
# DATASHEET

3U Solar Panel

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This user manual details the applications, features and operation of EnduroSat's 3U Solar Panel.

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

Figure 1: 3U Solar Panel X/Y

## 1 CHANGE LOG

| Date | Version | Note |
|---|---|---|
| 22/05/2016 | Rev 1 | Initial |
| 21/11/2017 | Rev 1.2 | Minor text enhancements, Solar panel with RBF and interfaces added |
| 23/10/2018 | Rev 1.3 | Technical writing enhancements. |
| 13/02/2019 | Rev 1.4 | Minor text change on Sections 8 & 11 |

# 2 ACRONYMS LIST

| | |
|---|---|
| ADCS | Attitude Determination and Control System |
| CIE | International Commission on Illumination |
| ECSS | European Cooperation Space Standardization |
| EPS | Electrical Power System |
| ESA | European Space Agency |
| GEO | Geostationary Earth Orbit |
| GEVS | General Environmental Verification Standard |
| GND | Ground |
| LEO | Low Earth Orbit |
| MTQ | Magnetorquer |
| PCB | Printed Circuit Board |
| RBF | Remove Before Flight |
| RH | Relative humidity |
| SCA | Solar Cell Assembly |
| SCIC | Satellite Communication Interface Connector |
| SPI | Serial Peripheral Interface |

# 3 DESCRIPTION

EnduroSat's 3U Solar Panels are equipped with 7 CESI Solar cells of type CTJ30 with up to a 29.5% efficiency. The wide effective cell area is the largest possible for solar panels suitable for 3U CubeSats and provides up to 8.43 Watts per panel in a LEO.

On the PCB, a network of sensors and a magnetorquer can be interfaced to an Attitude Determination and Control System(ADCS). The network can be all or a combination of the following: temperature sensor, Sun sensor, magnetorquer, and gyroscope. The temperature sensor and Sun sensor (photodiode) are positioned on the top surface of the solar panel whereas the magnetorquer and gyroscope are positioned within the solar panel and not visible. The magnetorquer is a series of large electrical coils positioned over several layers of a multi-layer PCB. Furthermore, the PCB is equipped with a connector for an external magnetorquer.

Solar panel configurations on the outside of the satellite can be simple or complex. Therefore, using our connector system on the PCB, multiple solar panels can be easily connected in an electrical series or parallel configuration. The solar panels are then typically connected to an Electrical Power System (EPS) module.

Also, customization of the panel for additional external connectors (e.g. an RBF 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 $cm^2$ 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 70 µm copper layers
- Plated, countersink mounting holes with ground connection
- Connector for external magnetorquer
- Maximum Voltage – 16.31V (for 7 cells at 25ºC)
- 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)

- Thickness 2.2 mm ±150 µm

### 4.2 Solar Cell Features and Characteristics

- Efficiency up to 29.5%
- Triple Junction Solar Cells InGaP/GaAs/Ge
- Very low solar cell mass (81-89 mg/cm2)
- Thickness of solar cell 155 µm ±15 µm
- Fully qualified under ESA Standard ECSS E ST20-08C for LEO and GEO
- Internal by-pass diode for optimized power output
- Cell area size 30.15 $cm^2$
- High radiation resistance
- Coverglass CMG (150 µm thick)
- Good mechanical strength

## 5 AVAILABLE CONFIGURATIONS

EnduroSat's 3U Solar Panels are available in 3 configurations.

- 3U Solar Panel X/Y
- 3U Solar Panel X/Y RBF (i.e. with Remove Before Flight pin)
- 3U Solar Panel X/Y MTQ (i.e. with Magnetorquer)

Where:

i) X/Y indicates the panel can be used on the side panels of the CubeSat.

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

## 5.1 3U Solar Panel X/Y and X/Y MTQ

| 3U Solar Panel X/Y<br>(i.e. without magnetorquer) | 3U Solar Panel X/Y MTQ<br>(i.e. with magnetorquer) |
|---|---|
| • 7 CTJ30 SCA CESI<br>• Temperature sensor<br>• Gyroscope (optional)<br>• Sun sensor<br>• Multiple panels can be connected in electrical series or parallel<br>• Internal by-pass diode for optimized output power<br>• Weight: 127 g | • 7 CTJ30 SCA CESI<br>• Magnetorquer<br>• Temperature sensor<br>• Gyroscope<br>• Sun sensor<br>• Multiple panels can be connected in electrical series or parallel<br>• Internal by-pass diode for optimized output power<br>• Weight: 155 g |

## 5.2 3U Solar Panel X/Y RBF

The 3U solar panel X/Y RBF has a Remove Before Flight (RBF) pin which ensures that the satellite cannot be switched on while the RBF pin is inserted. The RBF connector on the bottom side of the solar panel should be connected to the RBF connector of the power module with a cable.

