DATASHEET

UHF Antenna III

UHF ANTENNA III

DATASHEET

This datasheet is specially designed to describe the EnduroSat UHF Antenna II module, its functions and features.

Please read carefully the datasheet before unpacking the antenna in order to ensure safe and proper use.

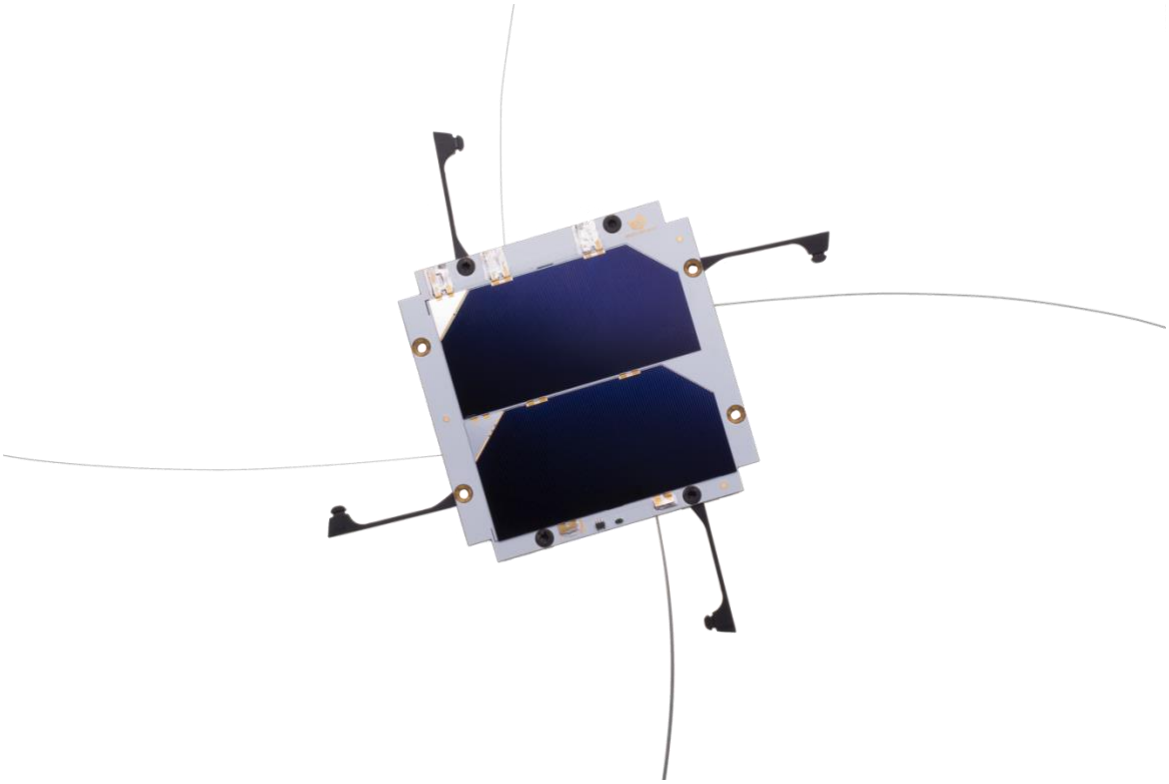


Figure 1 – EnduroSat UHF Antenna III (**Solar panel is a separate product**)

1 CHANGE LOG

Date	Version	Note
12/08/2019	Rev 1	Initial document
27/01/2020	Rev 1.1	Minor text changes

2 ACRONYMS LIST

LHCP	Left Hand Circular Polarization
MCX	Micro Coaxial Connector
PCB	Printed Circuit Board
RHCP	Right Hand Circuit Polarization
RF	Radio Frequency
UHF	Ultra-High Frequency
USB	Universal Serial Bus

3 OVERVIEW

The antenna is designed to cover the amateur satellite band 435-438 MHz. It has a circular polarization and uses a dual redundant burn wire mechanism with double feedback for the deployment of the antenna rods. The antenna is controlled and monitored via I2C interface. It has an additional redundancy feature for direct control of the burning resistor chains by general purpose outputs.

4 HIGHLIGHTED FEATURES

- UHF band for amateur satellite communications 435 – 438MHz
- Compatible with EnduroSat Solar panels
- Circularly polarized
- Weight: 85 g
- Gain > 0dBi
- Max RF output power 3.5W
- Burn wire mechanism with feedback for deployment
- Supply voltage: 5V
- I2C interface for monitoring and control
- Two redundant channels for direct deployment of the antenna rods with logical level
- Typical current consumption during antenna deployment: 250mA @5V
- Ultra-low current consumption in idle mode: 1mA @5V
- Rod deployment controlled sequence
- Two algorithms for antenna deployment
- Test mode jumper for I2C verification and preventing for unwanted deployment of the antenna
- MCX Connector and secondary UFL connector inside the antenna for compatibility with different kind of satellite structures.

5 FUNCTIONAL DESCRIPTION

The feed network for the RF part of the antenna is realized using strip lines. Each rod is fed with 90 degrees phase shift so that the antenna has a circular polarization. The antenna has a through hole for connecting it to EnduroSat' solar panel Z.

6 HARDWARE LAYOUT

Figure 2 depicts the bottom side of the antenna. All dimensions are in mm. There are 8 mounting holes (M3) as shown on figure 2. Four of them, shown on figure 4 are with already screwed bolts, which should not be removed. In order to mount the antenna to the structure the other four mounting holes should be used. There is an opening in the PCB, through which an EnduroSat solar panel can be connected. The right angle MCX connector, used for connecting the antenna to the communication module, is located next to the opening.

The thickness of the antenna and the height of the connector are shown on Figure 3. The overall thickness (and weight) of the antenna depends on the top cover. It can be a solar panel, a top cover or another module. On figure 3 is shown the thickness of the whole antenna with a cover of 1.6 mm.

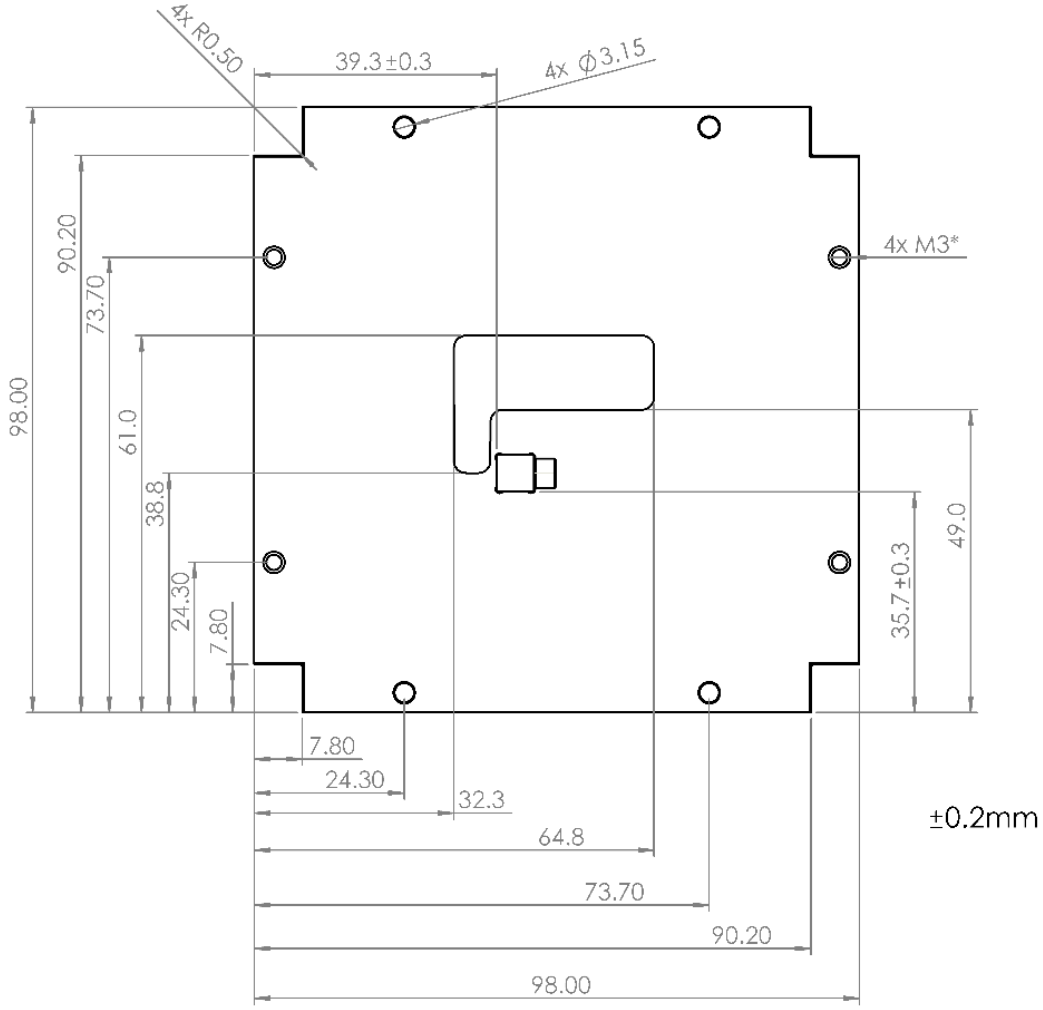


Figure 2: Physical Layout Bottom Side (dimensions in mm)

