USER MANUAL

Solar Panel 1U

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SOLAR PANEL – 1U

USER MANUAL

This user manual is specially designed to detail the EnduroSat solar panels description, functions and features.

Please read carefully the manual before unpacking the solar panels in order to ensure safe and proper use.

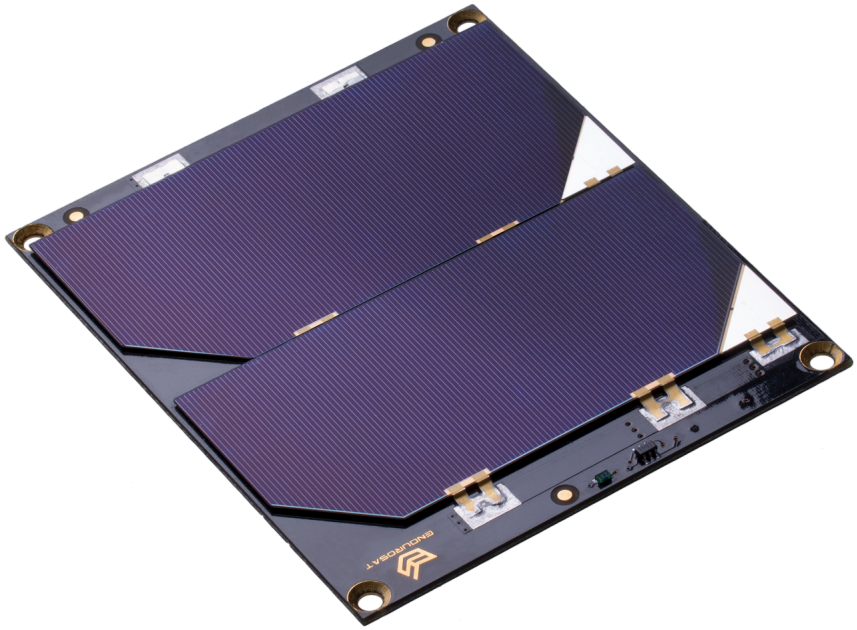


Figure 1 - Solar Panel X/Y

1 CHANGE LOG

Date	Version	Note
10/04/2016	Rev 1	
15/12/2016	Rev 1.2	Added Solar Panel X/Y with RBF (paragraph 5.3)
01/08/2017	Rev 1.3	Magnetic dipole measurement updated
23/11/2017	Rev1.4	Minor text enhancements

2 ACRONYMS LIST

CIE	International Commission on Illumination
ECSS	European Cooperation Space Standardization
ESA	European Space Agency
GEO	Geostationary Earth Orbit
GEVS	General Environmental Verification Standard
GND	Ground
LEO	Low Earth Orbit
PCB	Printed Circuit Board
RBF	Remove Before Flight
RH	Relative humidity
SCA	Solar Cell Assembly
SPI	Serial Peripheral Interface

3 DESCRIPTION

EnduroSat Solar Panels are equipped with 2 CESI Solar cells CTJ30 with 29.5% efficiency. The wide effective cell area (the largest possible for solar panels suitable for 1U CubeSats) provides up to 2.4 Watts in LEO per panel.

On the PCB, a network of sensors (Gyroscope, Sun sensor, temperature sensor) and magnetorquer provide inputs and output of the attitude determination and control system. Furthermore, the PCB is equipped with a connector for external magnetorquer.

For bigger CubeSats, multiple panels can be connected in series or in parallel. Also, customization of the panel for external connectors (e.g. remove before flight pin) and interfaces to access the Satellite can be provided upon request.

4 PRODUCT PERFORMANCE AND PROPERTIES

4.1 Solar Panels Features and Characteristics

- Two CESI Solar Cells CTJ30, space qualified triple junction (specs in the following paragraph);
- 60.30cm^2 effective cell area (2 solar cells);
- Temperature Sensor with SPI Interface (Accuracy: ±1.5°C from -25°C to 85°C (max), ±2.0°C from -55°C to 125°C (max));
- Up to 2.4 Watt in LEO;
- Gold plated invar interconnectors;
- Space-grade silicone adhesive with minimum outgassing behavior;
- Gyroscope;
- Sun Sensor;
- Multiple panels can be connected in series or parallel;
- Two internal 70µm copper layers;
- Plated, countersink mounting holes with ground connection;
- Connector for external magnetorquer;
- Max Voltage: up to 4.66V (for 2 cells);
- Max Current: up to 517mA;

4.2 Solar Cell Features and Characteristics

- Efficiency 29.5%;
- Triple Junction Solar Cells InGaP/GaAs/Ge;
- Polarity N on P;
- Very low solar cell mass (81-89 mg/cm2);
- Thickness 150 µm ±20 µm;
- Fully qualified under ESA Standard ECSS E ST20-08C for LEO and GEO;
- External By-pass diode for reverse bias protection;
- Size 30.15 cm^2;
- High Radiation Resistance;
- Cover glass;
- Good mechanical strength;