**Solar Panels X/Y RBF**
**(i.e. with RBF, and without magnetorquer)**

- 7 CTJ30 SCA CESI
- Temperature sensor
- Gyroscope (optional)
- Sun sensor
- Multiple panels can be connected in series or parallel
- Internal by-pass diode for optimized output power
- Remove Before Flight (RBF) pin
- Multiple Satellite Communication Interface Connectors (SCIC)
- Weight: 130 g

Figure 2 shows the front part of the 3U Solar Panel X/Y RBF and the location of the Remove Before Flight (RBF) pin.

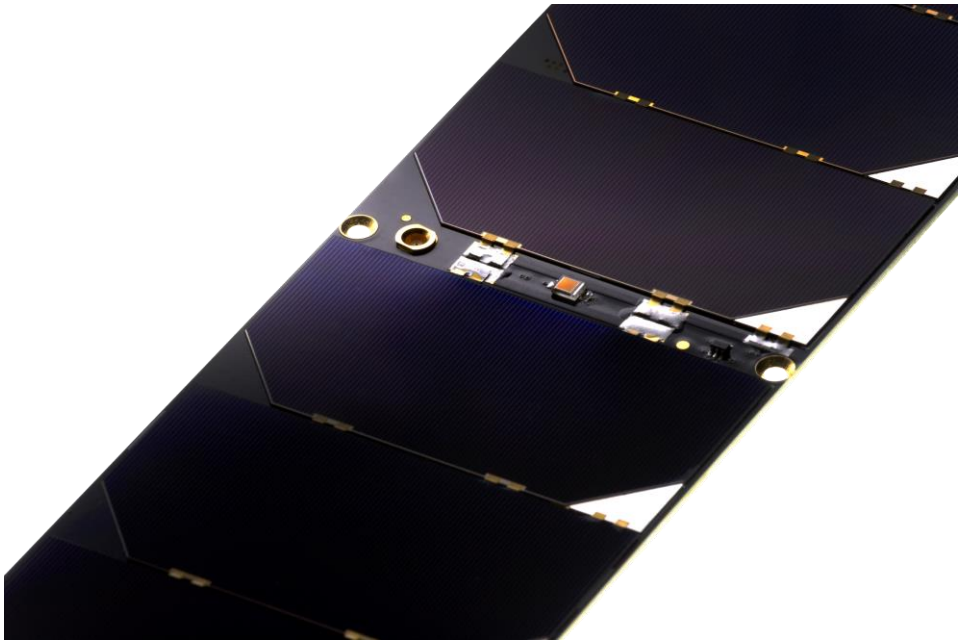


Figure 2: Close-Up of the 3U Solar Panel X/Y RBF

# 6 CONNECTORS

## 6.1 Power Output, and Sensors and Magnetorquer (MTQ) Connectors

EnduroSat's 3U solar panels provide three connectors for power output from the solar cells, sensor communication and magnetorquer control:

- H1 – Output Power Bus Connector
- H2 – Output Power Bus Connector
- H3 – Sensors and Magnetorquer Connector

The H1 and H2 connectors are connected on to the same power bus and are electrically identical. Having the two connectors (H1 and H2) allows other solar panels to be easily connected in either an electrical series or parallel configuration.

The H1,H2, and H3 connectors are in the same position for all 1U, 1.5U and 3U solar panels.