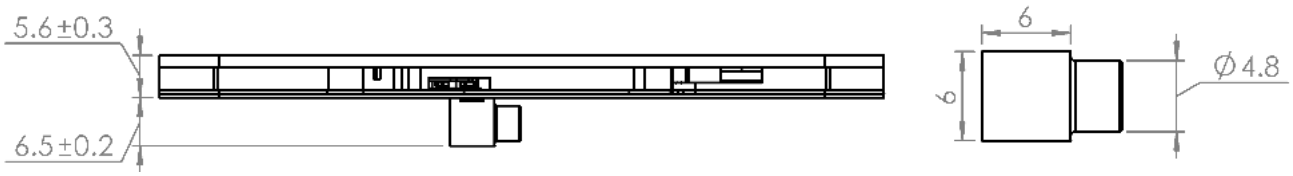


Figure 3: Side View (dimensions in mm)

** The dimensional tolerance is +/-0.2mm, unless otherwise specified.*

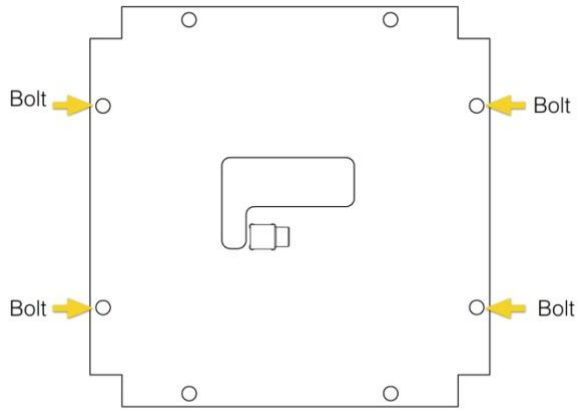


Figure 3: Proper installation of the 4 bolts configuration

The EnduroSat UHF antenna comes with four DIN965 M3x6 bolts already mounted on the positions above. The rest of the holes are used for mounting the antenna to the body. These holes are also designed for countersink screws.

7 CHARACTERISTICS

7.1 Frequency

Figure 5 shows the measured return loss of the UHF antenna.

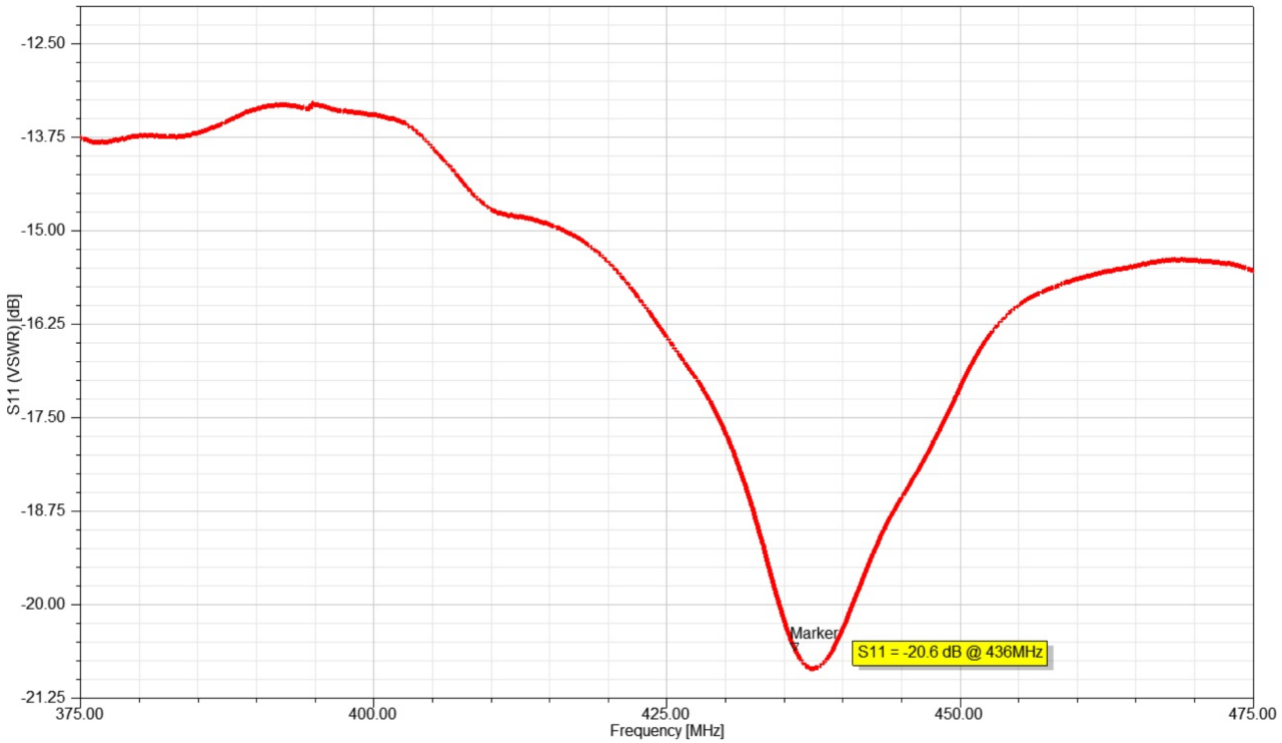


Figure 4 Measured return loss of the UHF antenna

7.2 Polarization

RHCP over the top cover of the antenna and LHCP downwards (on the side of the connectors).

7.3 Connectors

J1	MCX right angle (straight MCX or SMA upon request)
J2	Six pin Molex Pico-Lock™ 504050-0691