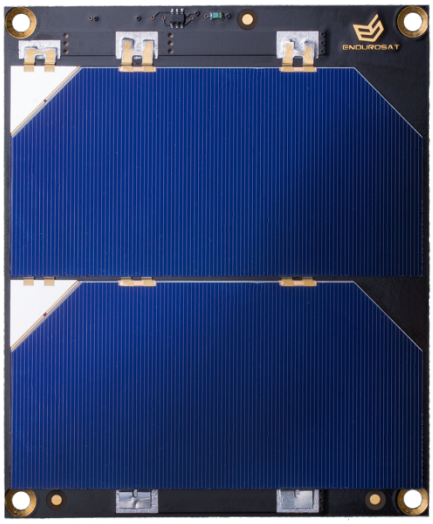
5 AVAILABLE CONFIGURATIONS

EnduroSat Solar Panels are available in 5 configurations.

- Solar Panel X/Y
- Solar Panel X/Y with Magnetorquer
- Solar Panel Z
- Solar Panel Z with Magnetorquer
- Solar Panel X/Y with RBF

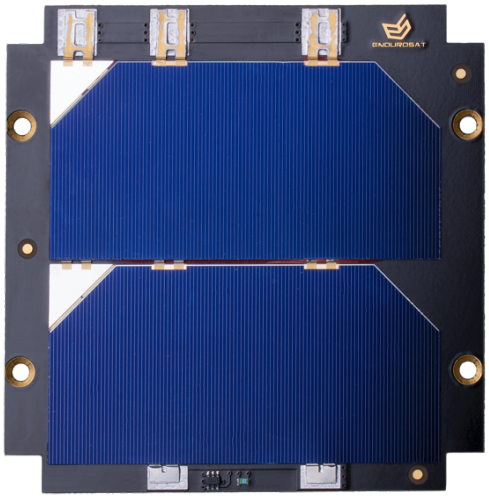
All configurations can be ordered with white or black solder mask.

5.1 Solar Panels X/Y



Solar Panels X/Y Standard (no magnetorquer)	Solar Panels X/Y with magnetorquer
• 2 CTJ30 SCA CESI • Temperature Sensor • Gyroscope (optional) • Sun sensor • Multiple panels can be connected in series or parallel • External By-pass diode for reverse bias protection • Weight: 44 g	• 2 CTJ30 SCA CESI • Magnetorquer • Temperature Sensor • Gyroscope • Sun sensor • Multiple panels can be connected in series or parallel • External By-pass diode for reverse bias protection • Weight: 53 g

5.2 Solar Panels Z



Solar Panels Z Standard (no magnetorquer)	Solar Panels Z with magnetorquer
• 2 CTJ30 SCA CESI • Temperature Sensor • Gyroscope (optional) • Sun sensor • Multiple panels can be connected in series or parallel • External By-pass diode for reverse bias protection • Weight: 48 g	• 2 CTJ30 SCA CESI • Magnetorquer • Temperature Sensor • Gyroscope • Sun sensor • Multiple panels can be connected in series or parallel • External By-pass diode for reverse bias protection • Weight: 57.5 g

5.3 Solar Panels X/Y with RBF

This configuration of the solar panel X/Y has a Remove Before Flight pin on the top right corner of the panel. The RBF ensures that the satellite cannot be switched on while the RBF pin is inserted. The internal RBF connector of the solar panel should be connected to the RBF connector of the power module with a cable.

Moreover, a 4-pin connector (+1 pin for polarization in order to avoid reverse connecting) provides general purpose input/output communication interface. In the EnduroSat platform, for instance, this interface is used to access the USB port of the OBC.

Solar Panels X/Y with RBF
(no magnetorquer)

- 2 CTJ30 SCA CESI
- Temperature Sensor
- Gyroscope (optional)
- Sun sensor
- Multiple panels can be connected in series or parallel
- External By-pass diode for reverse bias protection
- Remove Before Flight pin
- 4 pin connector for communication interface (+1 pin for polarization)
- Weight: 45 g

Figure 2 shows the front part of the solar panel and the location of the RBF pin and 4-pin connector.

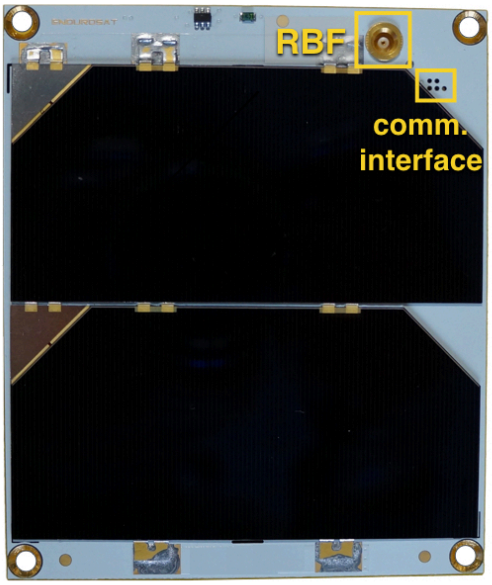


Figure 2 - Solar panel with RBF

6 CONNECTOR PINOUT

EnduroSat solar panels provide three connectors:

- H1 - Power Connector
- H2 - Power Connector
- H3 - Sensors Connector (Temperature Sensor, Gyroscope, Sun Sensor, Magnetorquer)

The hardware layout and connector pinout are the same for all the configurations. In the following paragraphs the solar panel X/Y is used as sample. The additional connectors of the solar panel with RBF are described in the paragraph 6.2.