### 6.1.1 H1, H2, and H3 Location

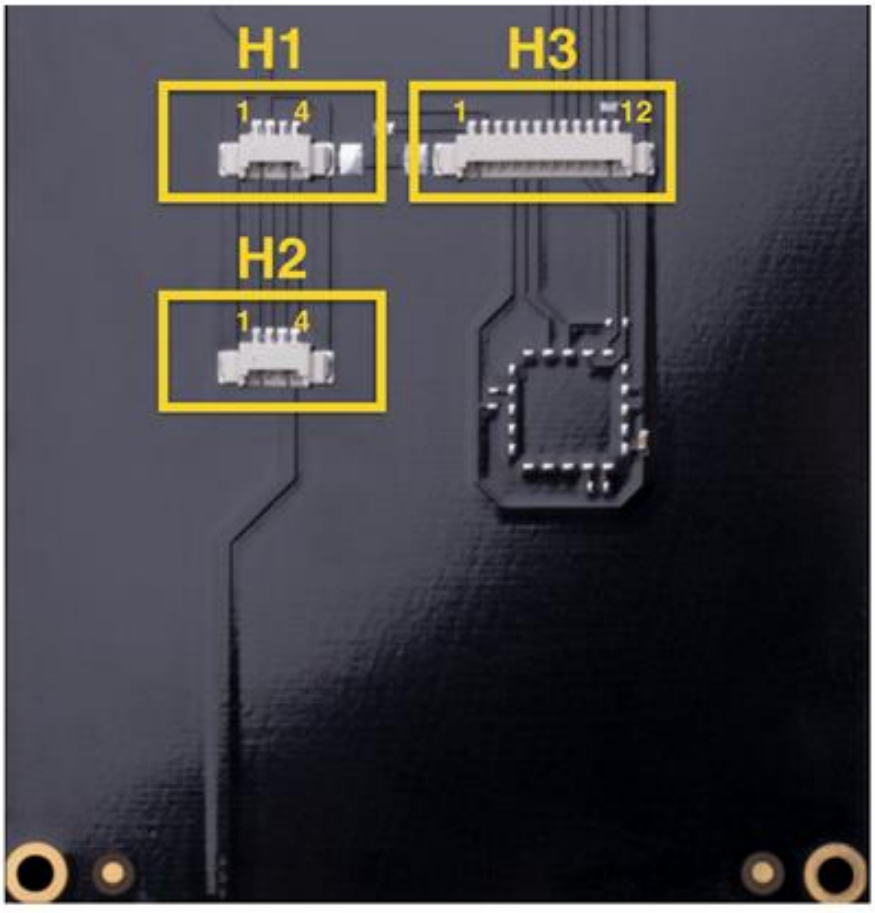



Figure 3: Solar Panel - Bottom Side

### 6.1.2 H1 Pinout (Power Output)

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

### 6.1.3 H2 Pinout (Power Output)

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

### 6.1.4 H3 Pinout (Sensors and Magnetorquer)

| 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 Remove Before Flight (RBF) Connector

The figure below shows the location and pinout of the RBF connector (MOLEX 53261-0271).

### 6.2.1 RBF Location

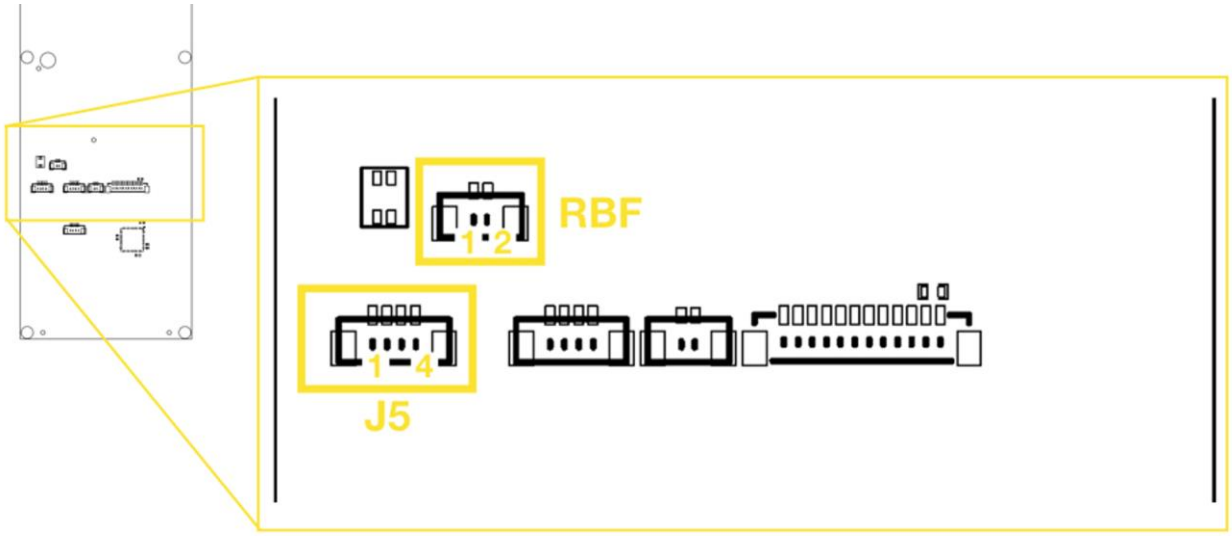



Figure 4: Remove Before Flight (RBF) Connector - Bottom Side

### 6.2.2 RBF Pinout

| Pin | Description |
|---|---|
| 1 | RBF |
| 2 | GND |

## 6.3 Satellite Communication Interface Connector (SCIC)

The 5-pin and 6-pin Satellite Communication Interface Connector (SCIC) sockets provide general purpose (e.g. testing) and user configurable communication or charging capabilities to the other modules within the satellite. Their purpose is to prevent disassembling of the satellite which can be very time consuming, or even forbidden after an official test campaign. The SCIC socket on the top side of the solar panel is an electrical bypass (of the solar panel) to its equivalent SCIC plug on the bottom side which can then be connected to the internal modules. In the EnduroSat platform for instance, these interfaces are used to access the USB port of the On-Board Computer (OBC), or for charging the batteries of the EnduroSat power module.

### 6.3.1 SCIC Location (J1,J2,J3, J4, and J5)

The figures below show the location and pinout of the Satellite Communication Interface Connectors (SCIC). The pitch of the SCIC connector is 1.27mm (50mils).

