



USER MANUAL

3U Solar Panel

1	Change Log	3
2	Acronyms List	4
3	Description	5
4	Product Performance And Properties.....	5
4.1	Solar Panels Features And Characteristics	5
4.2	Solar Cell Features And Characteristics	6
5	Available Configurations.....	6
5.1	3U Solar Panel X/Y	7
5.2	3U Solar Panels X/Y With RBF	8
6	Connector Pinout.....	9
6.1	Connectors Location	9
6.2	Connector Pinout 3U Solar Panel With RBF And Communication Interfaces.....	11
7	Specifications	13
8	Mechanical Characteristics	14
8.1	3U Solar Panels X/Y	15
8.2	3U Solar Panels X/Y With RBF	17
9	Customization.....	19
10	Material And Assembling.....	19
11	Included In The Shipment	20
12	Handling And Storage.....	20
13	Warnings	21

SOLAR PANEL – 3U

USER MANUAL

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

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

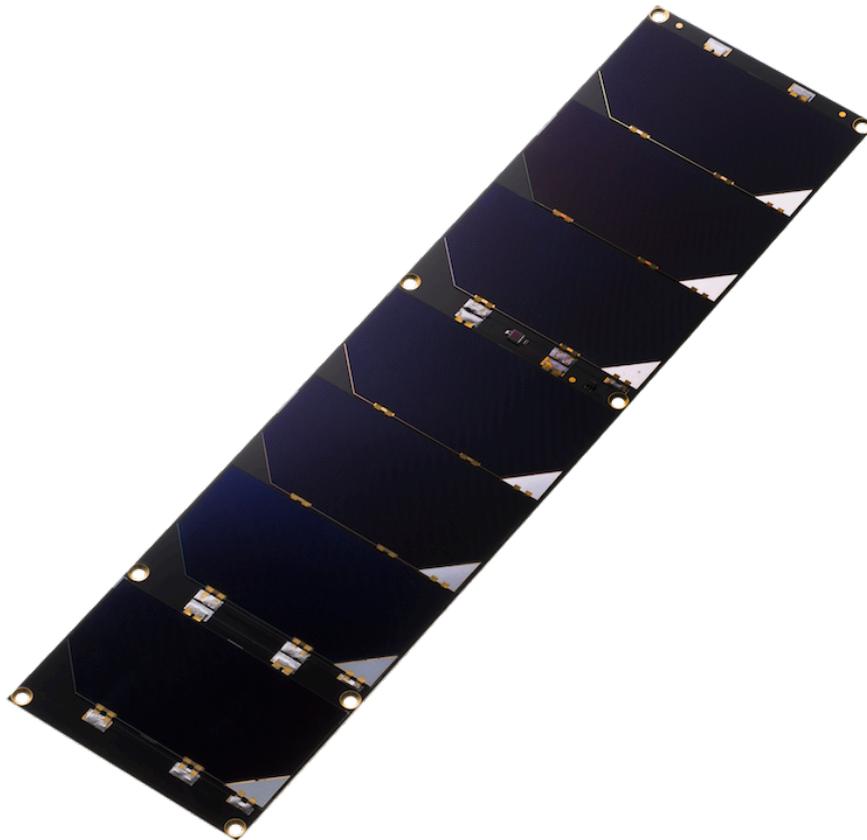


Figure 1

1 CHANGE LOG

Date	Version	Note
22/05/2016	Rev 1	
21/11/2017	Rev 1.2	Minor text enhancements, Solar panel with RBF and interfaces added

2 ACRONYMS LIST

GEO	Geostationary Earth Orbit
LEO	Low Earth Orbit
PCB	Printed Circuit Board
FT	Functional Test
SCA	Solar Cell Assembly
ESA	European Space Agency
ECSS	European Cooperation Space Standardization

3 DESCRIPTION

EnduroSat 3U Solar Panels are equipped with 7 CESI Solar cells CTJ30 with 29.5% efficiency. The wide effective cell area (the largest possible for solar panels suitable for 3U CubeSats) provides up to 8.43 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

- Seven CESI Solar Cells CTJ30, space qualified triple junction (specs in the following paragraph);
- 211.05 cm² effective cell area (7 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 8.43 Watt in LEO;
- Gold plated invar interconnectors;
- 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;
- Maximum Voltage – 16.31V (for 7 cells at 25°C);
- Maximum Current – 517mA;
- Solar cells bonding with silicone adhesive with minimum outgassing behavior according to ECSS-Q-70-02A (corresponds to former ESA PSS-01-701);
- Weight: 136g (without magnetorquer)

4.2 Solar Cell Features and Characteristics

- Efficiency up to 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;
- Cell area size 30.15 cm²;
- High Radiation Resistance;
- Cover glass CMG100 (100µm thick);
- Good mechanical strength.