6.1 Connectors location

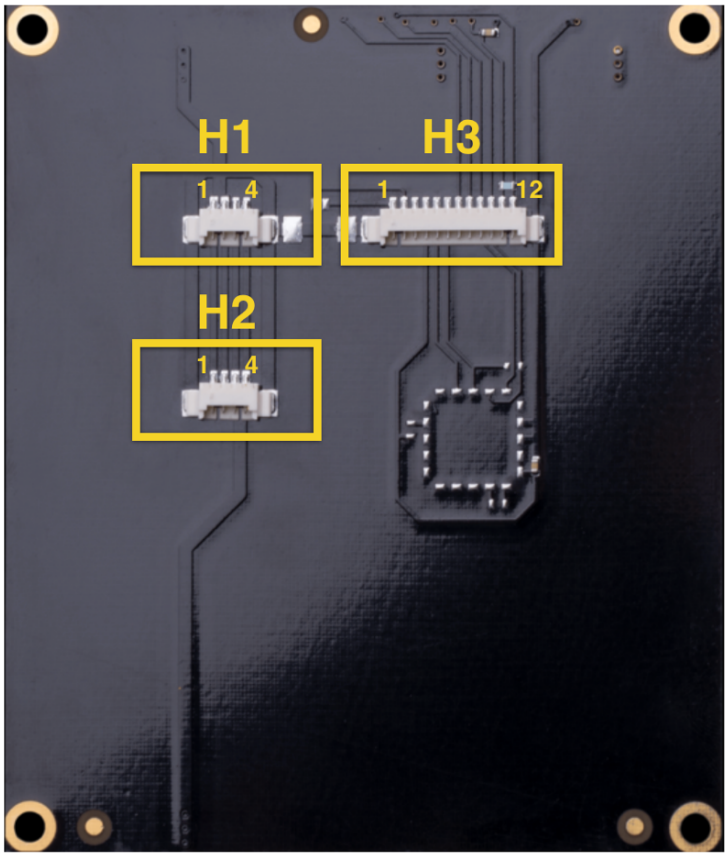


Figure 3 - Solar Panel X Y - bottom side - Connectors location

6.1.1 H1 Power Connector

Pin	Mnemonic	Description
1	-	Negative
2	-	Negative
3	+	Positive
4	+	Positive

6.1.2 H2 Power Connector

Pin	Mnemonic	Description
1	-	Negative
2	-	Negative
3	+	Positive
4	+	Positive

6.1.3 H3 Sensors Connector

Pin	Mnemonic	Description
1	PWMB	Magnetorquer control B
2	PWMA	Magnetorquer control A
3	GND	Ground
4	Vgyro	Gyroscope power input
5	SPI CS1	Chip select gyroscope
6	SPI MOSI	SPI MOSI
7	AGND	Analog ground photodiode
8	PhotoDiode	Photodiode cathode
9	SPI SCK	SPI clock
10	SPI MISO	SPI MISO
11	Vcc	3.3Vdc
12	SPI CS2	Chip select temperature sensor

6.2 Connector pinout solar panel X/Y with RBF

Figure 4 and Figure 5 show location and pinout of the communication interface (MOLEX 53261-0471) and RBF (MOLEX 53261-0271) connectors.

The pitch of the external communication interface connector is 1.27mm (50mils).