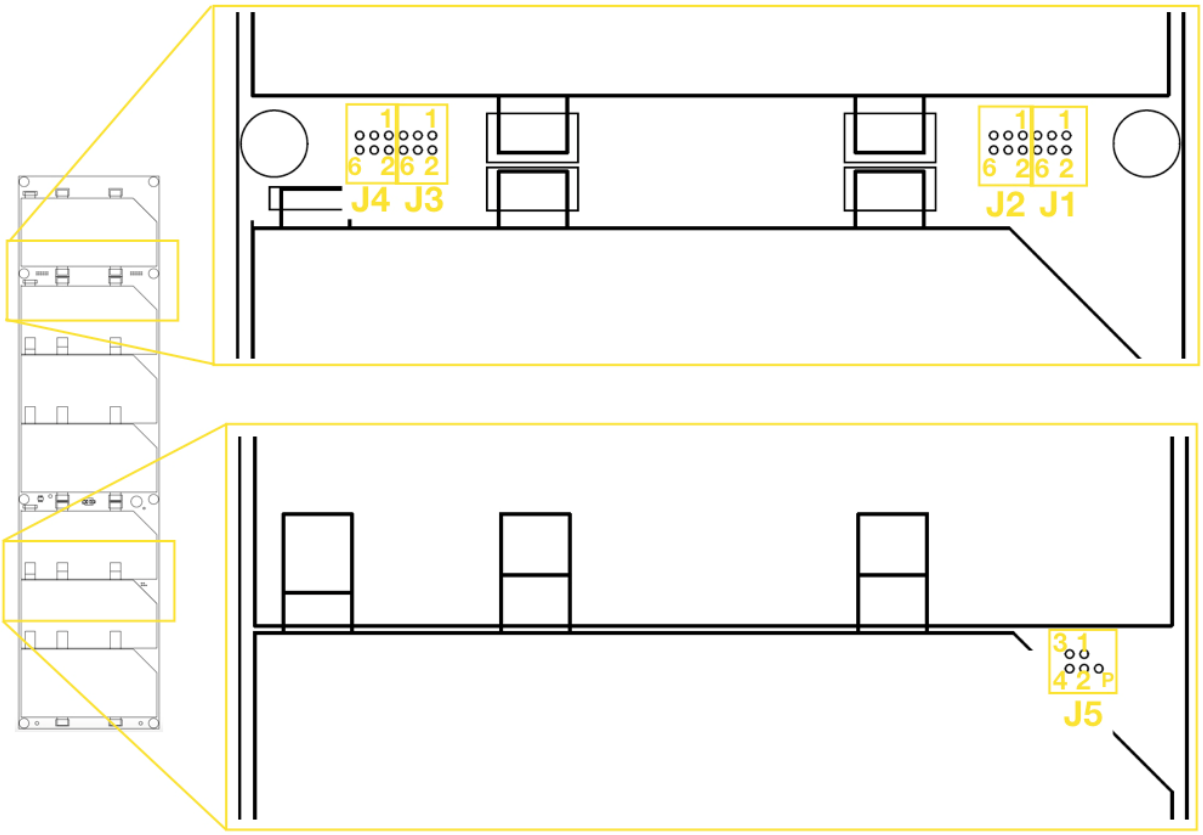



Figure 5: SCIC (J1,J2,J3,J4 and J5) Connectors – Top Side

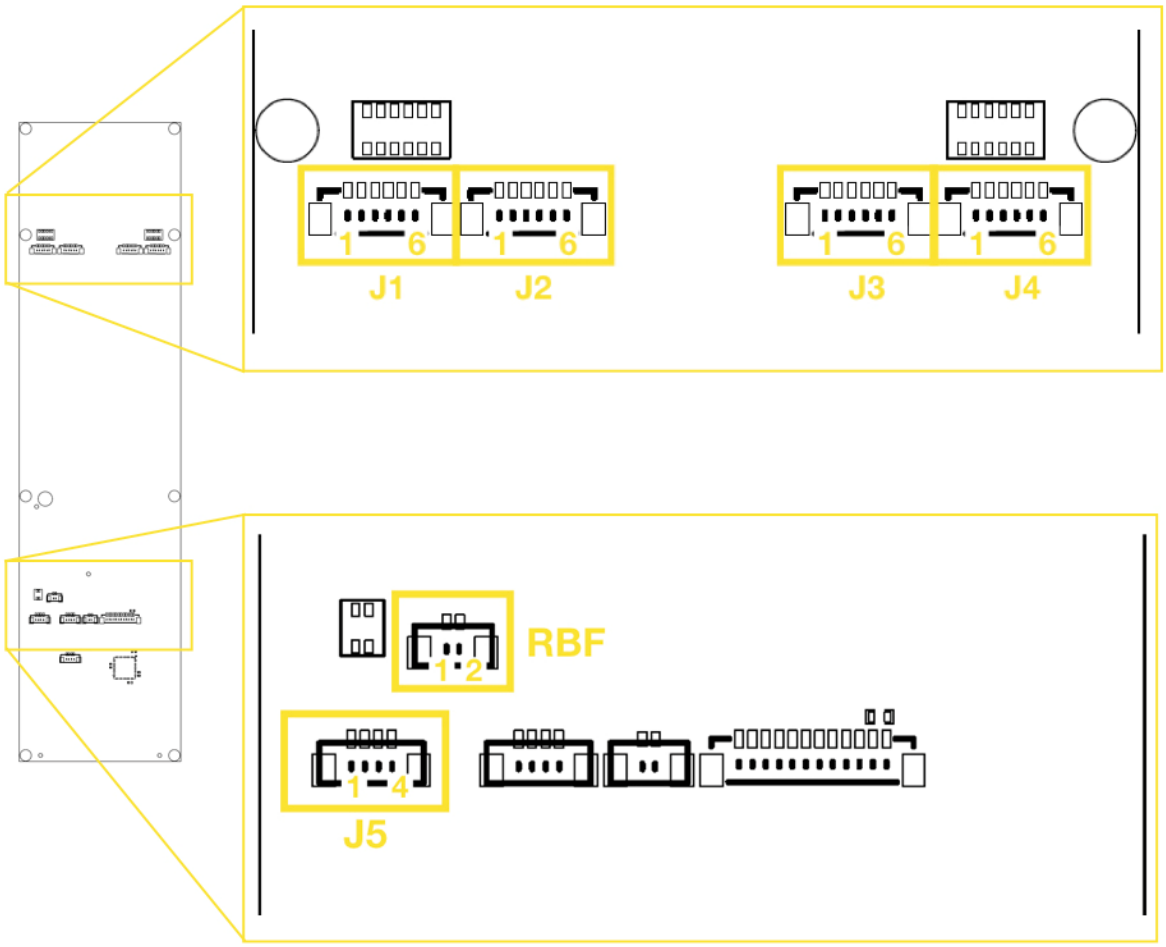



Figure 6: SCIC (J1,J2,J3,J4 and J5) Connectors - Bottom Side

### 6.3.2 SCIC Pinouts (J1, J2, J3, and J4)

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

### 6.3.3 SCIC Pinouts (J5)

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

# 7 SPECIFICATIONS

| SOLAR CELL STRING | | | | | |
|---|---|---|---|---|---|
| Parameter | Unit | Condition | Min | Typ | Max |
| Voltage ($V_m$) | V | 25ºC | | | 16.31 |
| Current at ($I_m$) | mA | 25ºC | | | 517 |
| Power | mW | 25ºC | | | 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's 3U Solar Panel X/Y should be mounted on the EnduroSat Structure using bolts of type:

- 4x DIN965/ISO 7046-1 Torx M3 – Length: 6mm – screwed at the top and bottom holes of the solar panel
- 4x DIN965/ISO 7046-1 Torx M3 – Length: 4mm – screwed at the four middle holes of the solar panel

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

A STEP file can be provided upon request.

