

# **DATASHEET**

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1.5U 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 Characteristic ..... 6

5 Available Configurations..... 6

6 Specifications ..... 7

    6.1 1.5U Solar Panels X/Y and X/Y MTQ ..... 9

    6.2 1.5U Solar Panel X/Y RBF..... 10

7 Connectors..... 11

    7.1 Power Output, and Sensors and Magnetorquer (MTQ) Connectors ..... 11

        7.1.2 H1 Pinout (Power Output) ..... 12

        7.1.3 H2 Pinout (Power Output) ..... 12

        7.1.4 H3 Pinout (Sensors and Magnetorquer) ..... 12

    7.2 RBF Connector ..... 13

        7.2.1 RBF Location ..... 13

        7.2.2 RBF Pinout..... 14

        7.3.2 SCIC Pinouts ..... 17

8 Mechanical Characteristics ..... 17

    8.1 1.5U Solar Panel X/Y ..... 18

    8.2 1.5U Solar Panel X/Y RBF..... 20

9 Customization..... 23

10 Material and Assembling ..... 24

11 Included in the Shipment..... 24

12 Handling and Storage ..... 24

13 Warnings ..... 25

# 1.5U SOLAR PANEL

## DATASHEET

This user manual details the applications, features and operation of EnduroSat's 1.5U Solar Panel.

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

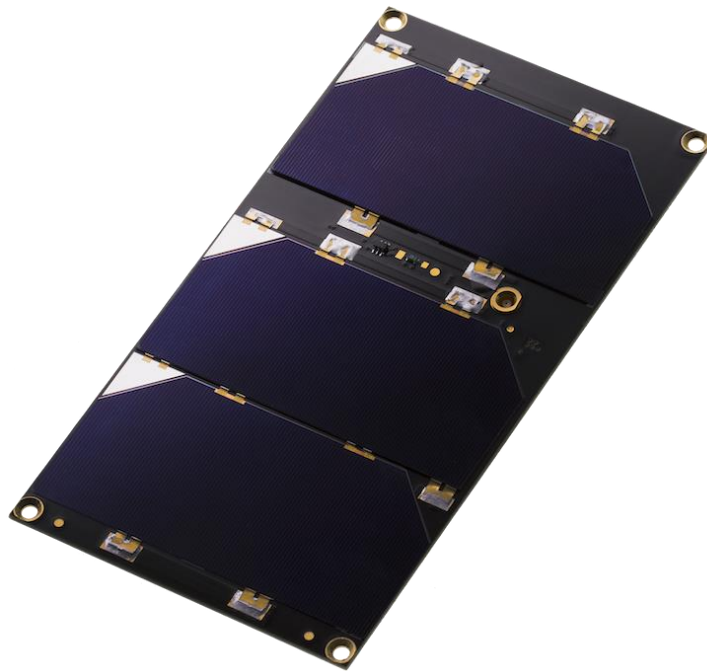


Figure 1 – 1.5U Solar Panel X/Y RBF

## 1 CHANGE LOG

Date	Version	Note
28/11/2017	Rev 1	Initial
22/10/2018	Rev 1.1	Technical writing enhancements

## 2 ACRONYMS LIST

ADCS	Attitude Determination and Control System
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
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 1.5U Solar Panels are equipped with 3 CESI Solar cells of type CTJ30 with up to a 29.5% efficiency. The wide effective cell area provides up to 3.6 Watts per panel in a LEO.

The PCB of the solar panel contains a network of sensors and an optional magnetorquer which 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

- CESI Solar Cells CTJ30, space qualified triple junction (specs in the following paragraph)
- 90.45cm<sup>2</sup> effective cell area (3 solar cells)
- Temperature Sensor with SPI Interface (Accuracy:  $\pm 1.5^{\circ}\text{C}$  from  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  (max),  $\pm 2.0^{\circ}\text{C}$  from  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (max))
- Up to 3.6 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 70 $\mu\text{m}$  copper layers
- Plated, countersink mounting holes with ground connection
- Connector for external magnetorquer
- Max Voltage 1: up to 6.99V (3.61W)
- Max Voltage 2: up to 4.66V (3.21W)
- Max Current 1: up to 517mA
- Max Current 2: up to 688mA
- Thickness 2.2 mm  $\pm 150 \mu\text{m}$

### 4.2 Solar Cell Features and Characteristic

- Efficiency up to 29.5%
- Triple Junction Solar Cells InGaP/GaAs/Ge
- Very low solar cell mass (81-89 mg/cm<sup>2</sup>)
- Thickness 155  $\mu\text{m} \pm 15 \mu\text{m}$
- Fully qualified under ESA Standard ECSS E ST20-08C for LEO and GEO
- Internal by-pass diode for optimized power output
- Size 30.15 cm<sup>2</sup>
- High radiation resistance
- Coverglass CMG (150  $\mu\text{m}$  thick)
- Good mechanical strength

## 5 AVAILABLE CONFIGURATIONS

EnduroSat's 1.5U Solar Panels are available in 3 configurations.