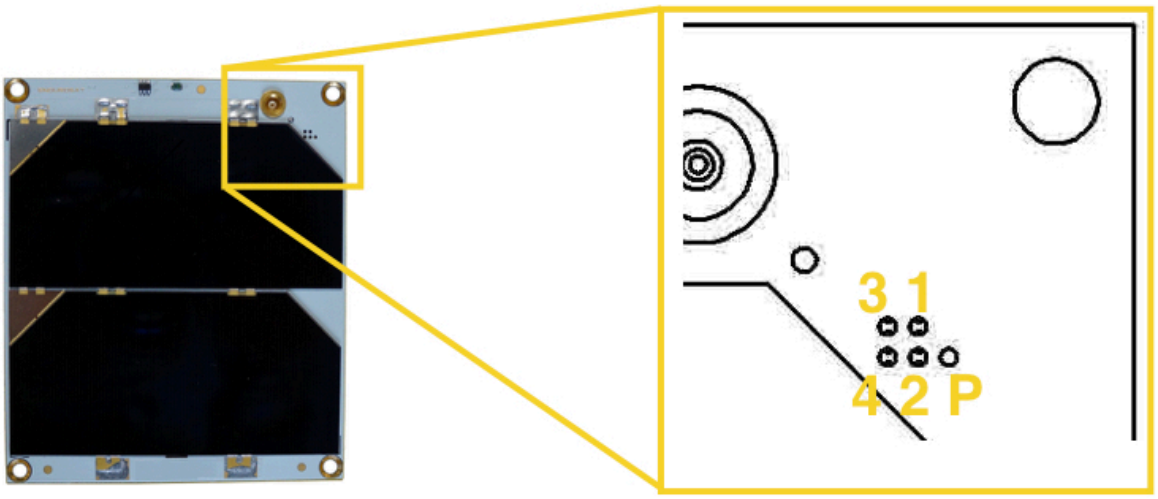


Figure 4 - communication interface pinout

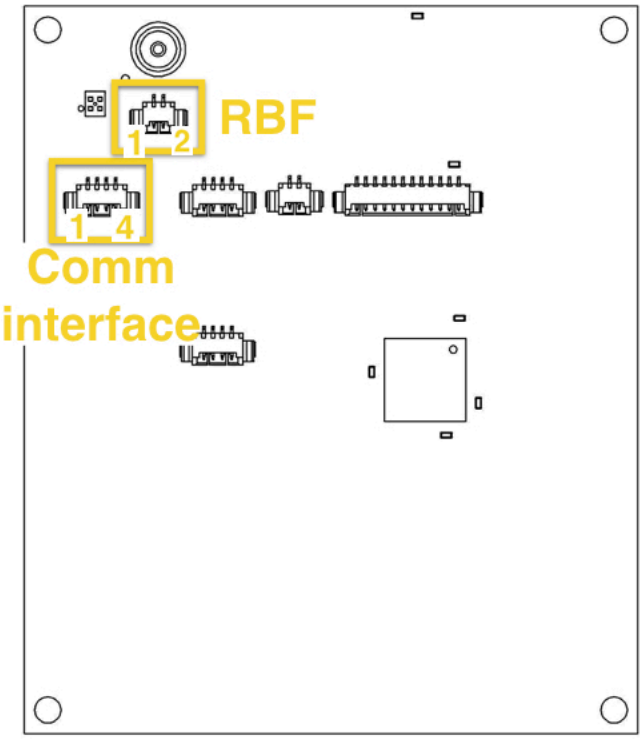


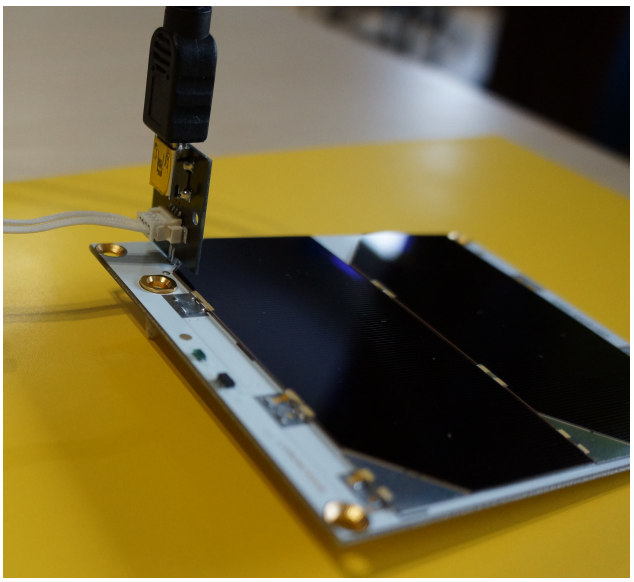
Figure 5 - RBF and communication interface connectors and pinout

6.2.1 Communication interface connector

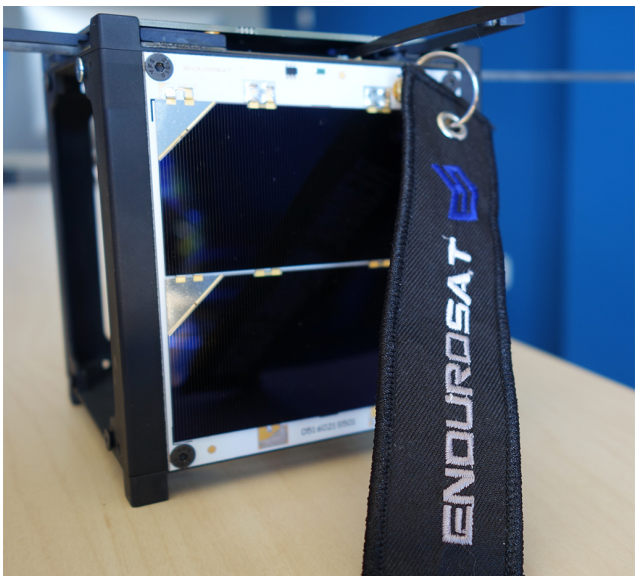
Pin	Description
1	User customizable
2	User customizable
3	User customizable
4	GND
P	Pin for polarization