## 8.1 3U Solar Panel X/Y and X/Y MTQ

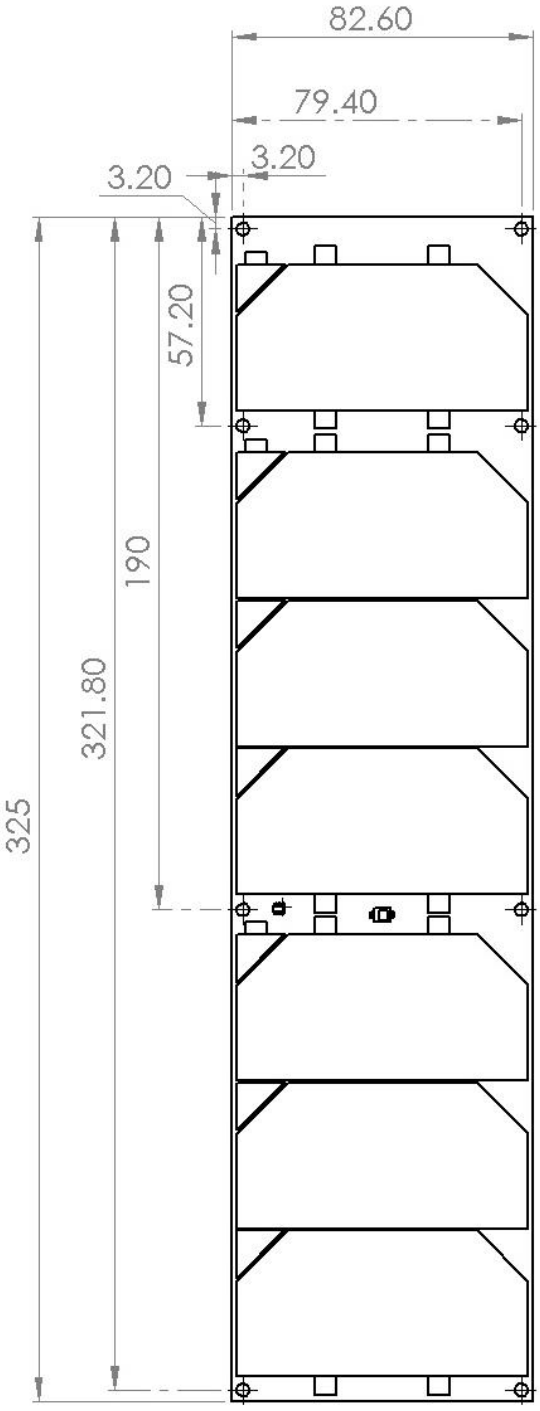



Figure 7: 3U Solar Panel X/Y and X/Y MTQ

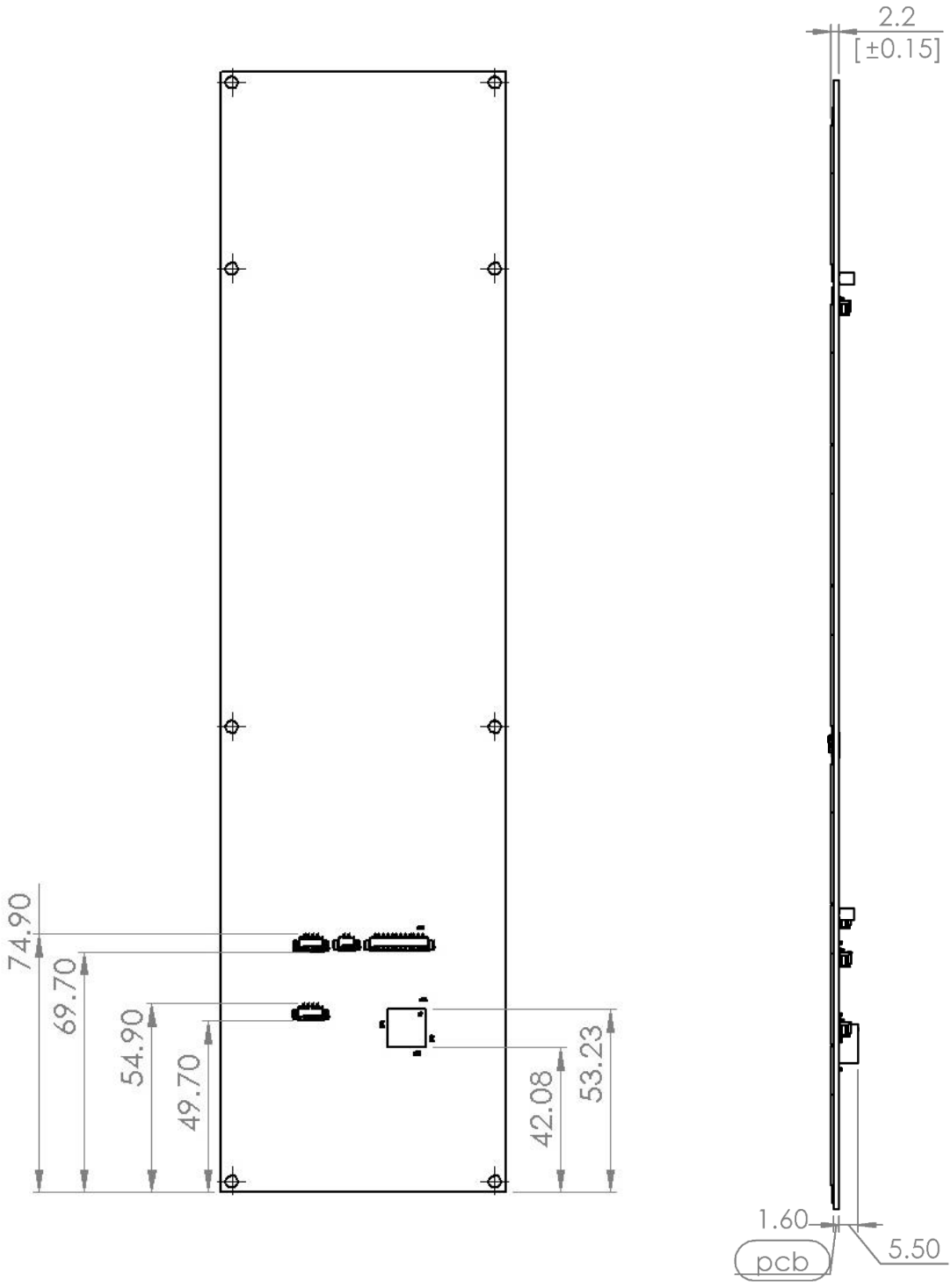



Figure 8: 3U Solar Panel X/Y and X/Y MTQ

## 8.2 3U Solar Panel X/Y RBF

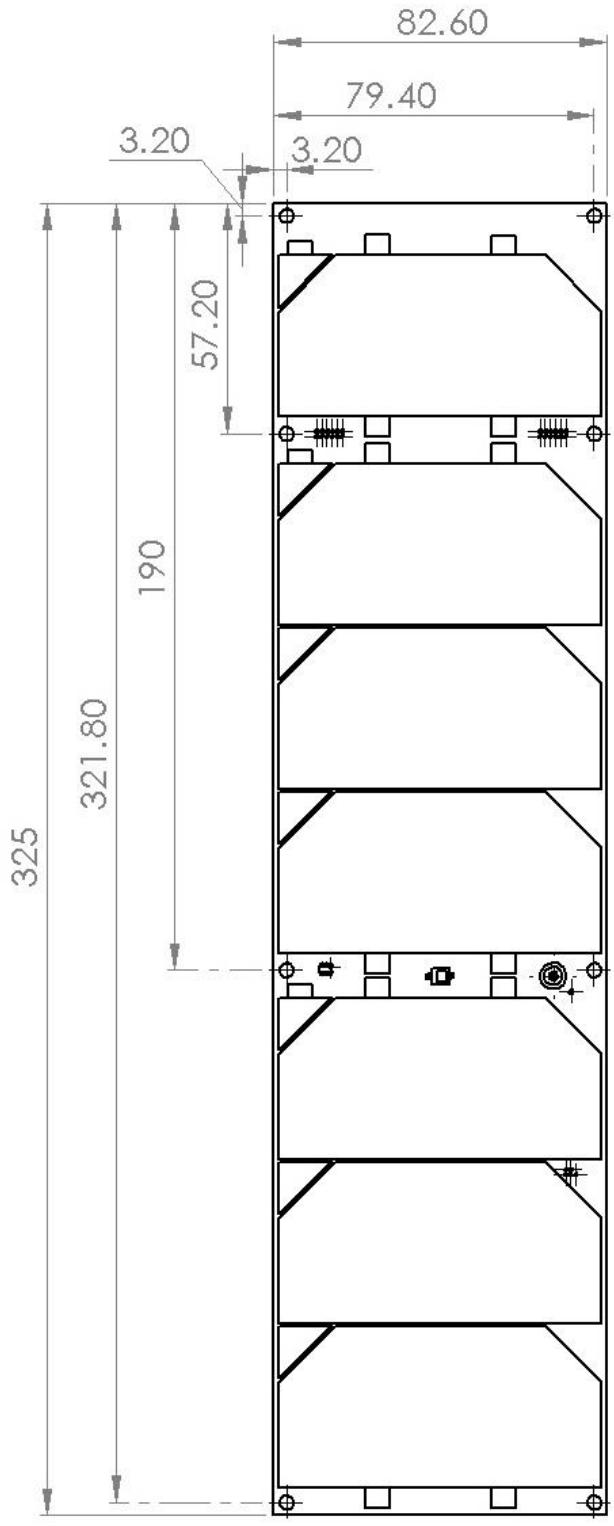



Figure 9: 3U Solar Panel X/Y RBF

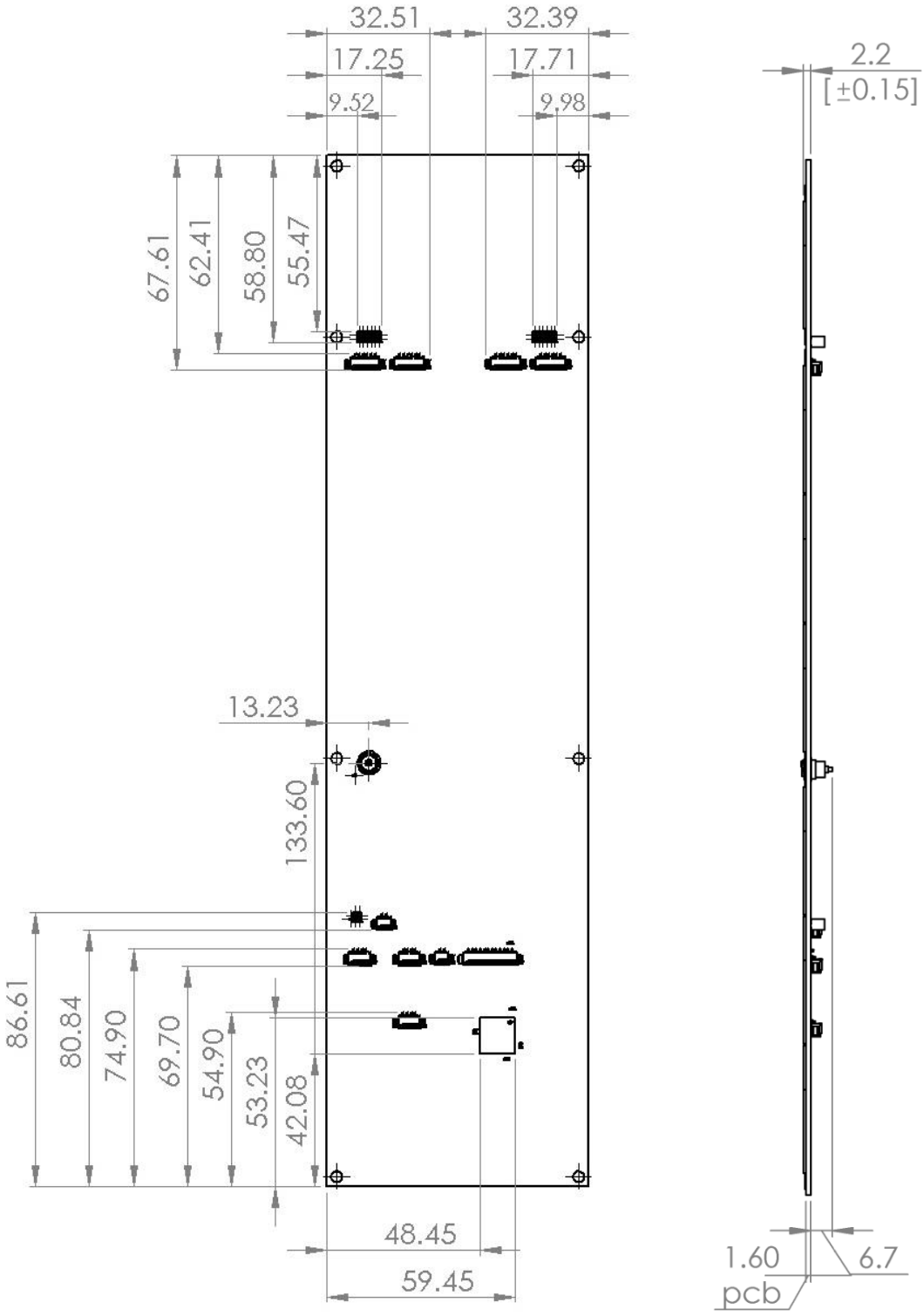



Figure 10: 3U Solar Panel X/Y RBF

Note: When it is inserted, the maximum height of the RBF pin from the surface of the PCB is 5mm.