- 1.5U Solar Panel X/Y
- 1.5U Solar Panel X/Y RBF (i.e. with Remove Before Flight pin)
- 1.5U 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 white or black solder mask.

## 6 SPECIFICATIONS

### SOLAR CELL STRING Configuration 1

Parameter	Unit	Condition	Min	Typ	Max
Voltage 1	V	25°C			6.99
Current 1	mA	25°C			517
Power 1	mW	25°C			3610
Efficiency	%				29.5

### SOLAR CELL STRING Configuration 2

Parameter	Unit	Condition	Min	Typ	Max
Voltage 2	V	25°C			4.66
Current 2	mA	25°C			688
Power 2	mW	25°C			3210
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

## 1.5U SOLAR PANEL – DATASHEET

### SUN SENSOR

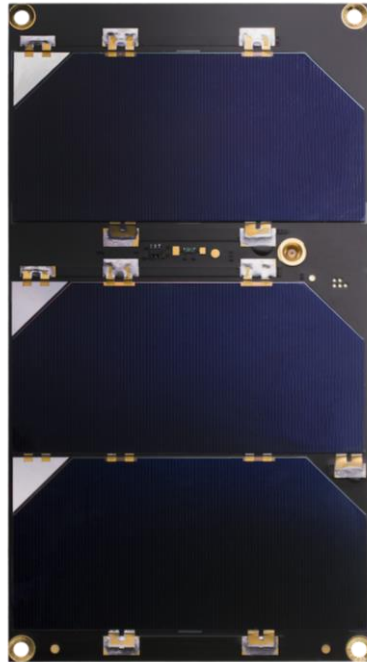
Parameter	Unit	Condition	Min	Typ	Max
Spectral Sensitivity	nA/lx	$V_R=5V$ , standard light A, $T=2856K$		6.3	
Wavelength of max sensitivity ( $\lambda_{s\max}$ )	nm			570	
Range of Spectral sensitivity ( $\lambda_{10\%}$ )	nm		400		900
Half angle	deg			$\pm 60^\circ$	

### MAGNETORQUER

Parameter	Unit	Condition	Min	Typ	Max
Resistance	$\Omega$			55	
Current	mA	@3.3V		60	
Dipole Momentum (calculated)	Am <sup>2</sup>	@3.3V		0.135	



## 6.1 1.5U Solar Panels X/Y and X/Y MTQ



### 1.5 Solar Panel X/Y (i.e. without magnetorquer)

- 3 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
- Weight: 65 g

### 1.5 Solar Panel X/Y MTQ (i.e. with magnetorquer)

- 3 CTJ30 SCA CESI
- Magnetorquer
- Temperature sensor
- Gyroscope
- Sun sensor
- Multiple panels can be connected in series or parallel
- Internal by-pass diode for optimized output power
- Weight: 79 g

### 6.2 1.5U Solar Panel X/Y RBF

This configuration of the 1.5U solar panel X/Y has a Remove Before Flight (RBF) 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.

#### Solar Panels X/Y RBF (no magnetorquer)

- 3 CTJ30 SCA CESI
- Temperature sensor
- Gyroscope (optional)
- Sun sensor
- Multiple panels can be connected in series or parallel
- External by-pass diode for optimized output power
- Remove Before Flight (RBF) pin
- 5 pin Satellite Communication Interface Connector (SCIC) - prevents incorrect orientation of the plug
- Weight: 66 g

Figure 2 shows the front part of the 1.5 U Solar Panel X/Y RBF and the location of the RBF pin and 5-pin Satellite Communication Interface Connector(SCIC).

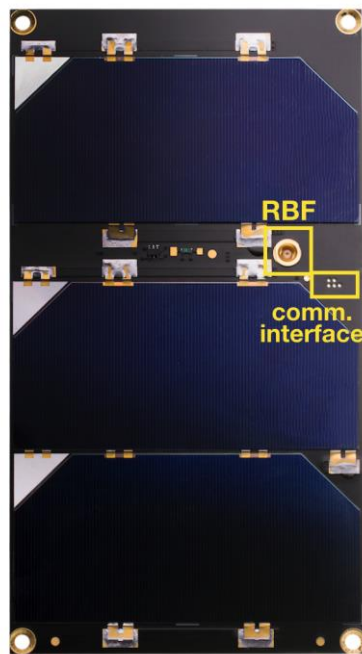


Figure 2: 1.5U Solar Panel X/Y RBF

## 7 CONNECTORS

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

EnduroSat's 1.5U 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.