6.2.2 RBF connector

Pin	Description
1	RBF
2	GND



Communication interface adaptor



RBF pin

7 SPECIFICATIONS

SOLAR CELL STRING					
Parameter	Unit	Condition	Min	Typ	Max
Voltage	V	25ºC			4.66
Current	mA	25ºC			517
Power	mW	25ºC			2400
Efficiency	%				29.5

TEMPERATURE SENSOR					
Parameter	Unit	Condition	Min	Typ	Max
Range	°C		-55		150
Accuracy	°C	-25°C to 85°C		±0.5	±1.5
	°C	-55°C to 125°C		±1	±2
	°C	-55°C to 150°C		±1.5	
Vcc	V		2.7		5.5
Quiescent Current	µA			50	75

GYROSCOPE					
Parameter	Unit	Condition	Min	Typ	Max
Sensitivity	°/sec/LSB	25°C, dynamic range = ±320°/sec		0.07326	
	°/sec/LSB	25°C, dynamic range = ±160°/sec		0.03663	
	°/sec/LSB	25°C, dynamic range = ±80°/sec		0.01832	
Vcc	V		4.75	5	5.25
Operating Temperature			-40°C		105°C
Calibration Temperature			-40°C		85°C

SUN SENSOR					
Parameter	Unit	Condition	Min	Typ	Max
Reverse light Current	µA	E_V=100lx CIE illuminant A	0.03	0.04	0.09
Range of Spectral bandwidth ($\lambda_{0.5}$)	nm			430 to 610	
Angle of half sensitivity	deg			±60°	

MAGNETORQUER					
Parameter	Unit	Condition	Min	Typ	Max
Resistance	Ω			42	
Current	mA	@3.3V		78	
Dipole Momentum[1]	Am^2	@3.3V		0.131	

[1] measured

8 MECHANICAL CHARACTERISTICS

EnduroSat Solar Panel should be mounted on the EnduroSat Structure using bolts:

Torx - DIN965/ISO 7046-1 - M3 – Length: 6mm

In the following paragraphs main dimensions of the solar panels are shown. All dimensions are in mm.

STEP file can be provided upon request.