### 8.3 Tolerances

The outer edge dimensions of the 3U solar panels have a tolerance of ±0.1mm (±4mil).

The thickness of the 3U solar panels have a tolerance of ±0.15mm (±6mil).

## 9 CUSTOMIZATION

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

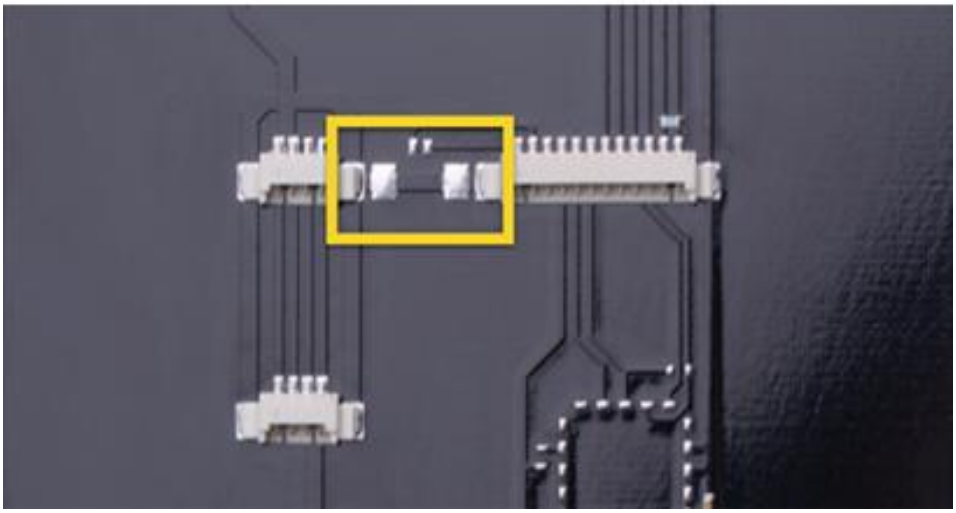


Figure 5: 3U Solar Panel X/Y (Bottom Side) - location of the pads for the external magnetorquer connector

Upon request, solar panels can be customized with additional connectors and external interfaces.

## 10 MATERIAL AND ASSEMBLING

The 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
- Screws DIN965/ISO 7046-1 Torx - M3
- USB stick with user manual

Customized cables and connectors can be provided upon request.

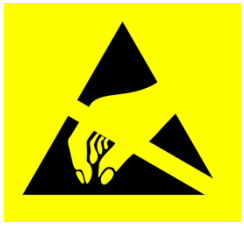
## 12 HANDLING AND STORAGE

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 as 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, then the 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)

## 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.