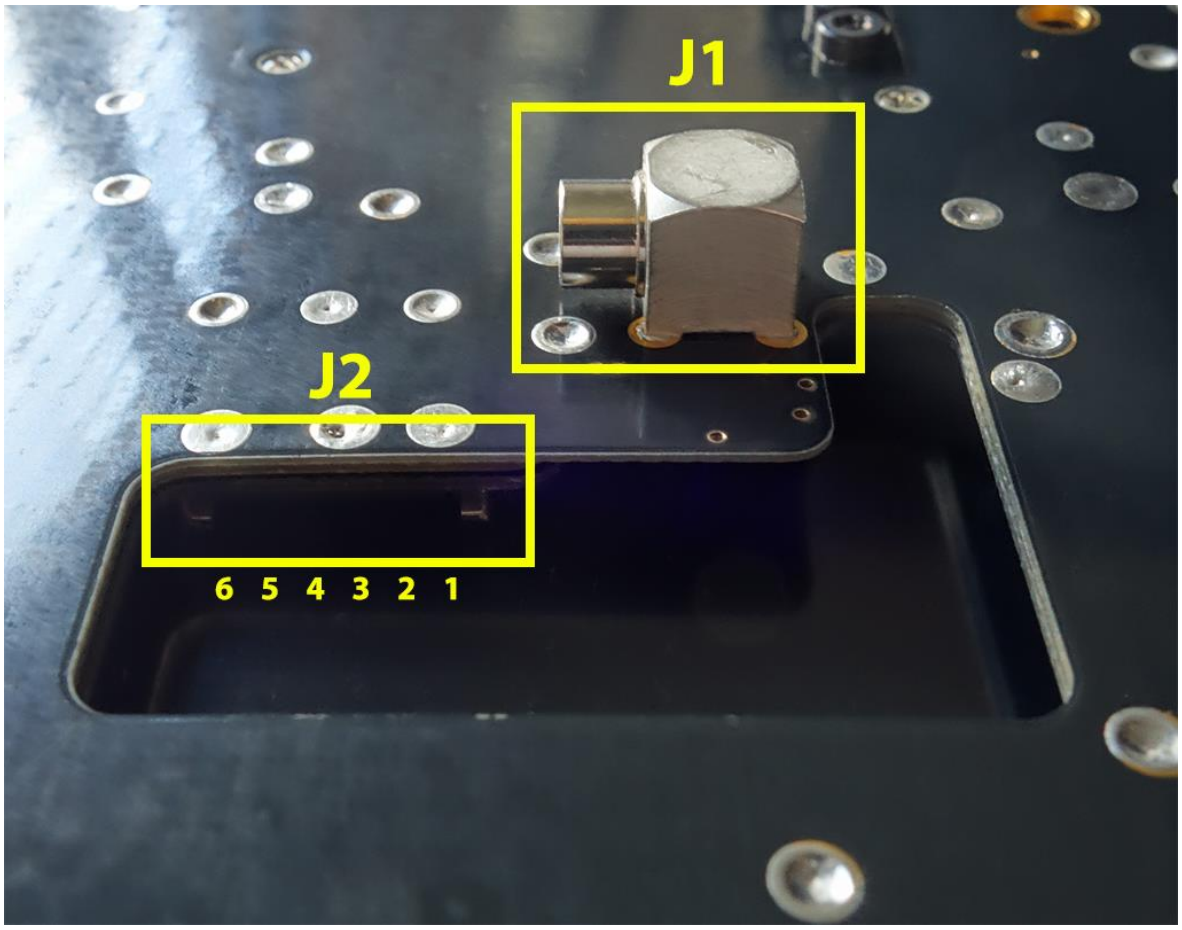


Figure 5 Bottom Side – connector location

In the case of collision between the MCX connector and the structure of the satellite, UFL connector on the internal side can be accessed by disassembling the top cover of the antenna.

J2 pinout:

Pin	Mnemonic	Description
1	Release All B	Activate all four back-up burning resistors
2	Release All A	Activate all four primary burning resistors
3	Ground	Ground
4	I2C SDA	I_2C Data
5	I2C SCL	I_2C Clock
6	+5V	+5V Power supply bus

7.4 Gain

The following figures depict the simulated radiation pattern of the antenna and when mounted on 1U, 2U, 3U.

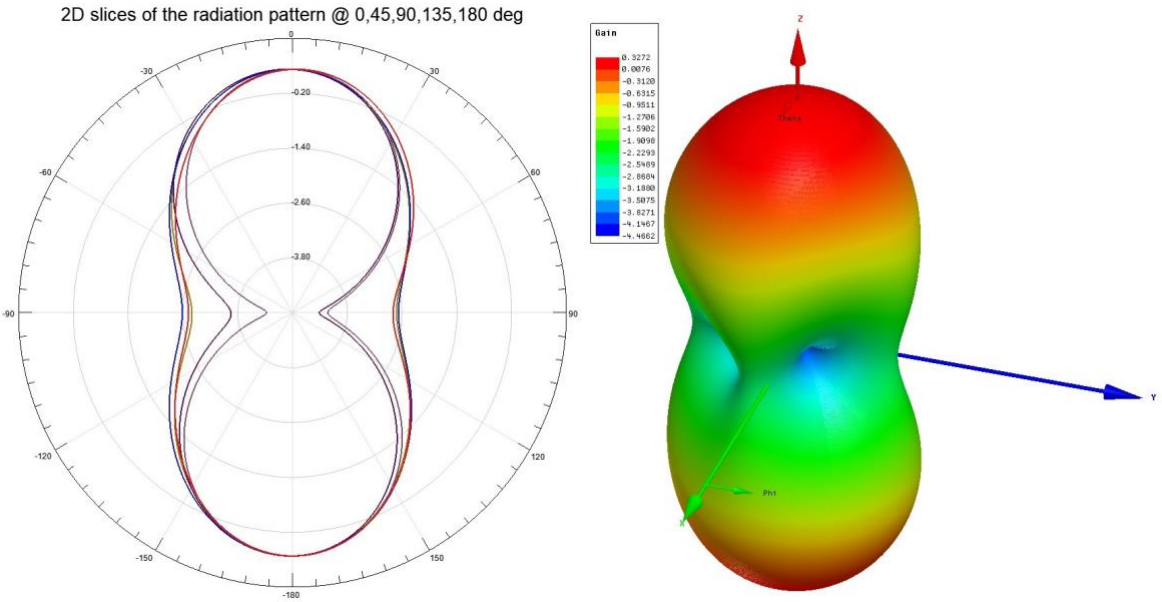


Figure 6: Radiation pattern of the antenna (free space)