8.1 Solar Panels X/Y

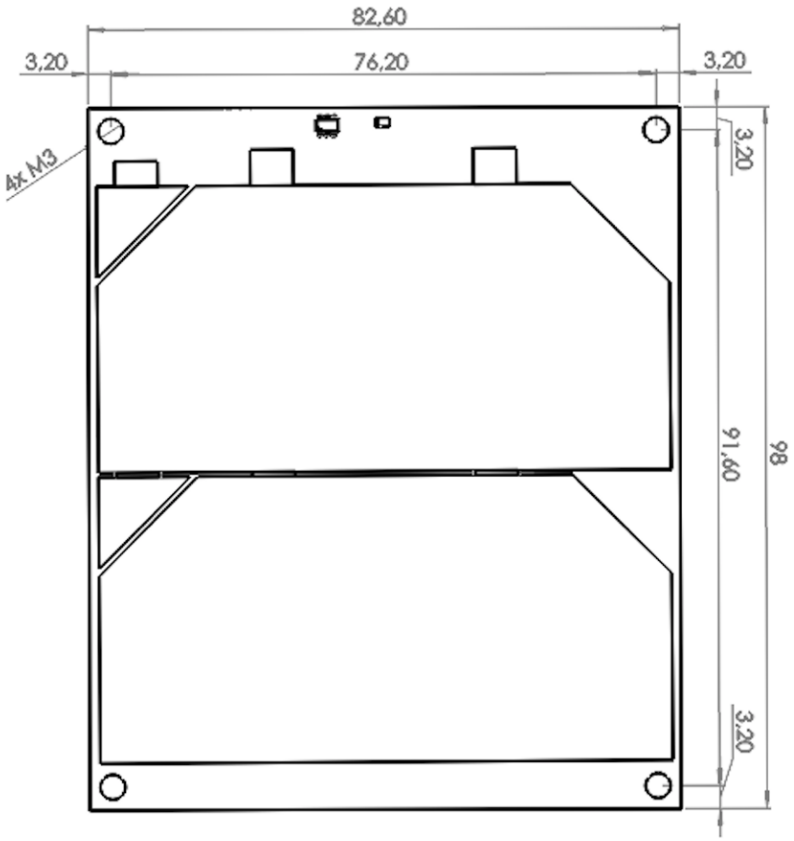


Figure 6 - Solar Panels X/Y - top side

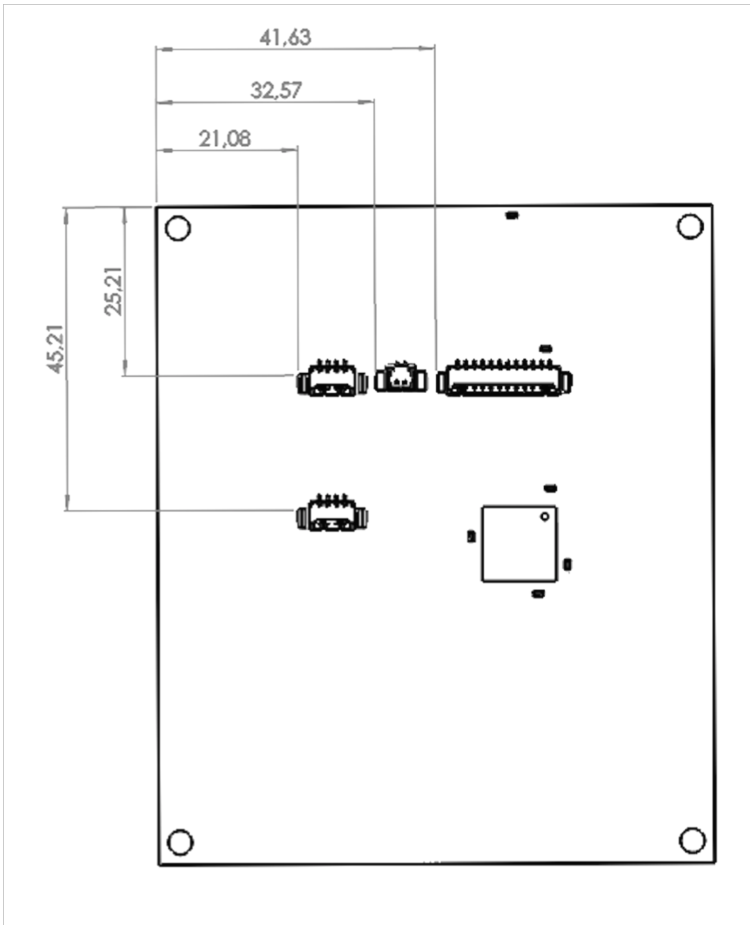


Figure 7 - Solar Panel X/Y - Bottom side (connector location)

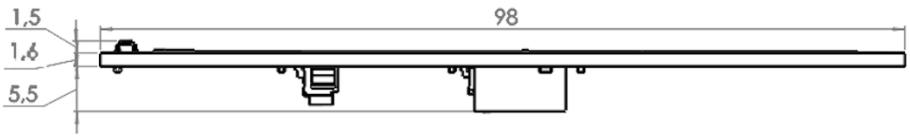


Figure 8 - Solar Panel X/Y - Side view

8.2 Solar Panels X/Y with magnetorquer

Solar Panels X/Y with and without magnetorquer differ only on the thickness of the PCB. The difference is due to the presence of the electromagnetic coils inside the PCB of the Solar panels with magnetorquer.