5 AVAILABLE CONFIGURATIONS

EnduroSat 3U Solar Panels are available in 3 configurations.

- 3U Solar Panel X/Y
- 3U Solar Panel X/Y with RBF pin and Communication Interface Connector
- 3U Solar Panel X/Y MTQ (with Magnetorquer customizable upon request)

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

5.1 3U Solar panel X/Y**3U Solar Panels X/Y Standard
(no magnetorquer)**

- 7 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: 127 g

**3U Solar Panels X/Y with
magnetorquer**

- 7 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: 155 g

5.2 3U Solar Panels X/Y with RBF

This configuration of the 3U solar panel X/Y has a Remove Before Flight pin which 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)

- 7 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
- 3 communication interfaces
- Weight: 130 g

5.2.1 Figure 2 shows the front part of the 3U solar panel and the location of the RBF pin and 4-pin connector.

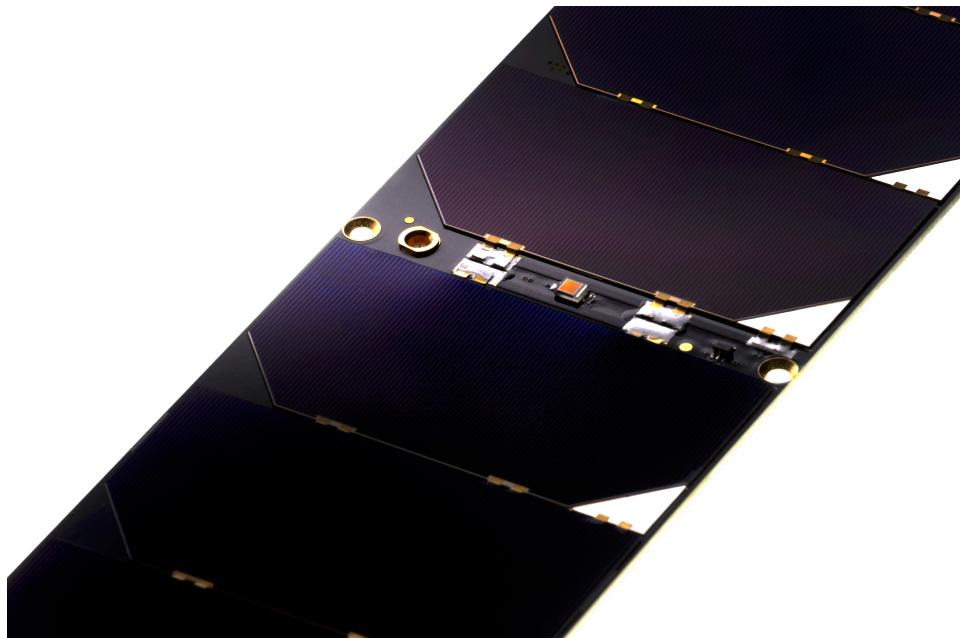


Figure 2 – close up of the 3U Solar panel with RBF and communication interfaces

6 CONNECTOR PINOUT

EnduroSat 3U 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.