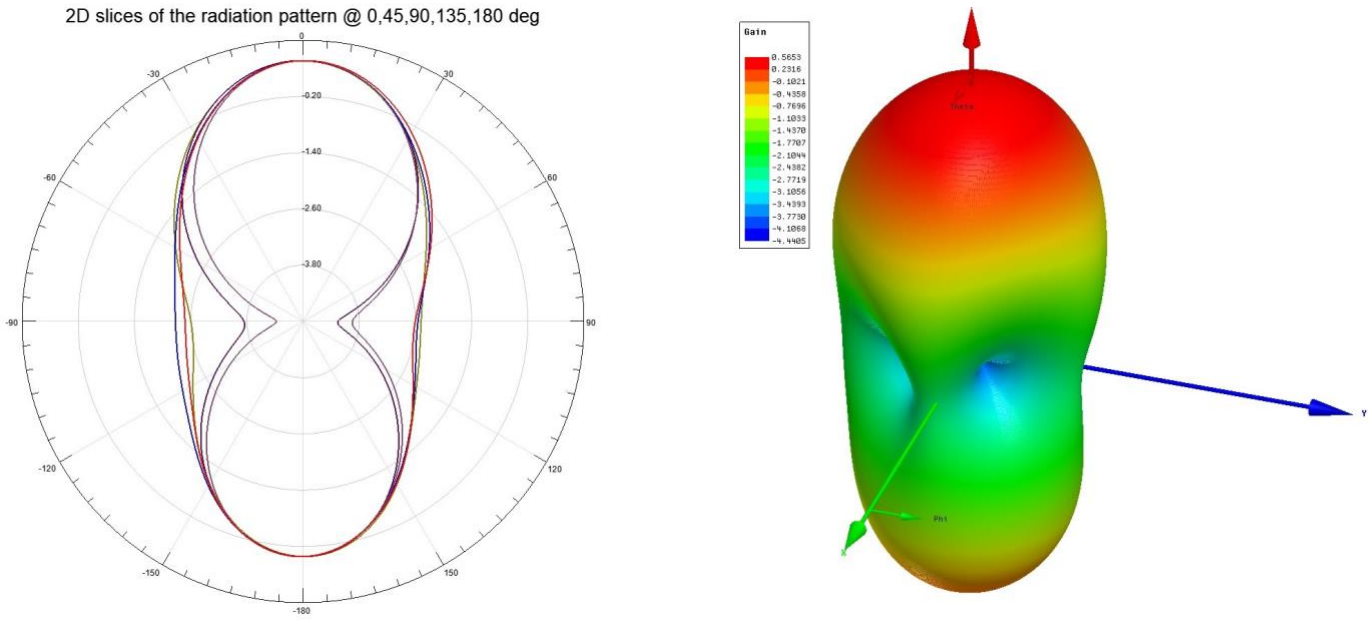


Figure 8: Radiation pattern when mounted on a 1U structure

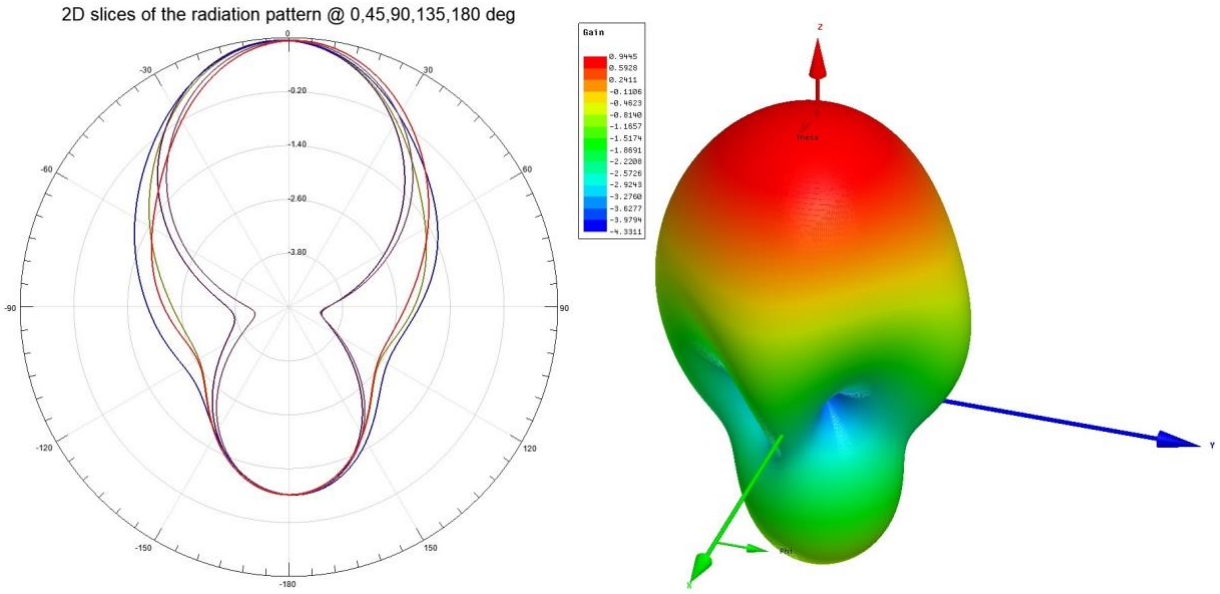


Figure 9: Radiation pattern when mounted on a 2U structure

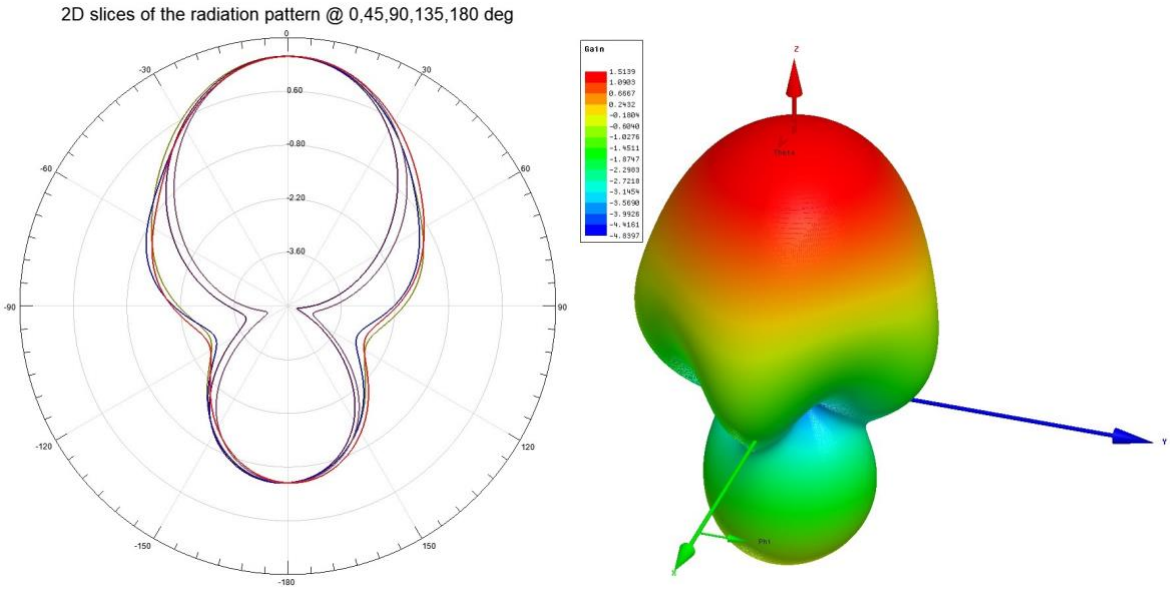


Figure 10: Radiation pattern when mounted on a 3U structure

In the above figures the antenna is positioned at the origin of the coordinate system and the satellite is along the z axis in the positive direction.

8 ELECTRICAL CHARACTERISTIC

Parameter	Condition	Min	Typ	Max
Supply Voltage [V]		4.8	5	6
Current Consumption [mA]	Idle mode		0.5	2*
	Primary burning resistor		250	280
	Primary and Back-up burning resistor		500	560
	All primary burning resistors (pin 5 activated)		1000	1120
	All back-up burning resistors (pin 6 activated)		1000	1120
Burning resistors voltage activation [V]	Logical level threshold for activation of all burning resistors (primary or back-up burning wire resistor chains – pin 1, 2)	1.5	3.3	6

*Peak current consumption during I2C communication with 4.7 kOhm pull-up resistors

9 DEPLOYMENT MECHANISM

The deployment mechanism uses burning resistors to cut a wire and release the doors holding the antenna rods. Each antenna rod can be deployed by two independent resistors for redundancy controlled via I_2C. The additional direct control feature enables activation of the entire burning wire resistor chains by general purpose outputs. Deployment status feedback information can be collected through the I_2C interface pins on the connector.

In order to avoid significant voltage drop, the length of cables should be minimized. The recommended cable is AWG 24.

10 MATERIALS

The frame and doors used for holding the antenna rods rolled and encapsulated is made of aluminum with hard anodization, which prevents a short circuit between the frame and the antenna rods. Rods are made from SMA – Shape Memory Alloy with super elastic properties to ensure straight shape after release. All PCBs are made from FR-4.

11 MECHANICAL AND ENVIRONMENTAL TEST

A full campaign of tests at qualification level was performed on the 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
- Sinusoidal Vibration
- Pyroshock Test
- Total Ionizing Dose > 40 kRad

12 INCLUDED IN THE SHIPMENT

EnduroSat provides along with the UHF antenna:

- Coaxial cables can be supplied upon request
- Power and command cable (PTFE Material Jacket, 24AWG), connector MOLEX 504051-0601 can be provided with a specific length upon request
- USB stick with user manual

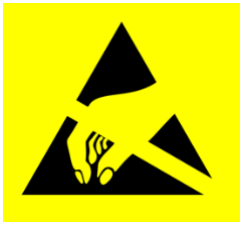
13 HANDLING AND STORAGE

Particular attention shall be paid to the avoidance of damage to the UHF antenna during handling, storage and preservation. The handling of the UHF antenna module should be performed in compliance with the following instructions:

- Handle using PVC, latex, cotton (lint free) or nylon gloves
- The environment where UHF antenna module 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.
- Store in such a manner as to preclude stress and prevent damage
- To prevent the deterioration, the UHF antenna 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.

DATASHEET

1U Solar Panel

SOLAR PANEL – 1U

DATASHEET

This user manual details the applications, features and operation of EnduroSat's 1U Solar Panel.

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

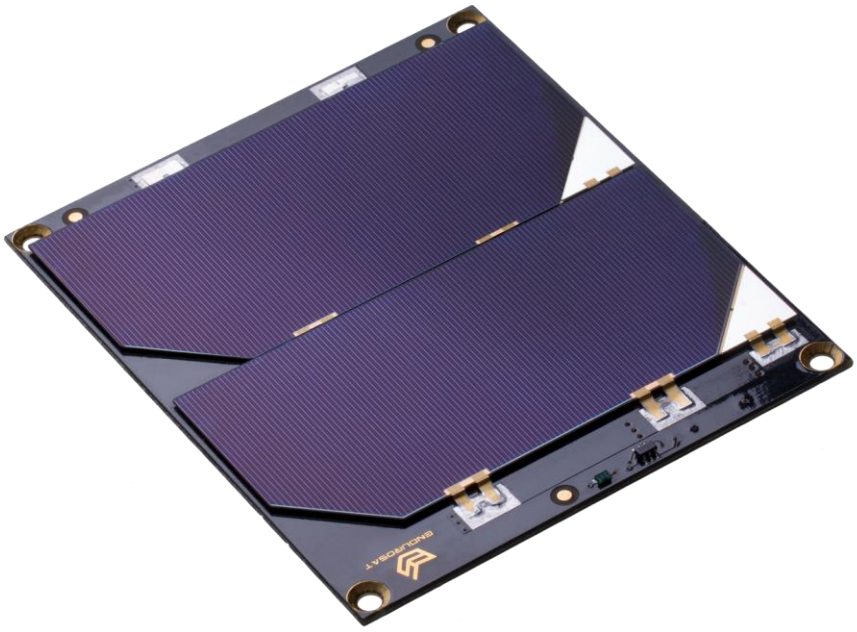


Figure 1: 1U Solar Panel X/Y

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	Rev 1.4	Minor text enhancements
22/10/2018	Rev 1.5	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 1U Solar Panels are equipped with 2 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 1U CubeSats and provides up to 2.4 Watts per panel in a LEO. The 1U Solar Panels are also compatible with EnduroSat's 3U and 6U structures.