#### 7.1.1 H1, H2, and H3 Location

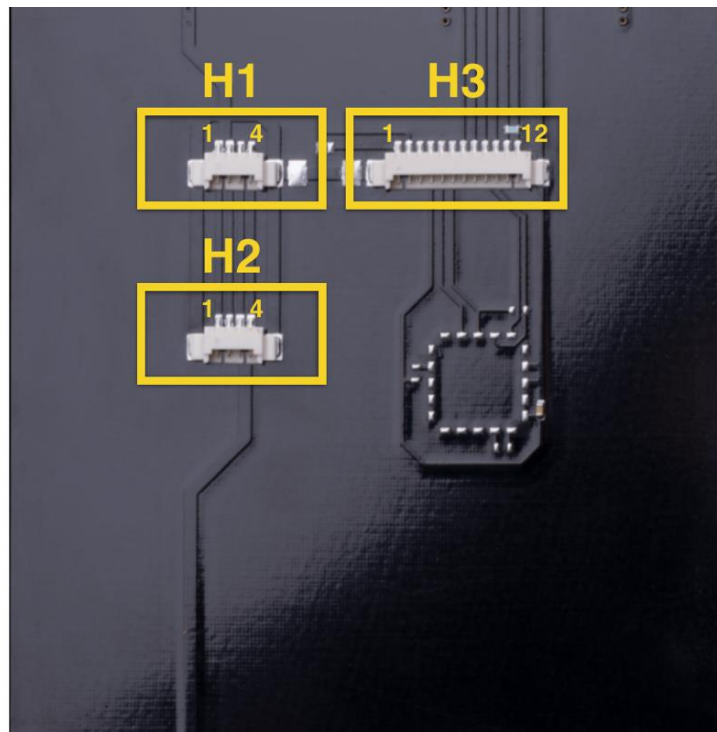


Figure 3: Solar Panel - Bottom Side

### 7.1.2 H1 Pinout (Power Output)

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

### 7.1.3 H2 Pinout (Power Output)

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

### 7.1.4 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

### 7.2 RBF Connector

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

#### 7.2.1 RBF Location

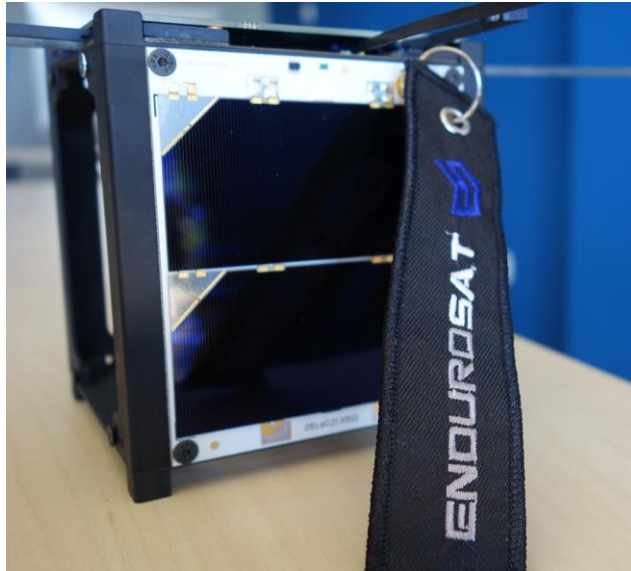


Figure 4: Example of Remove Before Flight (RBF) Handle and Pin

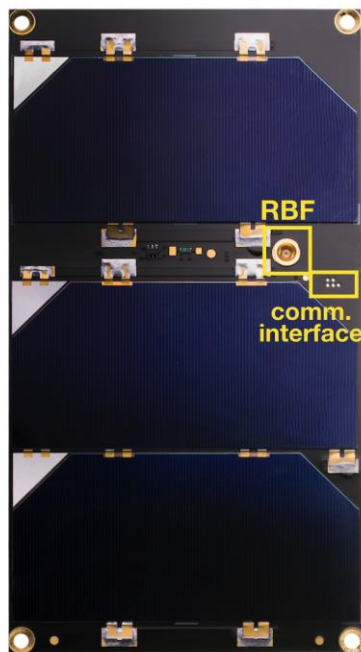


Figure 5: Remove Before Flight (RBF) Connector Socket – Top Side

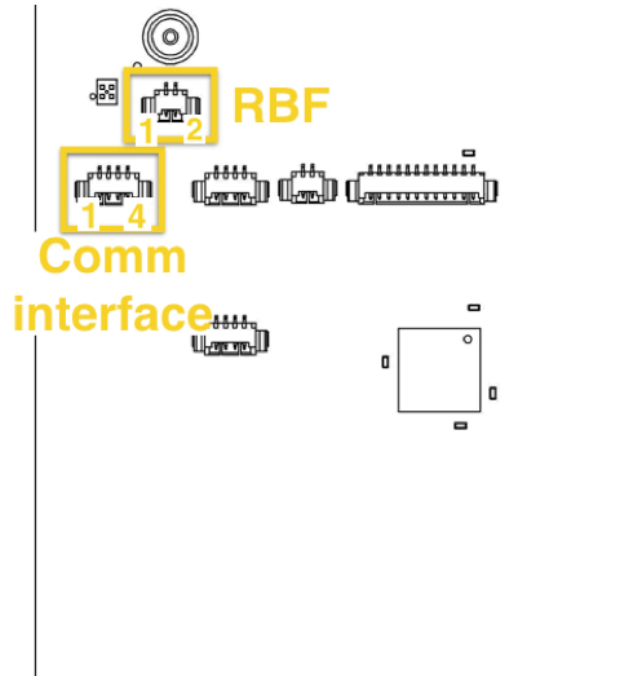


Figure 6: Remove Before Flight (RBF) Connector and Pinout – Bottom Side

### 7.2.2 RBF Pinout

Pin	Description
1	RBF
2	GND

### 7.3 Satellite Communication Interface Connector (SCIC)

The 5-pin Satellite Communication Interface Connector (SCIC) socket provides general purpose (e.g. testing) and user configurable communication or charging capabilities to the other modules within the satellite. Its 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

#### 7.3.1 SCIC Location

The figures below show the location and pinout of the Satellite Communication Interface Connectors (SCIC). The top side SCIC has a pitch of 1.27mm (50mils), and the bottom side connector is a (MOLEX 53261-0471).