6.1 Connectors location

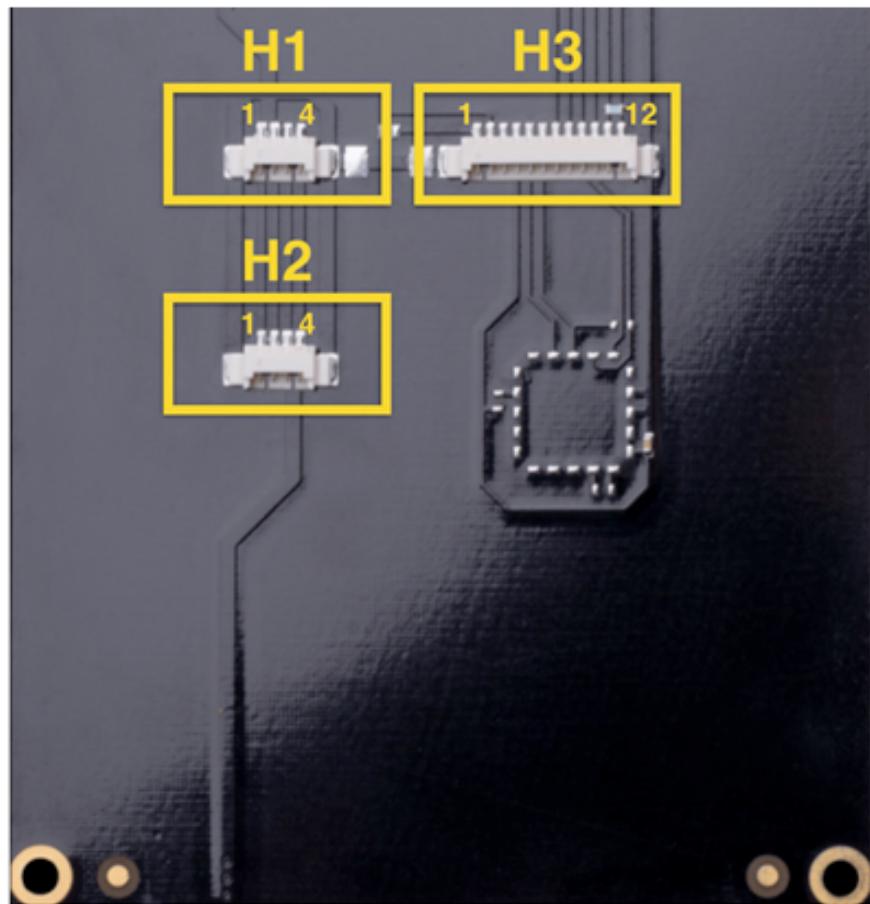


Figure 3 – 3U Solar Panel X/Y - bottom side close-up view - Connectors location

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 3U solar panel with RBF and communication interfaces

The figures below show location and pinout of the 3 communication interfaces and of the RBF connector.