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 Panel 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 70 µm 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
- 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 155 µm ±15 µm
- Fully qualified under ESA Standard ECSS E ST20-08C for LEO and GEO
- Internal by-pass diode for optimized output power
- Size 30.15 cm^2
- High radiation resistance
- Coverglass CMG (150 µm thick)
- Good mechanical strength

5 AVAILABLE CONFIGURATIONS

EnduroSat's 1U Solar Panels are available in 5 configurations.

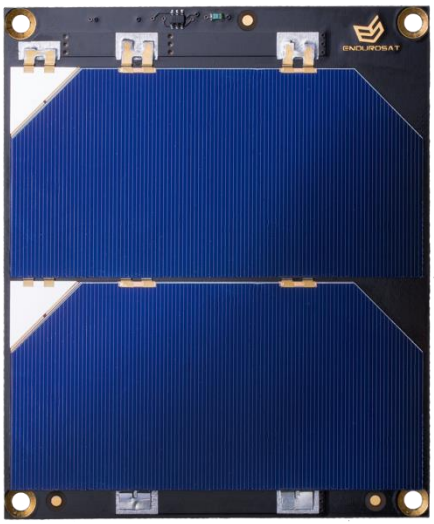
- Solar Panel X/Y
- Solar Panel X/Y RBF (i.e. with Remove Before Flight Pin)
- Solar Panel X/Y MTQ (i.e. with Magnetorquer)
- Solar Panel Z
- Solar Panel Z MTQ (i.e. with Magnetorquer)

Where:

i) X/Y indicates the panel can be used on the side panels of the CubeSat.
ii) Z indicates the panel can be used on the top and bottom of the CubeSat.

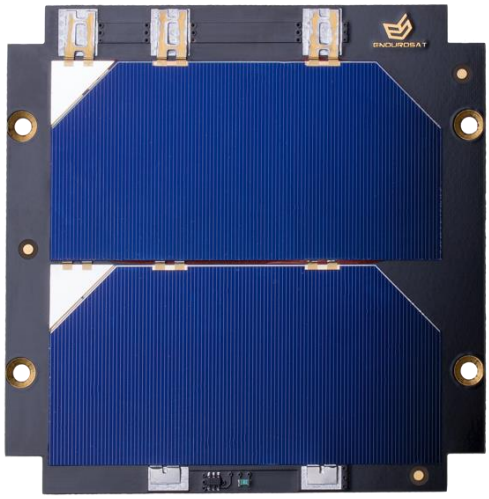
All configurations can be ordered with a white or black solder mask.

5.1 1U Solar Panel X/Y and X/Y MTQ



1U Solar Panel X/Y (i.e. without magnetorquer)	1U Solar Panel X/Y MTQ (i.e. with magnetorquer)
• 2 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: 44 g	• 2 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: 53 g

5.2 1U Solar Panel Z and Z MTQ



1U Solar Panel Z (i.e. without magnetorquer)	Solar Panels Z MTQ (i.e. with magnetorquer)
• 2 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: 48 g	• 2 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: 57.5 g

5.3 1U Solar Panel X/Y RBF

The 1U Solar Panel X/Y RBF has a Remove Before Flight (RBF) 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 RBF connector on the bottom side of the solar panel should be connected to the RBF connector of the power module with a cable.

Moreover, a 5-pin connector socket (which is designed to prevent incorrect orientation of the plug) provides a general purpose input/output communication interface. In the EnduroSat platform for instance, this interface is used to access the USB port of the OBC, or for charging the batteries of the EnduroSat power module.

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

- 2 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
- 5 pin connector for communication interface (prevents incorrect orientation of the plug)
- Weight: 45 g

Figure 2 shows the front part of the 1U Solar Panel X/Y RBF and the location of the RBF pin and 5-pin connector.

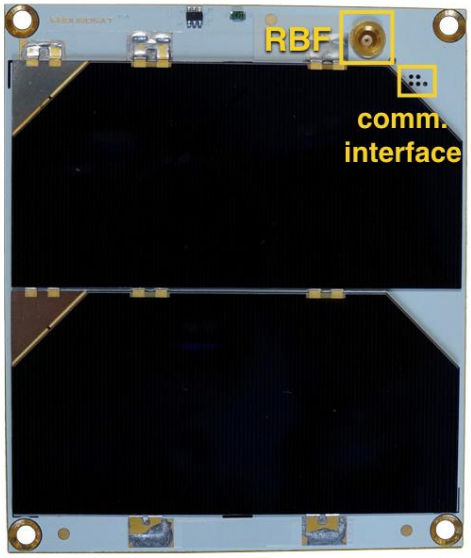


Figure 2: 1U Solar Panel X/Y RBF -Top Side

6 CONNECTORS

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

EnduroSat's 1U 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 - Sensor & Magnetorquer