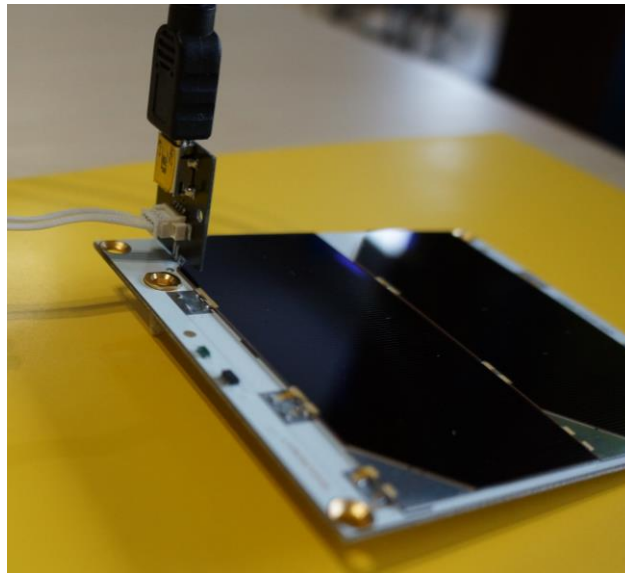


Figure 7: Example of SCIC Adaptor - Top Side

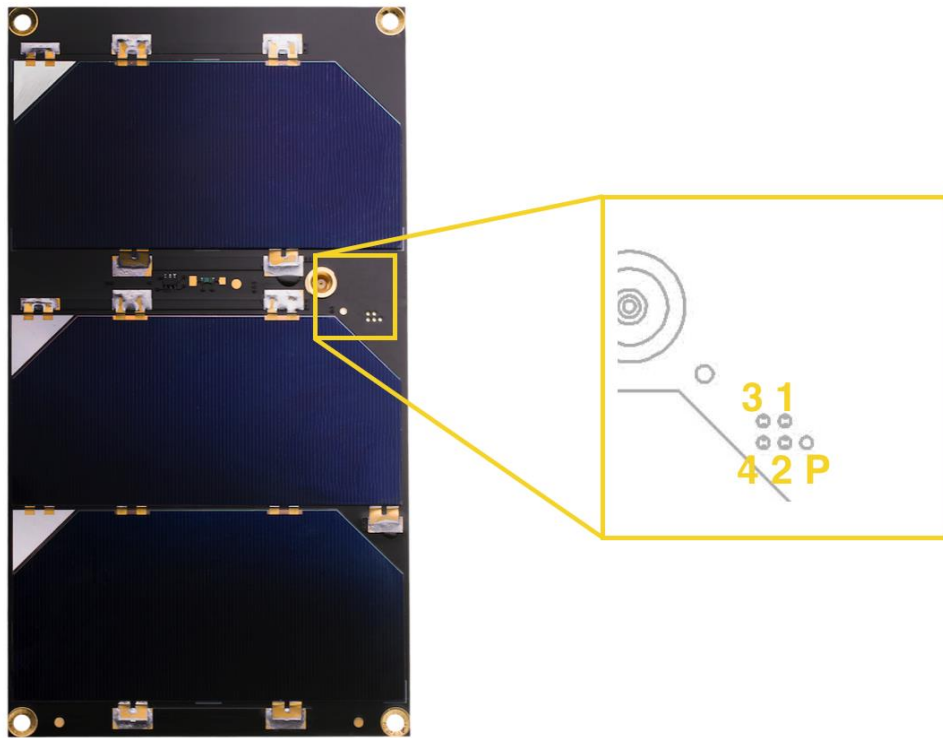


Figure 8: SCIC Connector - Top Side

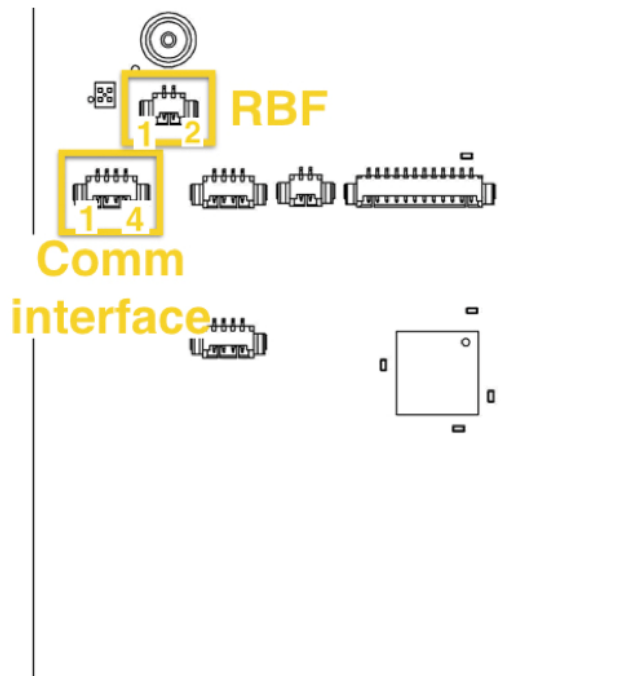


Figure 9: Satellite Communication Interface Connector (SCIC) and Pinout – Bottom Side



## 7.3.2 SCIC Pinouts

Pin	Description
1	User customizable
2	User customizable
3	User customizable
4	GND
P	Pin for polarization (ensures proper orientation)

## 8 MECHANICAL CHARACTERISTICS

EnduroSat solar panels should be mounted on the EnduroSat Structure using bolts of type:

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.

A STEP file can be provided upon request.