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

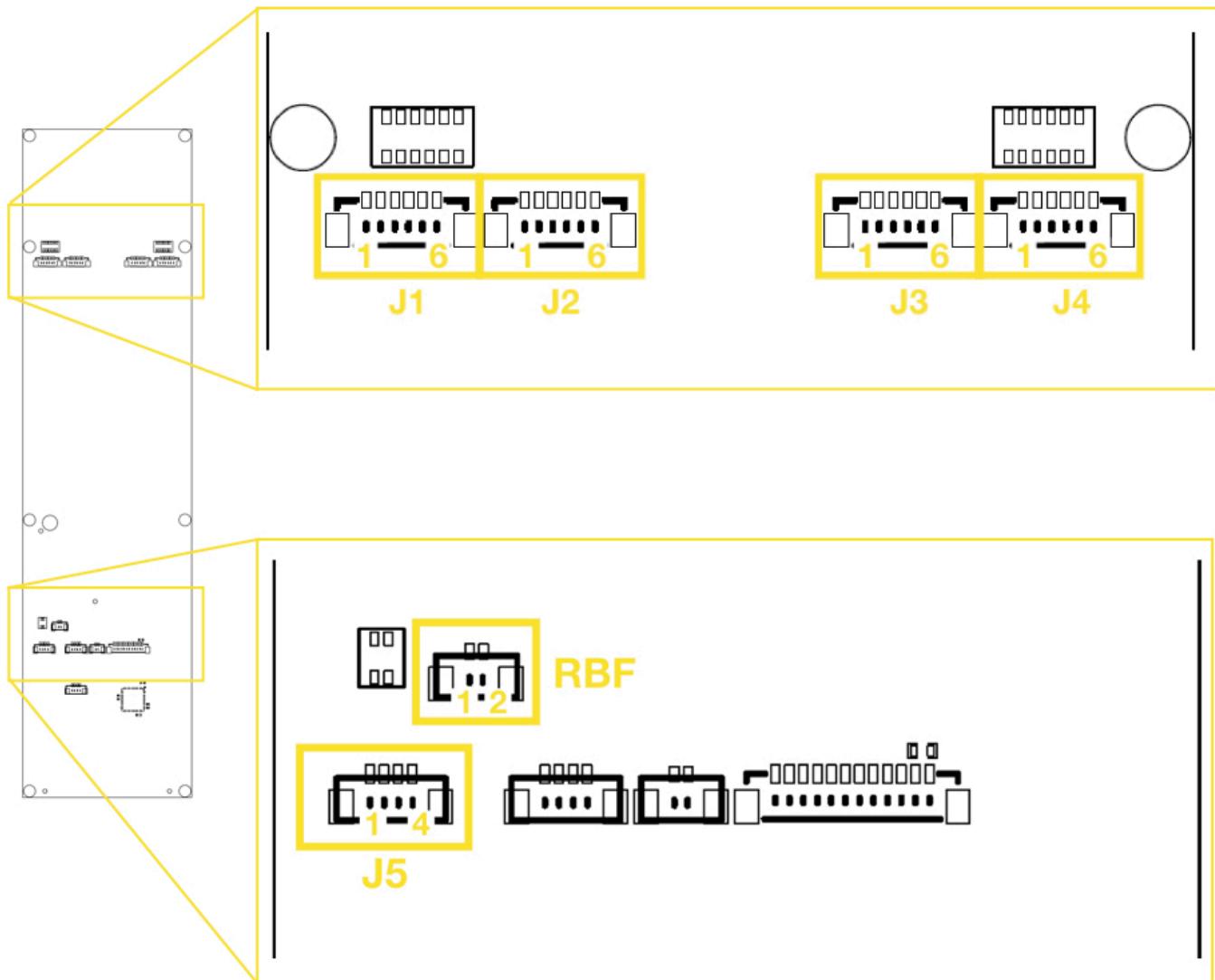


Figure 4 - RBF and interface communication connectors - 3U solar panel back

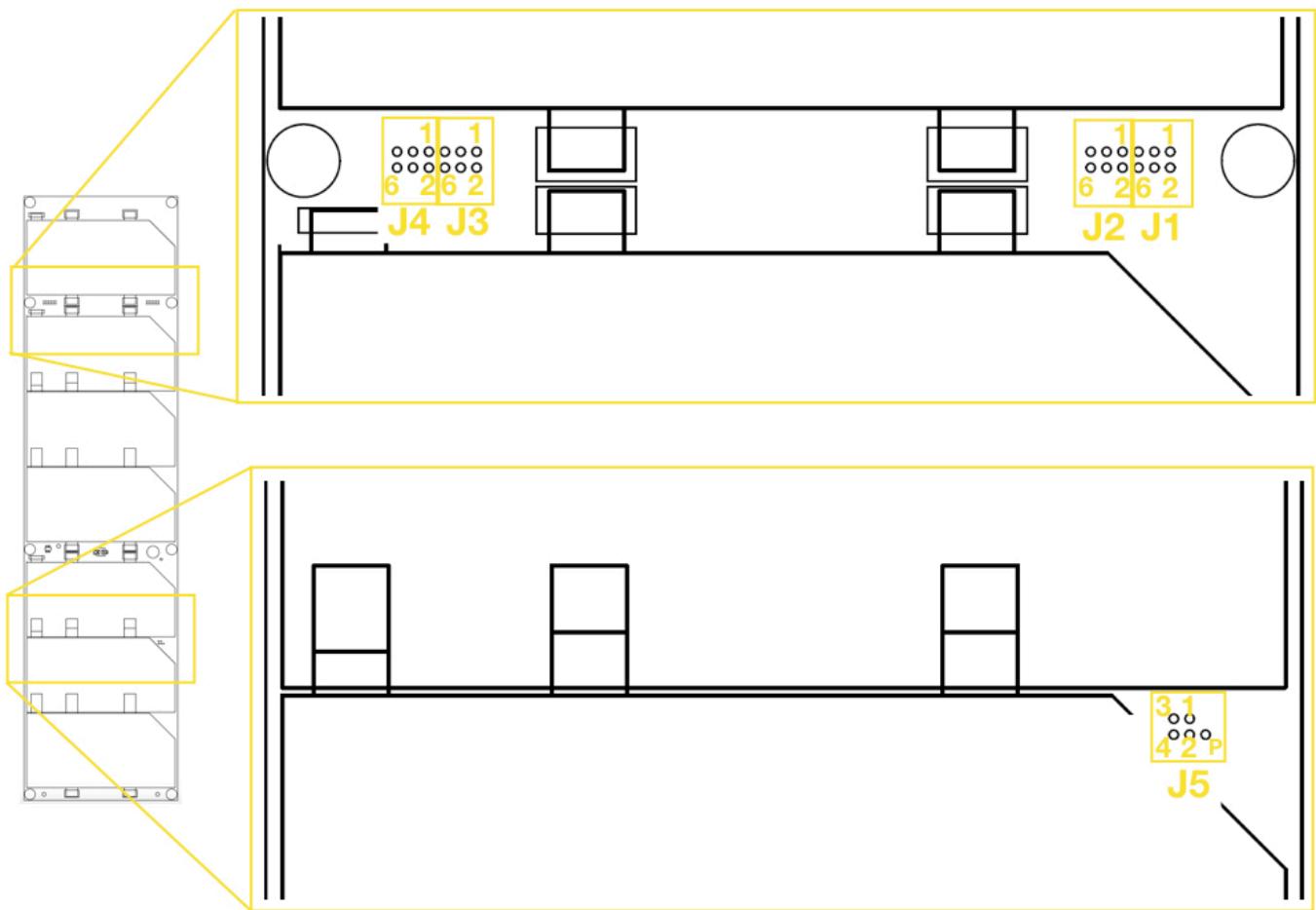


Figure 5 - RBF and interface communication connectors - 3U solar panel back

6.2.1 Communication interface connector J1-J4

Pin	Description
1	User customizable
2	User customizable
3	User customizable
4	User customizable
5	User customizable
6	User customizable