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

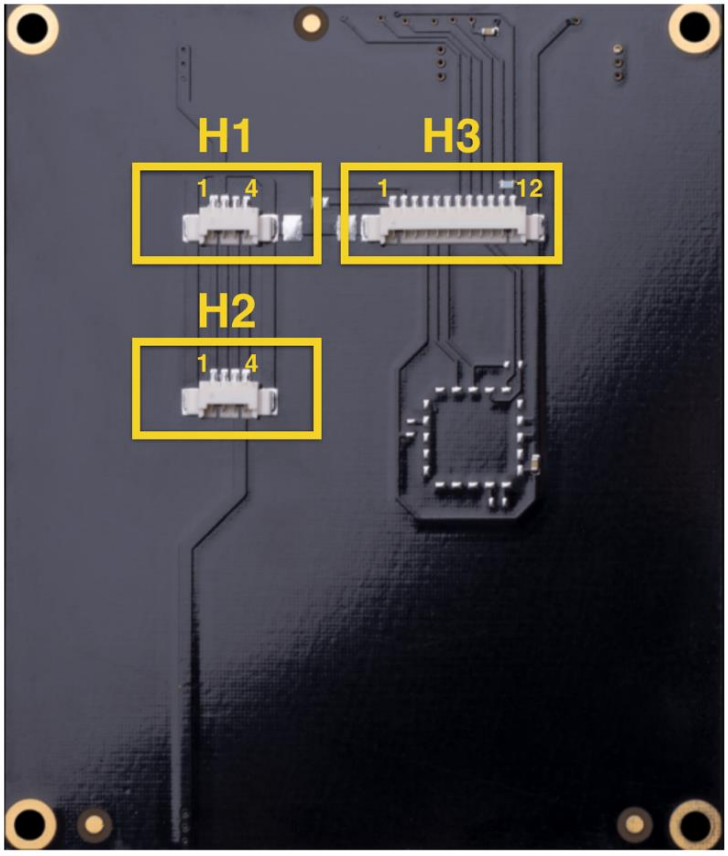


Figure 3: Solar Panel – Bottom Side

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

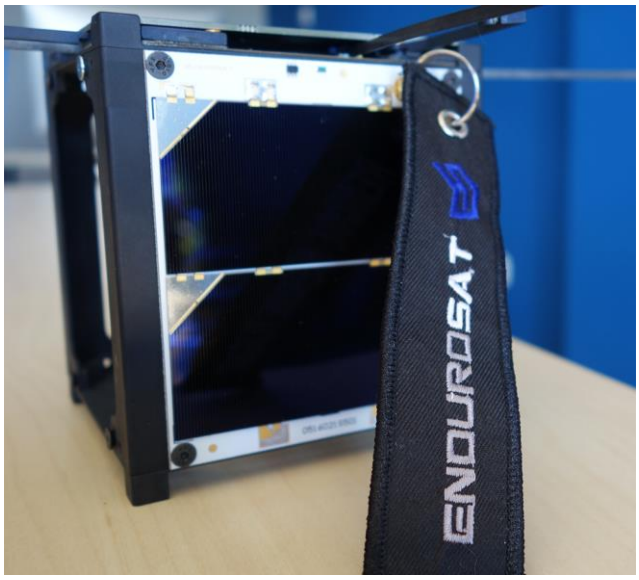


Figure 4: Remove Before Flight (RBF) Handle and Pin

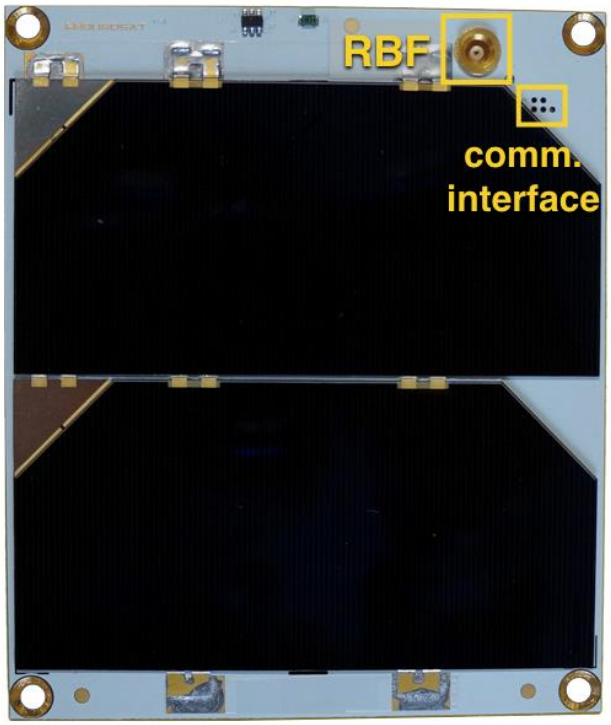


Figure 5: Remove Before Flight (RBF) Connector Socket – Top Side

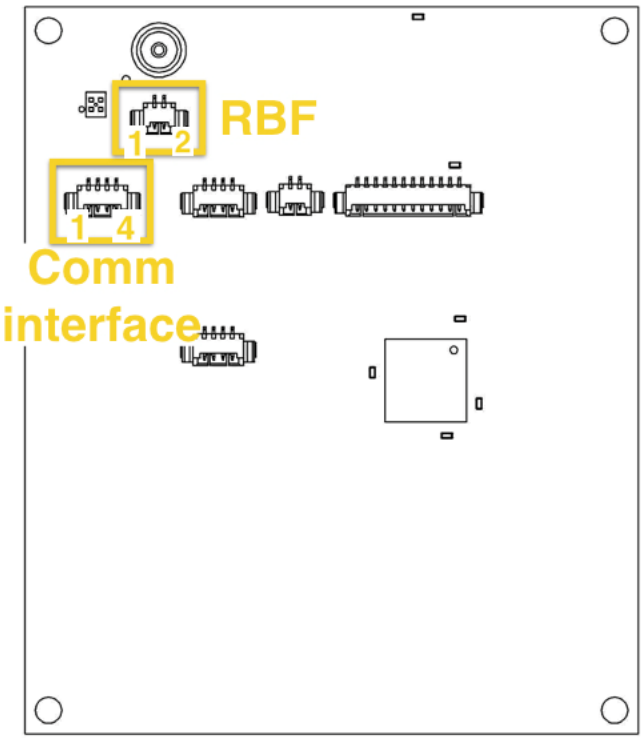


Figure 6: Remove Before Flight (RBF) Connector and Pinout – Bottom Side

6.2.2 RBF Pinout

Pin	Description
1	RBF
2	GND

6.3 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.

6.3.1 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).

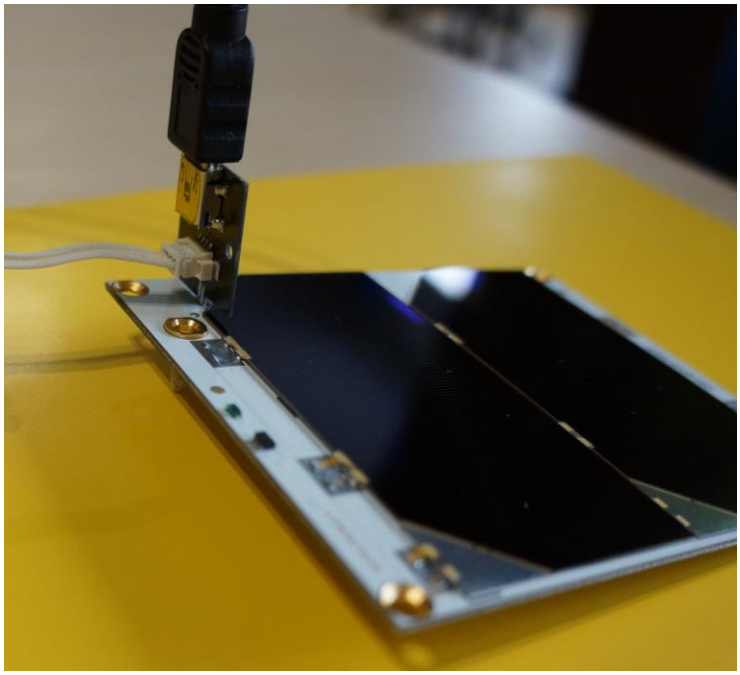


Figure 7: SCIC Adaptor - Top Side

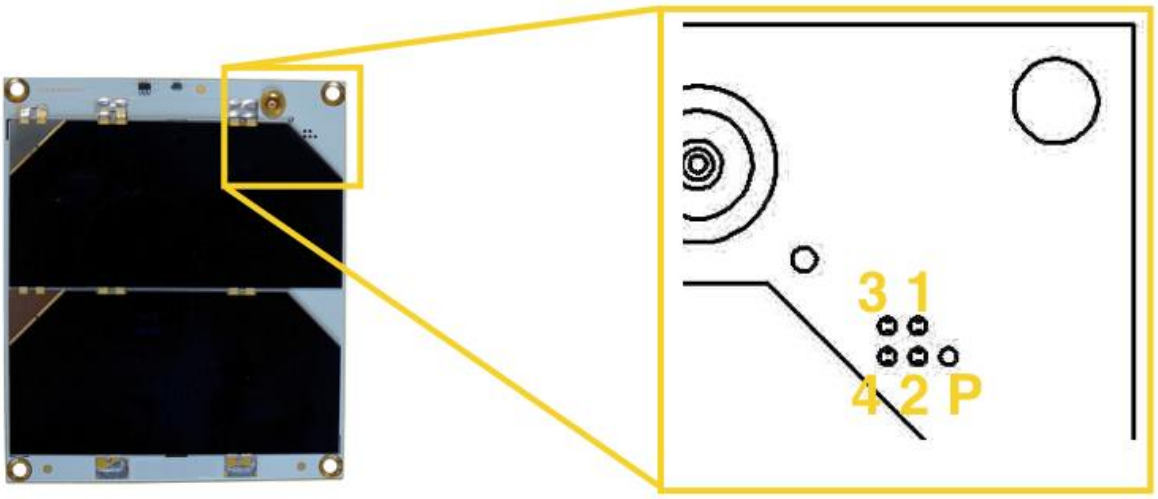


Figure 8: SCIC Connector - Top Side

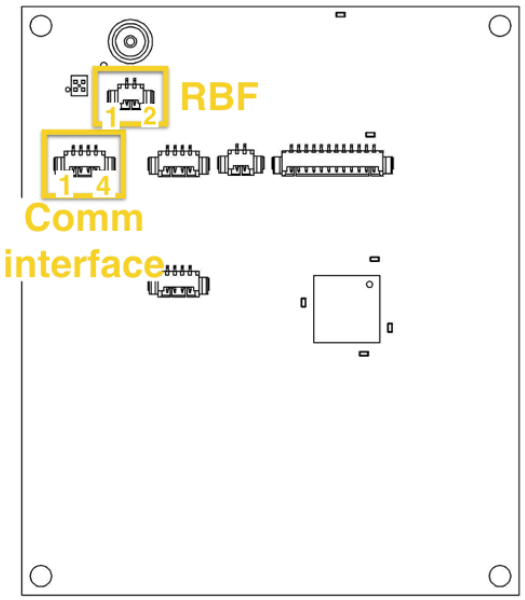


Figure 9: Satellite Communication Interface Connector (SCIC) and Pinout – Bottom Side