8.1 1.5U Solar Panel X/Y

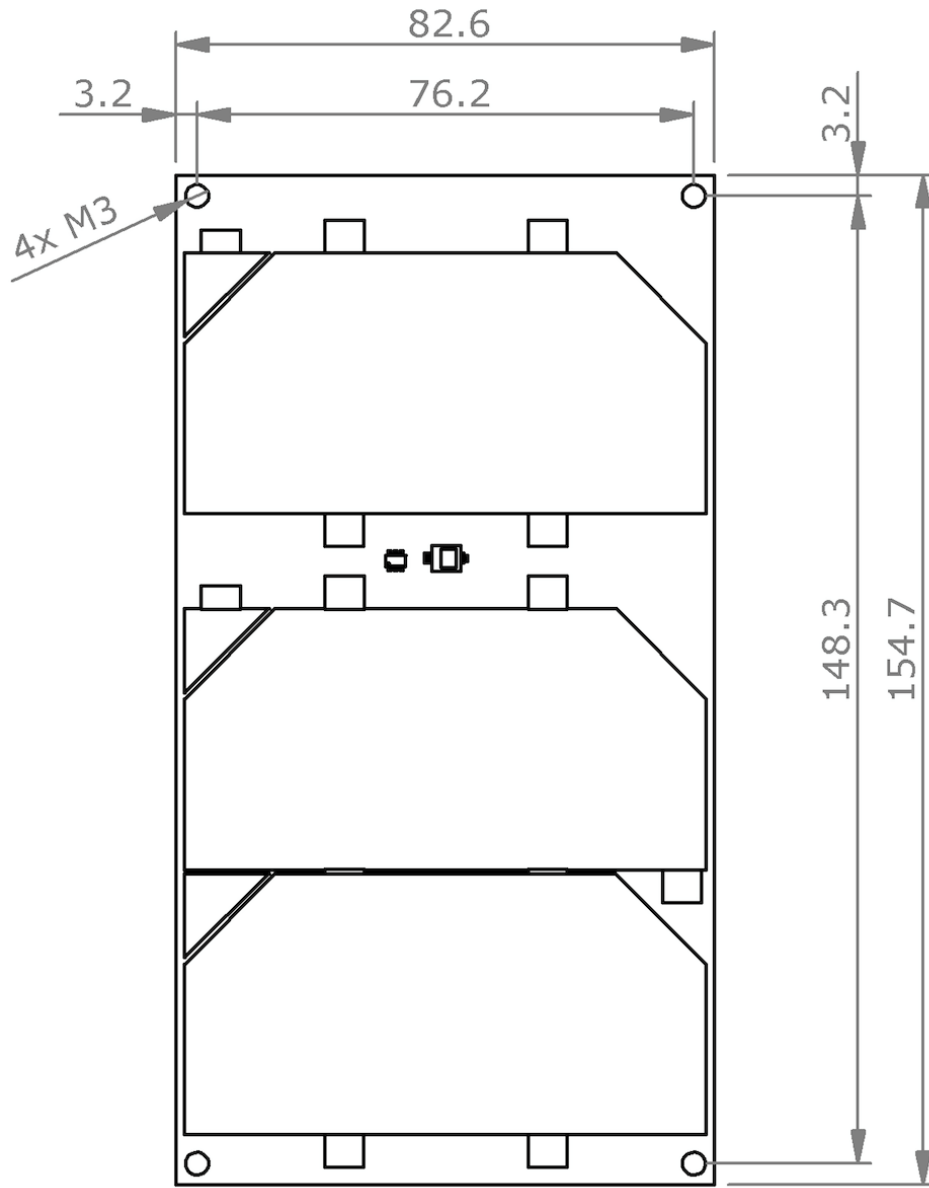


Figure 10 - 1.5U Solar Panel X/Y - Top Side