6.2.2 Communication interface connector 5

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

6.2.3 RBF connector

Pin	Description
1	RBF
2	GND

7 SPECIFICATIONS

SOLAR CELL STRING					
Parameter	Unit	Condition	Min	Typ	Max
Voltage (V_m)	V	25°C			16.31
Current at (I_m)	mA	25°C			517
Power	mW	25°C			8432
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
Spectral Sensitivity	nA/lx	V _R =5V, standard light A, T=2856K		6.3	
Wavelength of max sensitivity ($\lambda_{S_{max}}$)	nm			570	
Range of Spectral sensitivity ($\lambda_{10\%}$)	nm		400		900
Half angle	deg			±60°	

8 MECHANICAL CHARACTERISTICS

EnduroSat 3U 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 3U Solar Panels X/Y

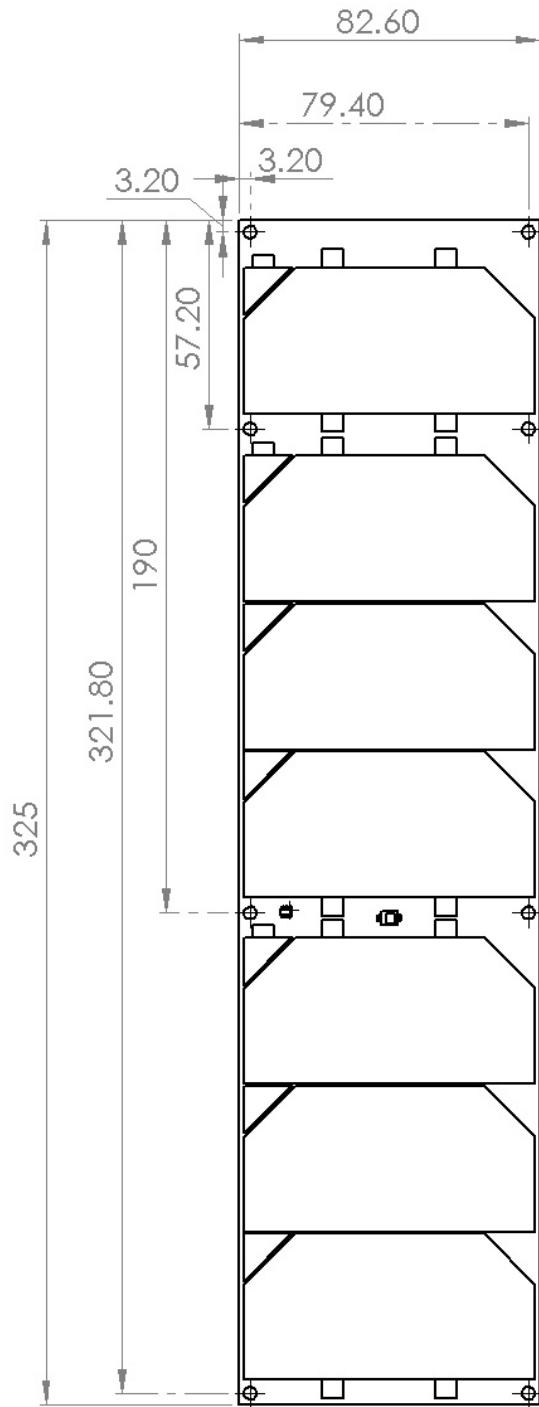


Figure 6 – 3U Solar Panel X/Y

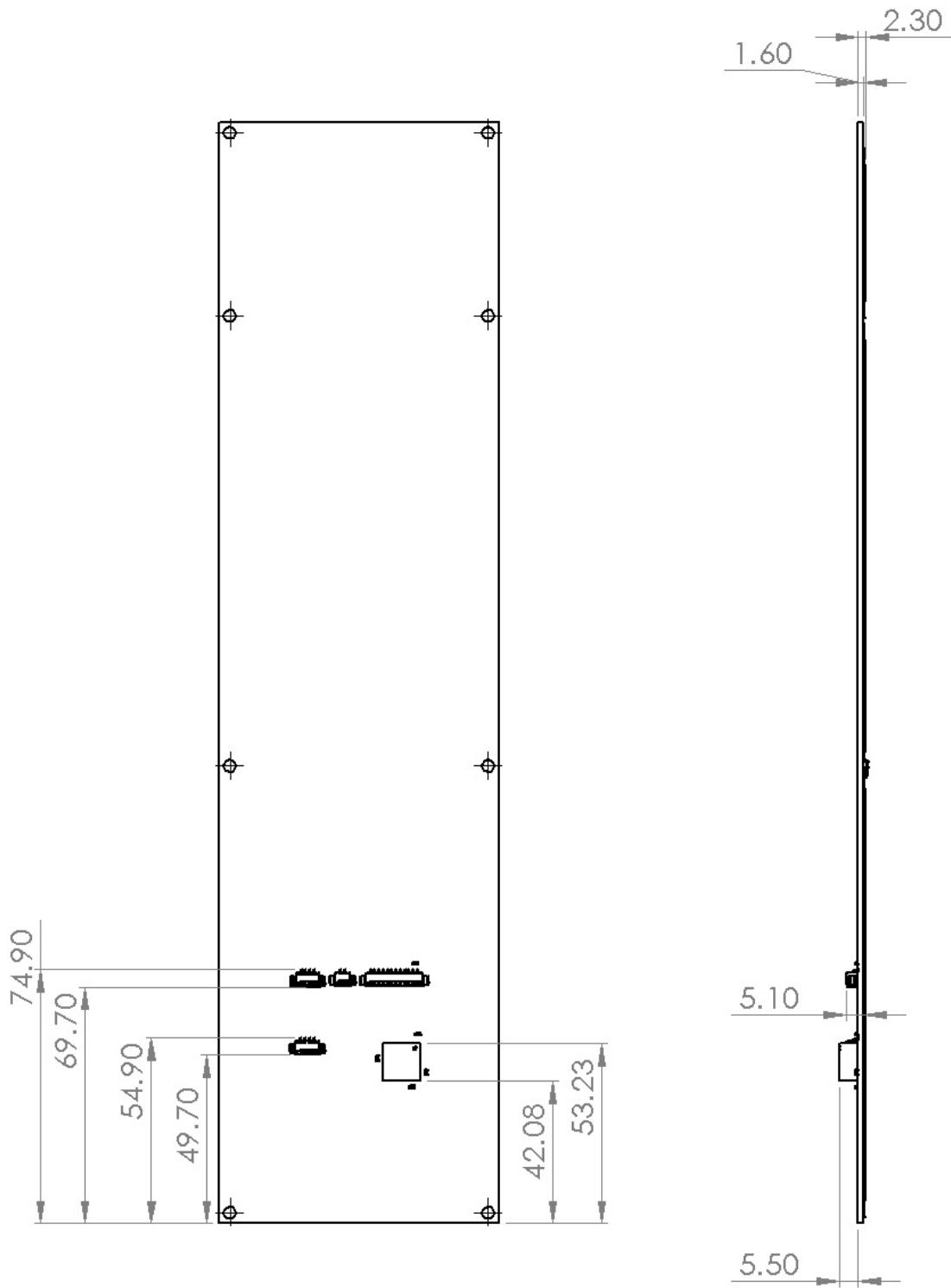


Figure 7 – 3U Solar Panel X/Y 3U

8.2 3U Solar Panels X/Y with RBF

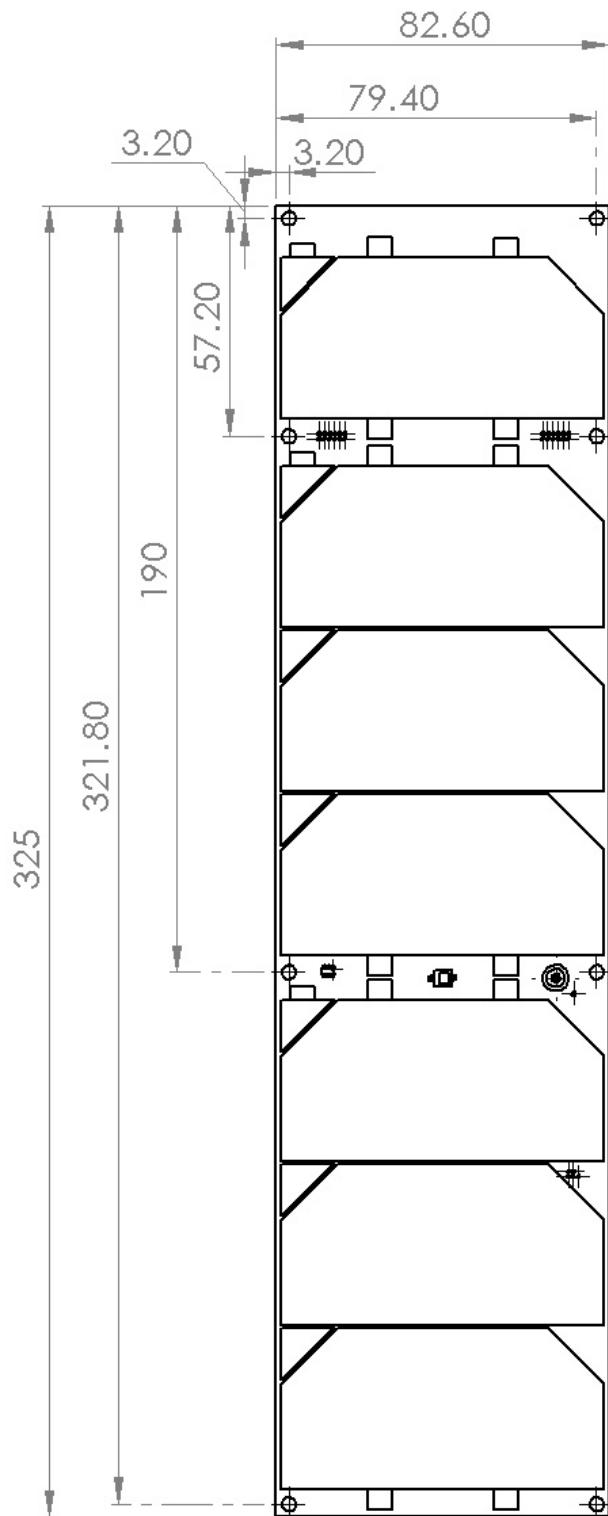


Figure 8 - 3U Solar Panels X/Y with RBF

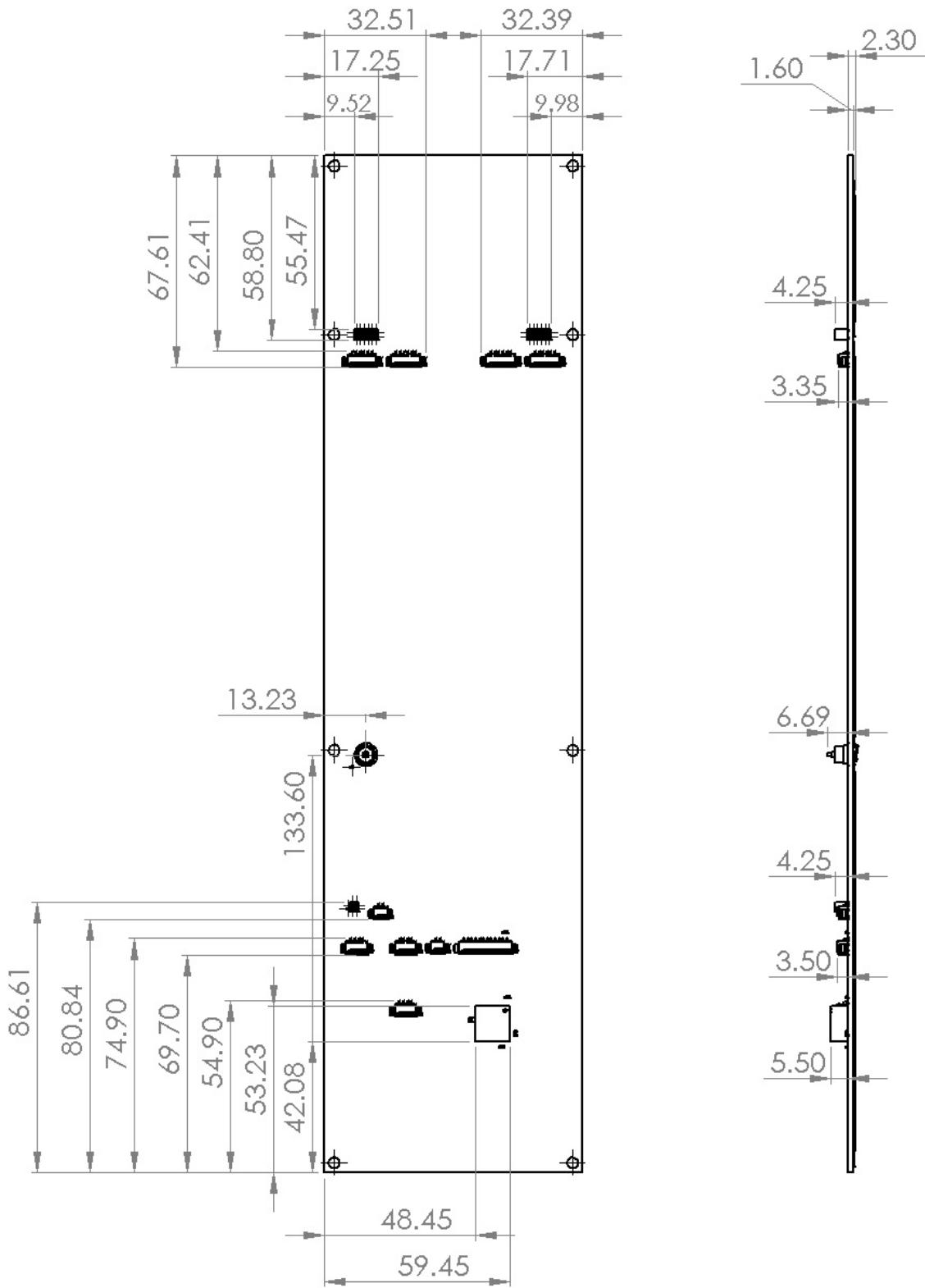


Figure 9 - 3U Solar Panels X/Y with RBF

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.

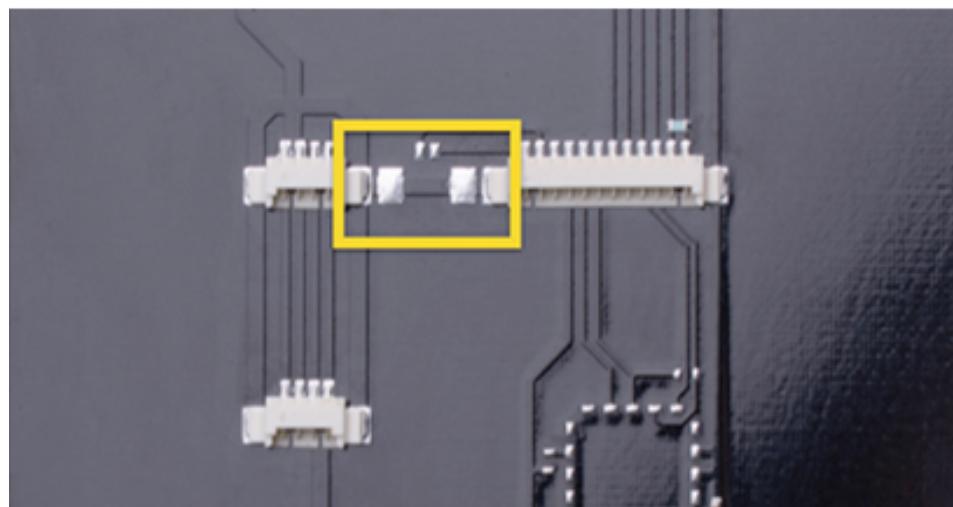


Figure 10 – 3U Solar Panels X/Y - bottom side - pads location for the external magnetorquer connector

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)