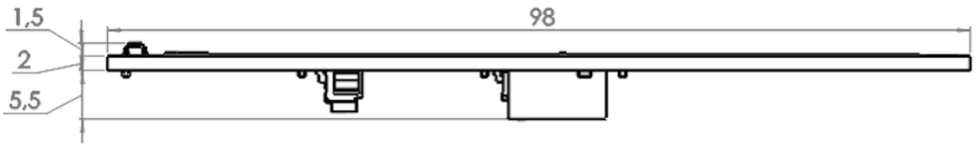


Figure 9 - Solar Panel X/Y with magnetorquer - Side view

8.3 Solar Panels Z

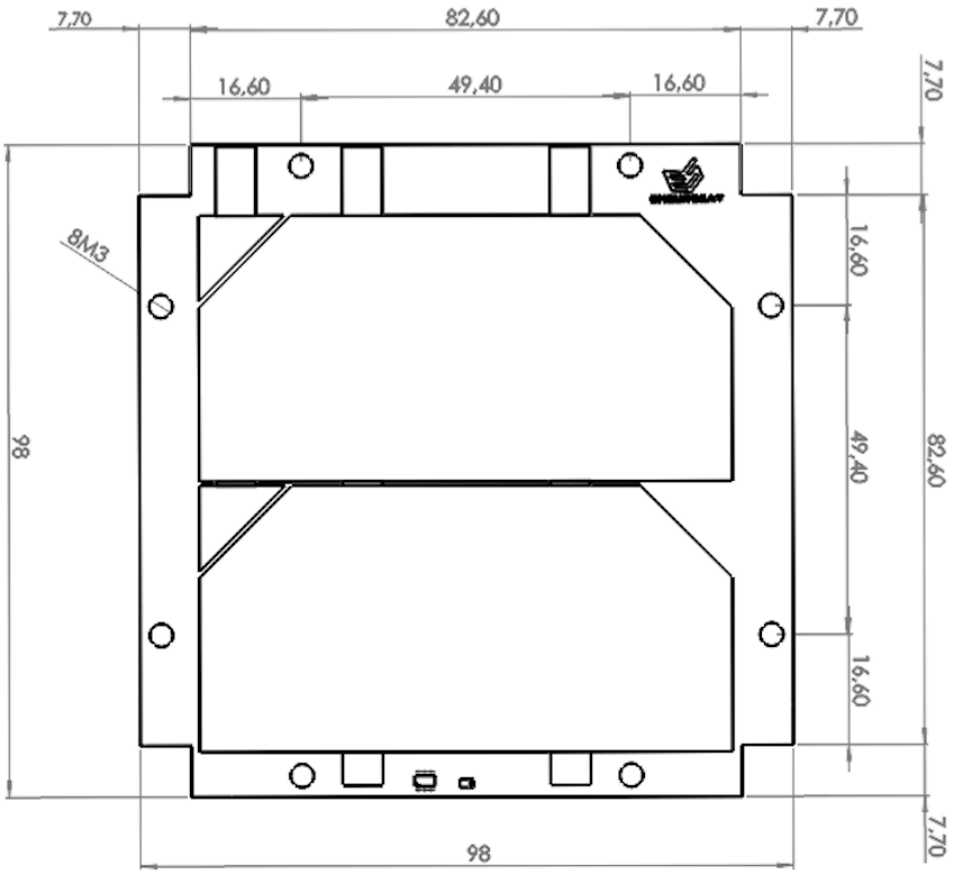


Figure 10 - Solar Panel Z - Top view

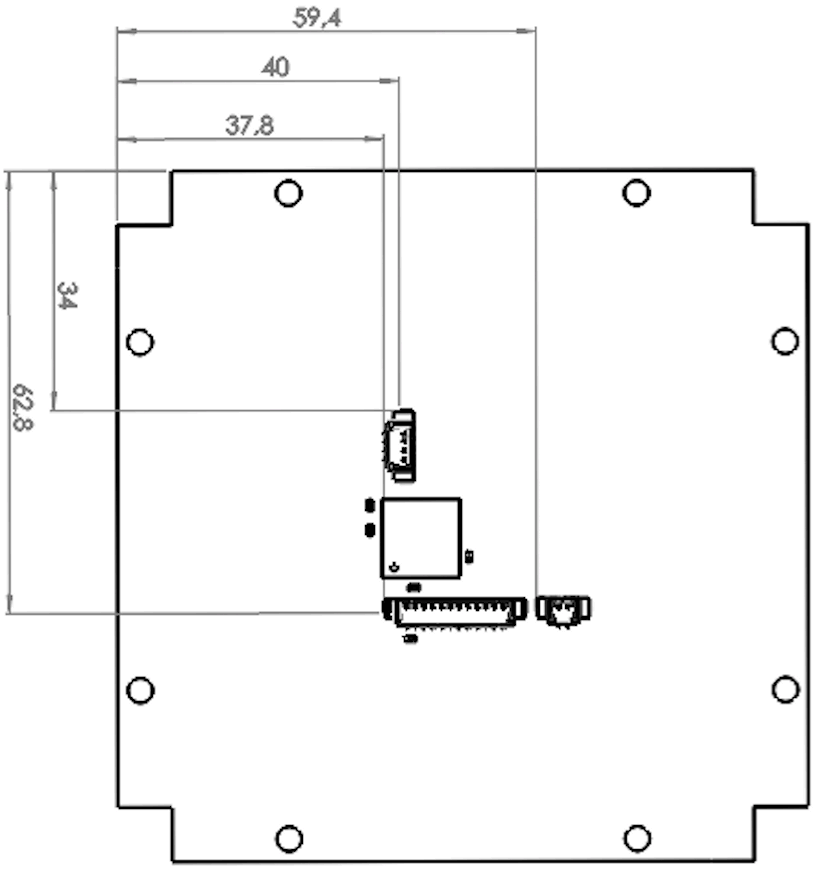


Figure 11 - Solar panel Z - Bottom view (connector location)

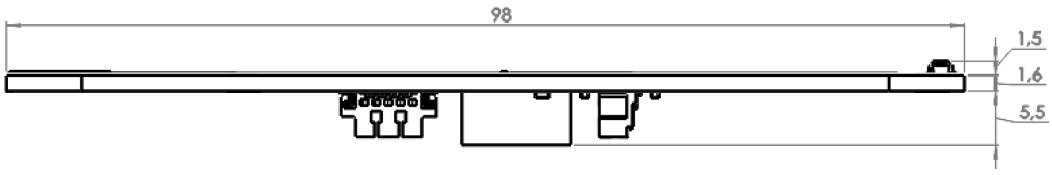


Figure 12 - Solar Panel Z - Side view

8.4 Solar Panels Z with magnetorquer

Solar Panels Z with and without magnetorquer differ only on the thickness of the PCB. The difference is due to the presence of the electromagnetic coils inside the PCB of the Solar panels with magnetorquer.

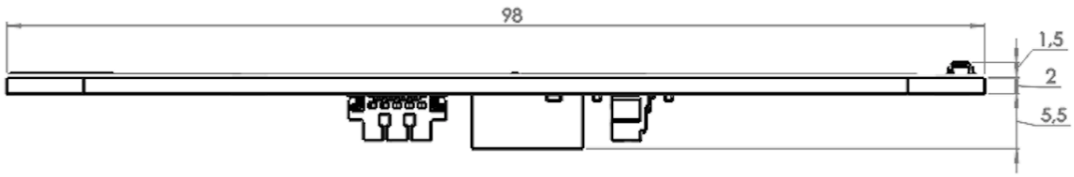


Figure 13 - Solar Panel Z with magnetorquer - Side view

9 CUSTOMIZATION

EnduroSat Solar Panels can be customized with an additional connector for external magnetorquer. Figure 3 shows the location of the pads for mounting the MOLEX 53261-0271 connector.