6.3.2 SCIC Pinouts

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

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

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 1U Solar Panel X/Y

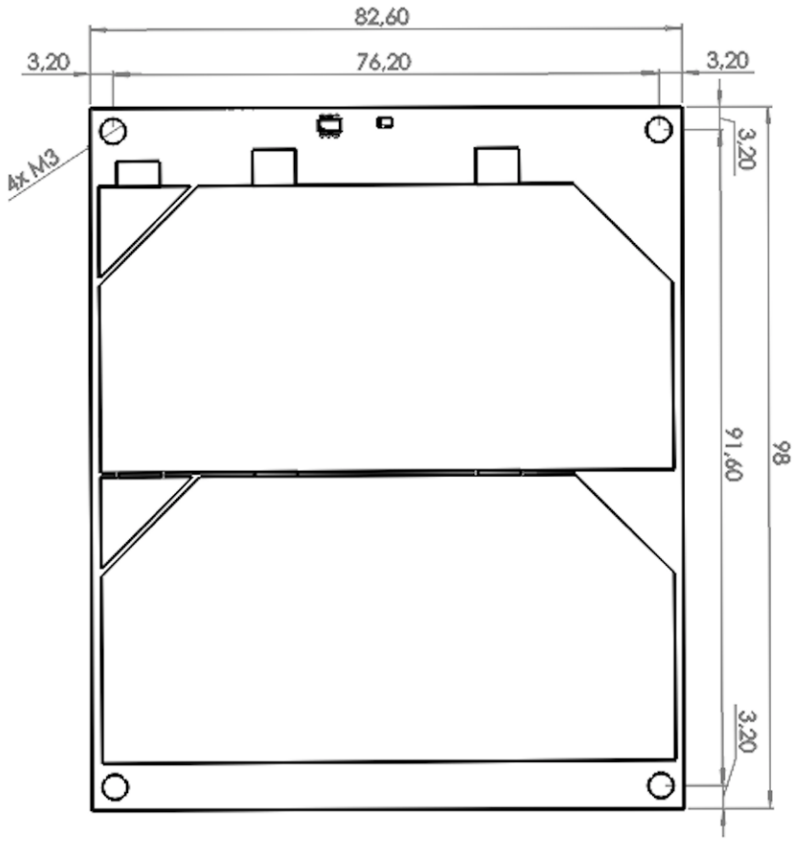


Figure 10: 1U Solar Panel X/Y - Top Side

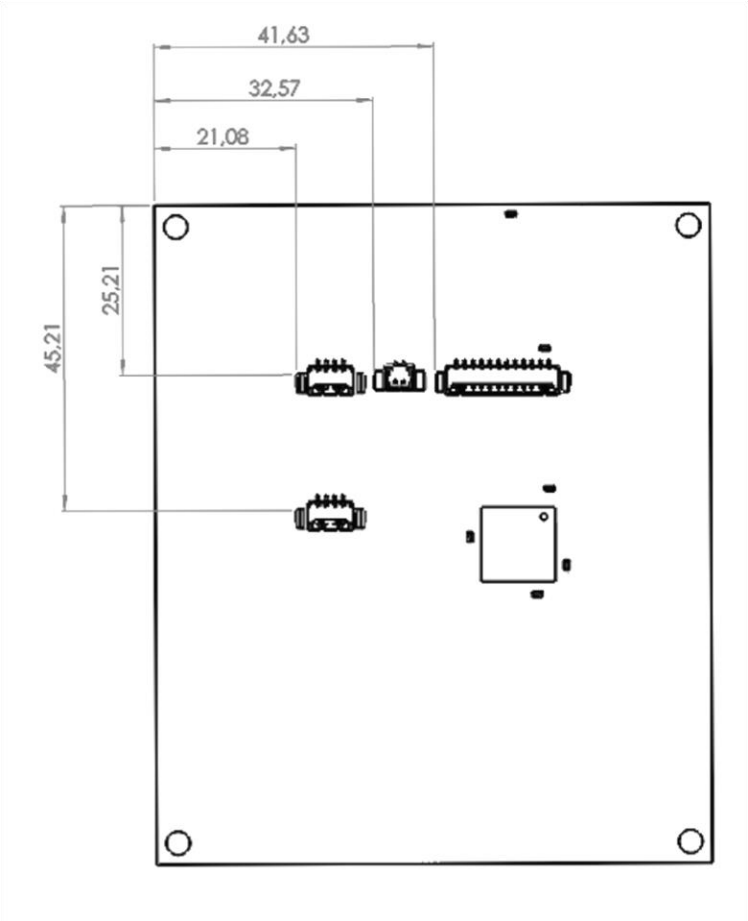


Figure 11: Solar Panel X/Y - Bottom Side (connector location)

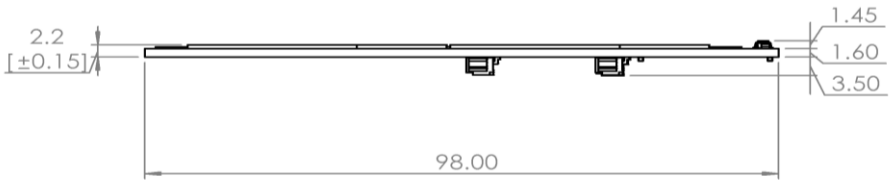


Figure 12: Solar Panel X/Y - Side View

8.2 1U Solar Panel X/Y MTQ

The dimensions of the 1U Solar Panel X/Y MTQ are identical to the 1U Solar Panel X/Y except for the thickness. The difference is due to the presence of the electromagnetic coils of the magnetorquer inside the PCB of the X/Y MTQ version.

