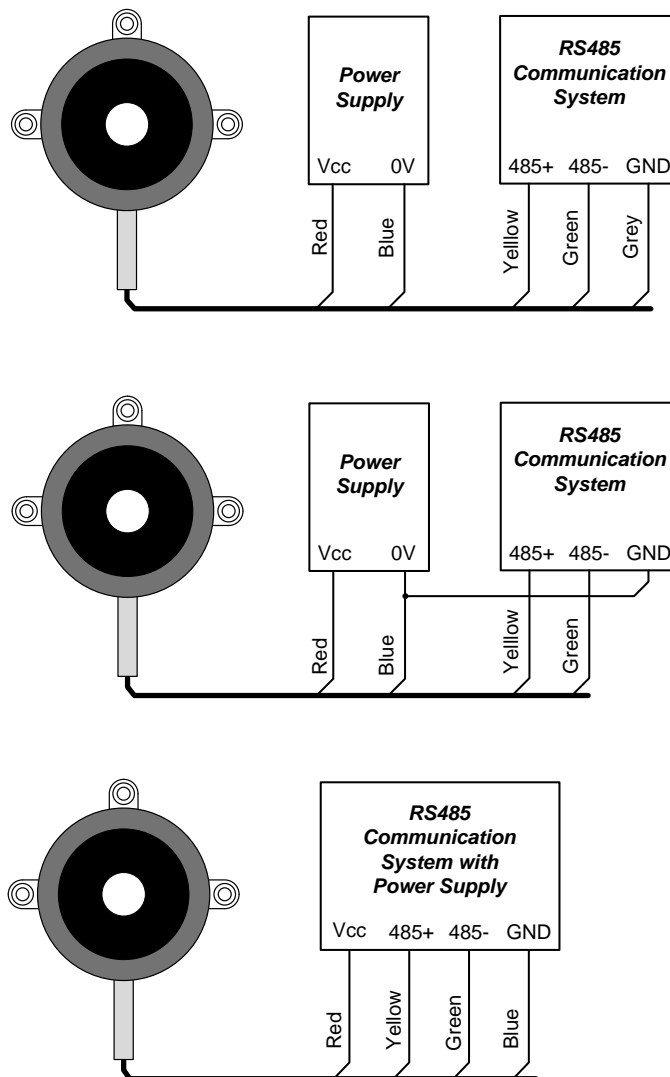
Tabla 8. ISS-TX modbus registers

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 9. Recommended wiring diagram

The housing of the sun sensor ISS-TX is isolated electrically.

10. Mechanical data

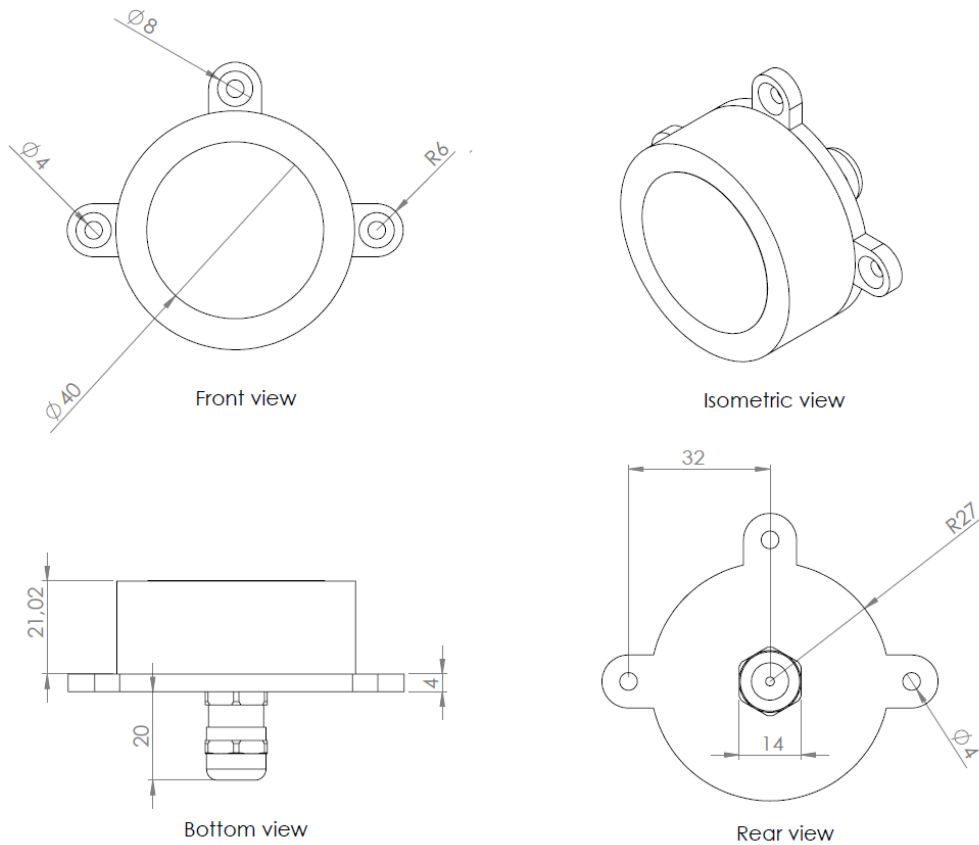


Fig 10. ISS-TX dimensions

The box of the ISS-TX 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-TX 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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Solar MEMS has a system of quality and environment according to the ISO 9001 and ISO 14001 standards, provided by the certification company Applus CTC.