# 1.5U SOLAR PANEL – DATASHEET

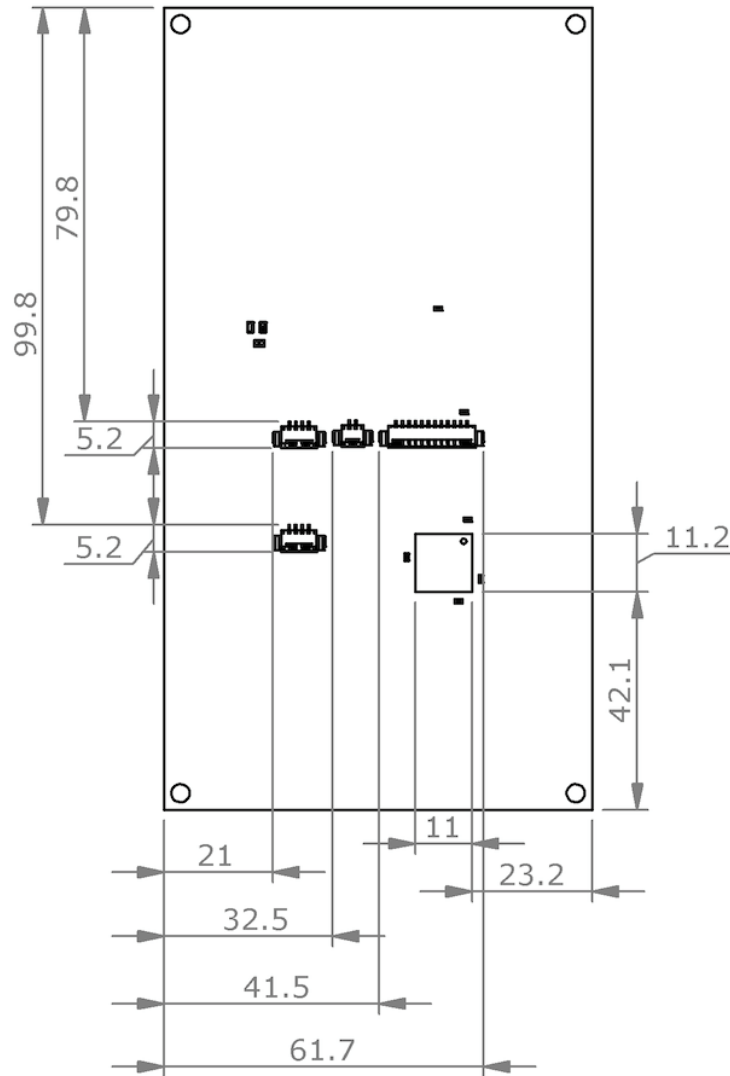


Figure 11 - 1.5U Solar Panel X/Y - Bottom Side (connector location)