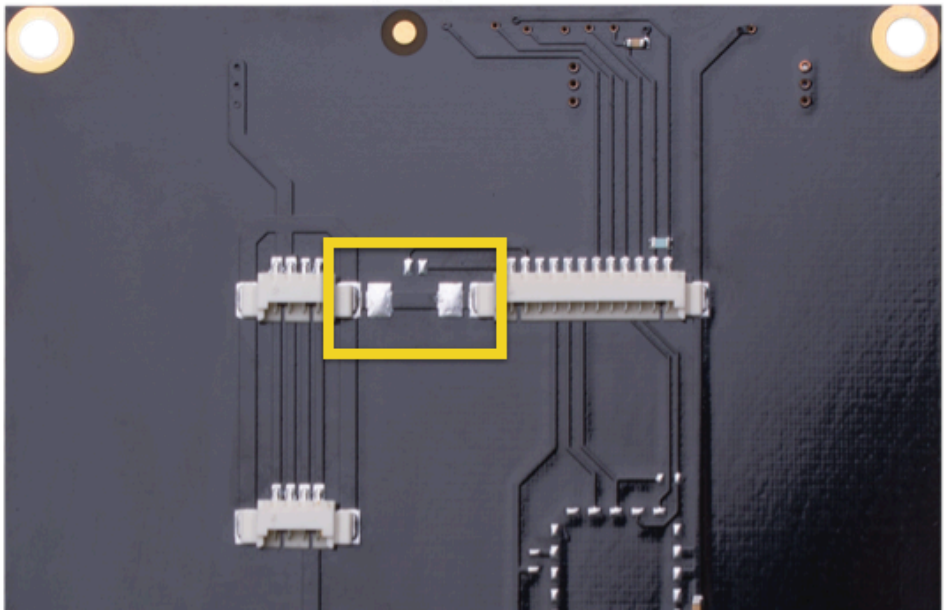


Figure 14 - Solar Panels X Y - bottom side - pads location for the external magnetorquer connector

To access the satellite, solar panels can be customized upon request with connectors and external interfaces.

10 MATERIAL AND ASSEMBLING

Solar Panels PCB Material is FR4-Tg170. Production process follows quality standard:

- IPC-A-600H II (Surface),
- IPC-A-6012 (Function),
- IPC-TM-650 (Test method).

11 ENVINRONMENTAL AND MECHANICAL TESTS

A full campaign of tests at qualification level was performed on the Solar Panel qualification engineering model Qualification tests level and duration follow the ESA standard ECSS-E-ST-10-03C and GEVS: GSFC-STD-7000A. Test performed:

- Thermal Cycling
- Thermal Vacuum
- Random Vibration
- Sine Vibration
- Shock Test

12 INCLUDED IN THE SHIPMENT

EnduroSat provides along with the Solar Panel:

- Power cable (PTFE Material Jacket, 26AWG), connector MOLEX 51021-0400[1]
- Sensors and magnetorquer cable (PTFE Material Jacket, 26AWG), connector MOLEX 51021-1200[2]
- Bolts Torx - DIN965/ISO 7046-1 - M3 – Length: 6mm
- RBF external pin (solar panel X/Y with RBF)
- USB stick with user manual

[1]Available lengths: 21cm, 15cm, 8cm.

[2]Available lengths: 20cm, 18cm, 10cm, 5cm

Customized cables and connectors can be provided upon request

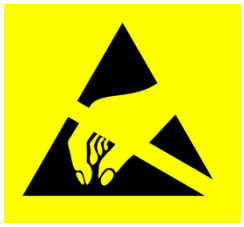
13 HANDLING AND STORAGE

Particular attention shall be paid to the avoidance of damage to the Solar Cells of the solar panels during handling, storage and preservation. The handling of the Solar Panel should be performed in compliance with the following instructions:

- Handle using PVC, latex, cotton (lint free) or nylon gloves.
- The environment where the solar panels will be handled shall meet the requirements for a class environment 100,000, free of contaminants such dust, oil, grease, fumes and smoke from any source.
- Do not touch the solar cells
- Solar panels must be handled by touching PCB edges only
- Solar Panels shall be stored in such a manner as to preclude stress and prevent damage
- To prevent the deterioration of the Solar Cells, Solar panel must be stored in a controlled environment, i.e. the temperature and humidity levels shall be maintained in the proper ranges:
    - Ideal storage temperature range: 15ºC to 27ºC
    - Ideal storage humidity range: 30% to 60% relative humidity (RH)

14 WARNINGS

This product uses very fragile components. Observe precautions for Handling.



This product uses semiconductors that can be damaged by electrostatic discharge (ESD). Observe precautions for Handling

Sensitive Electronic device. Do not ship or store near strong electrostatic, electromagnetic, magnetic or radioactive fields.