Component mounting quality standards:

- IPC-A-600 Acceptability of printed boards,
- IPC-A-610E Acceptability of Electronic Assemblies,
- J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies,
- ISO 14644 Cleanrooms and associated controlled environments,
- IEC 61340 Electrostatics ESD: Protection of electronic devices from electrostatic phenomena.

11 INCLUDED IN THE SHIPMENT

EnduroSat provides along with the 3U Solar Panel:

- Power cable (PTFE Material Jacket, 26AWG), connector MOLEX 51021-0400
- Sensors and magnetorquer cable (PTFE Material Jacket, 26AWG), connector MOLEX 51021-1200
- Bolts Torx - DIN965/ISO 7046-1 - M3 – Length: 6mm
- USB stick with user manual

Customized cables and connectors can be provided upon request.

12 HANDLING AND STORAGE

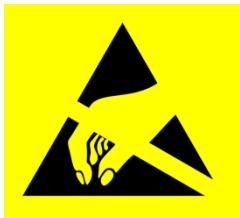
Particular attention shall be paid to the avoidance of damage to the Solar Cells of the solar panels during handling, storage and preservation. The handling of the Solar Panel should be performed in compliance with the following instructions:

- 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: 15°C to 27°C
 - Ideal storage humidity range: 30% to 60% relative humidity (RH)

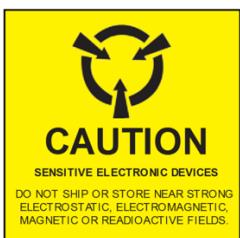
13 WARNINGS



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.