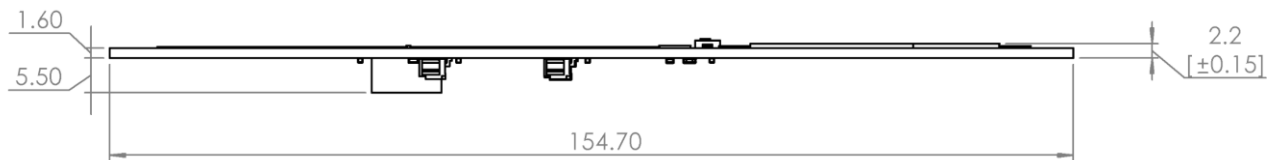


Figure 12 - 1.5U Solar Panel X/Y - Side View

8.2 1.5U Solar Panel X/Y RBF

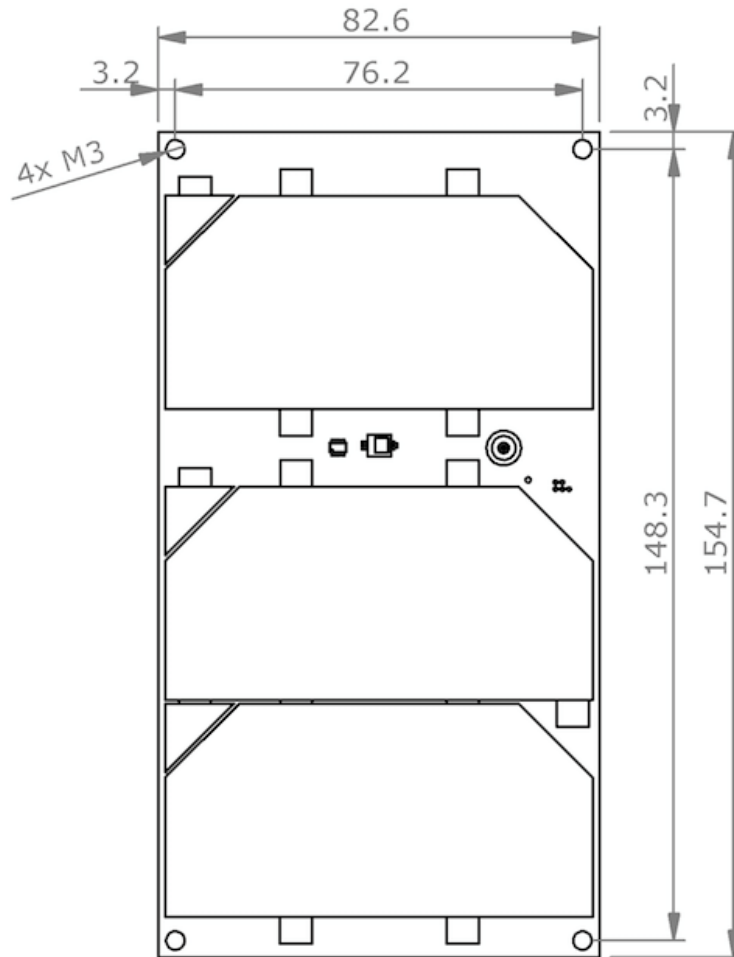


Figure 13 - 1.5U Solar Panel X/Y RBF - Top View

# 1.5U SOLAR PANEL – DATASHEET

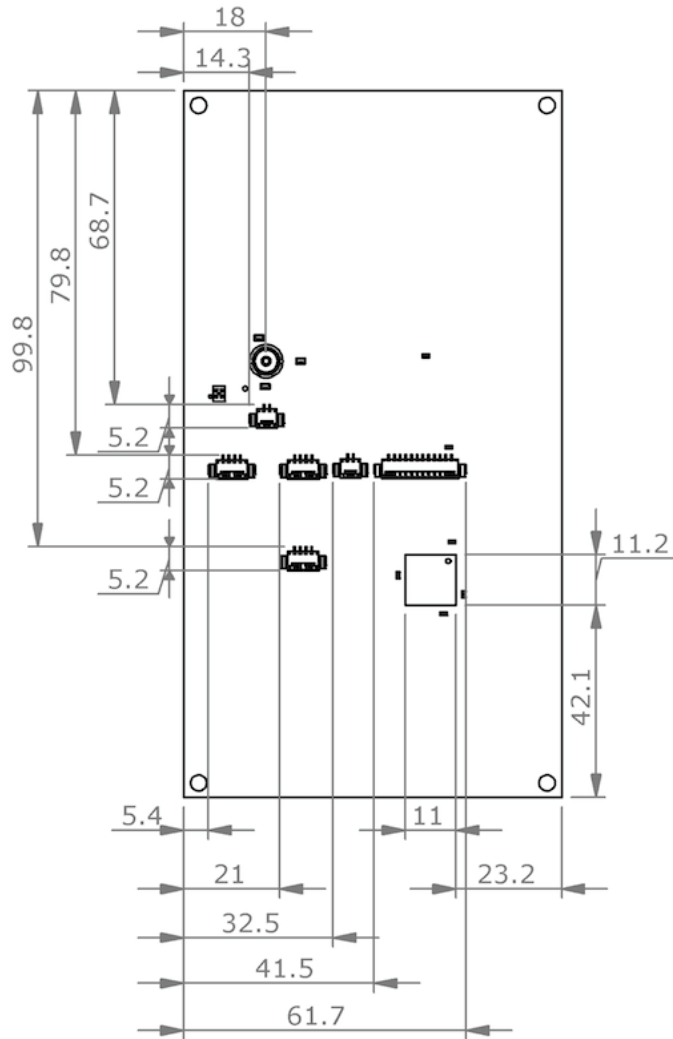


Figure 14 - 1.5U Solar Panel X/Y RBF - Bottom Side (connector location)

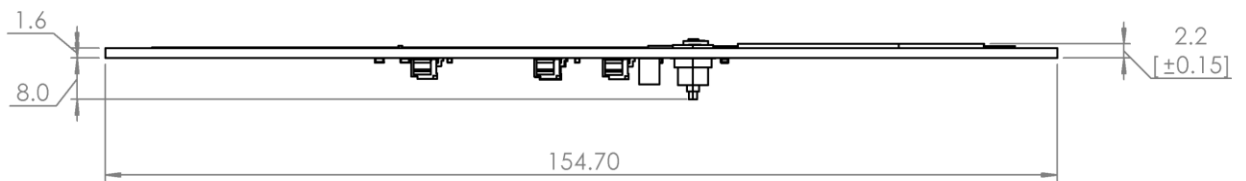


Figure 15- 1.5U Solar Panel X/Y RBF - Side View

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 1.5U solar panels have a tolerance of  $\pm 0.1\text{mm}$  ( $\pm 4\text{mil}$ ).

The thickness of the 1.5U solar panels have a tolerance of  $\pm 0.15\text{mm}$  ( $\pm 6\text{mil}$ ).

### 9 CUSTOMIZATION

EnduroSat's 1.5U 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.

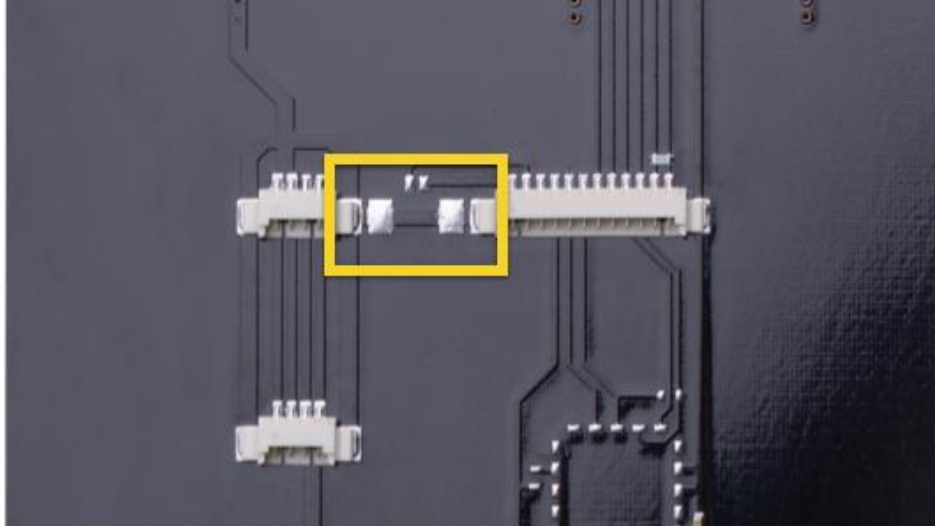


Figure 16: Solar Panel - Bottom Side (location of pads for the external magnetorquer connector)

Upon request, solar panels can be customized with additional 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 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
- RBF external pin (solar panel X/Y with RBF)
- 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: 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.