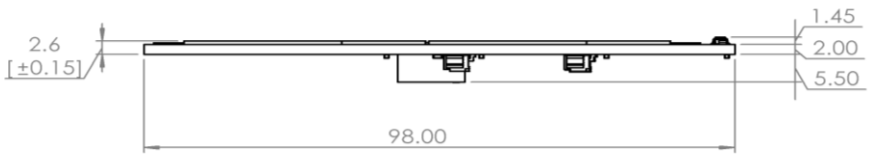


Figure 5: Solar Panel X/Y MTQ - Side View

8.3 1U Solar Panel Z

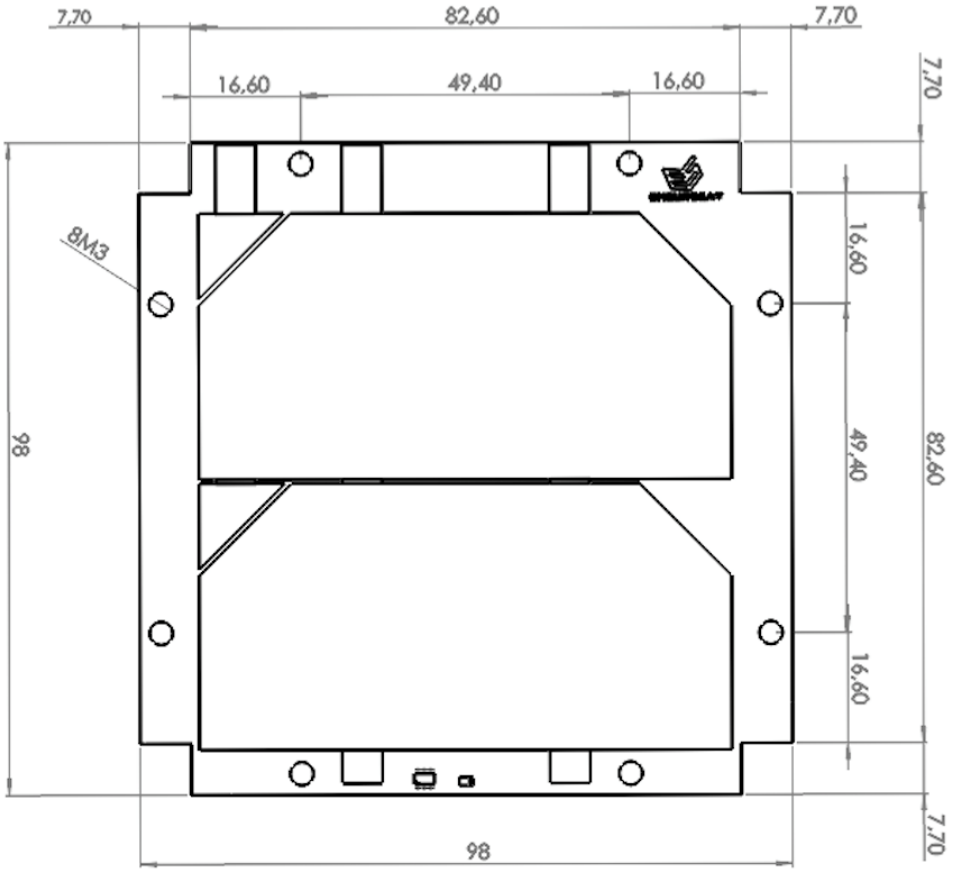


Figure 13: 1U Solar Panel Z - Top View

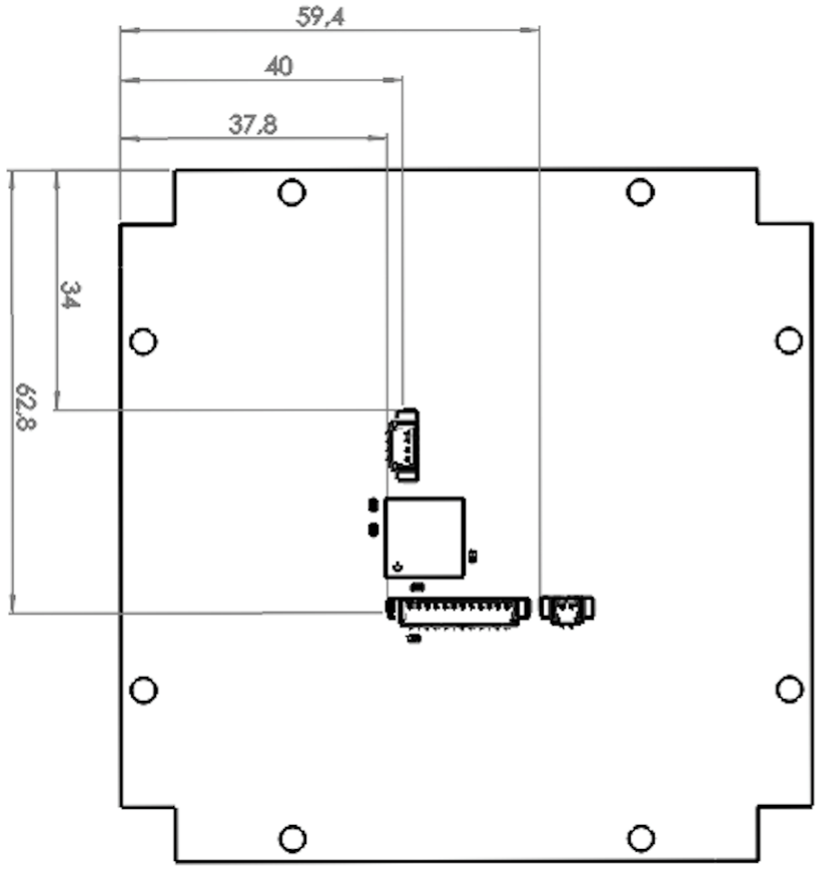


Figure 14: Solar panel Z - Bottom View (connector location)

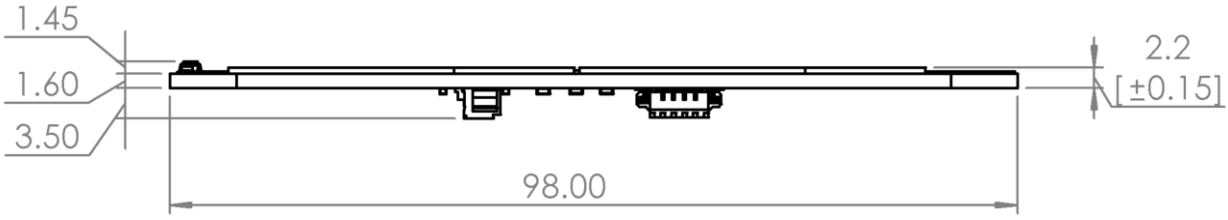


Figure 15: Solar Panel Z - Side View

8.4 1U Solar Panel Z MTQ

The dimensions of the 1U Solar Panel Z MTQ are identical to the 1U Solar Panel Z except for the thickness. The difference is due to the presence of the electromagnetic coils of the magnetorquer inside the PCB of the Z MTQ version.

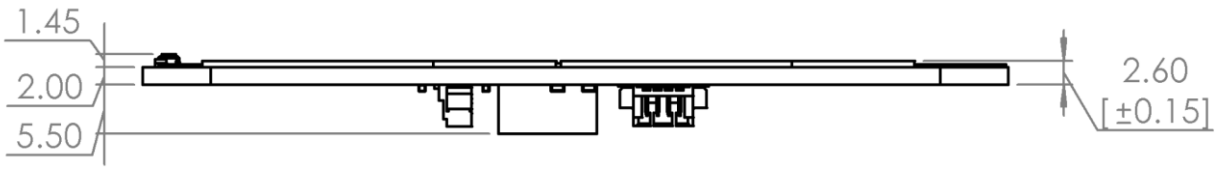


Figure 16: Solar Panel Z with Magnetorquer - Side View

8.5 1U Solar Panel X/Y RBF

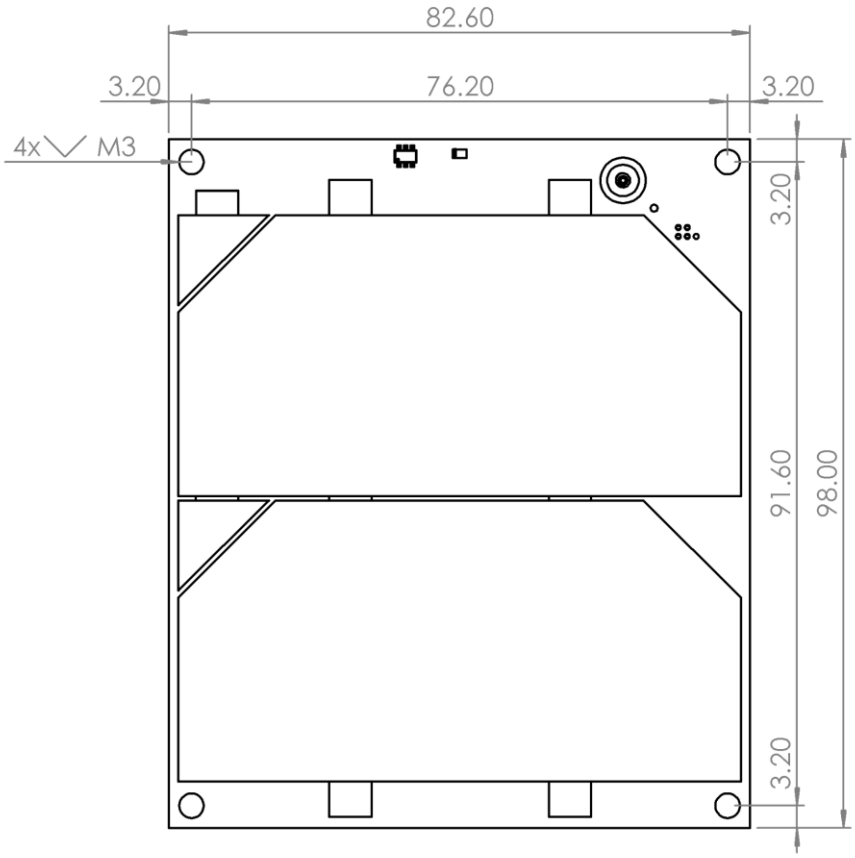


Figure 17: 1U Solar Panel X/Y RBF - Top View

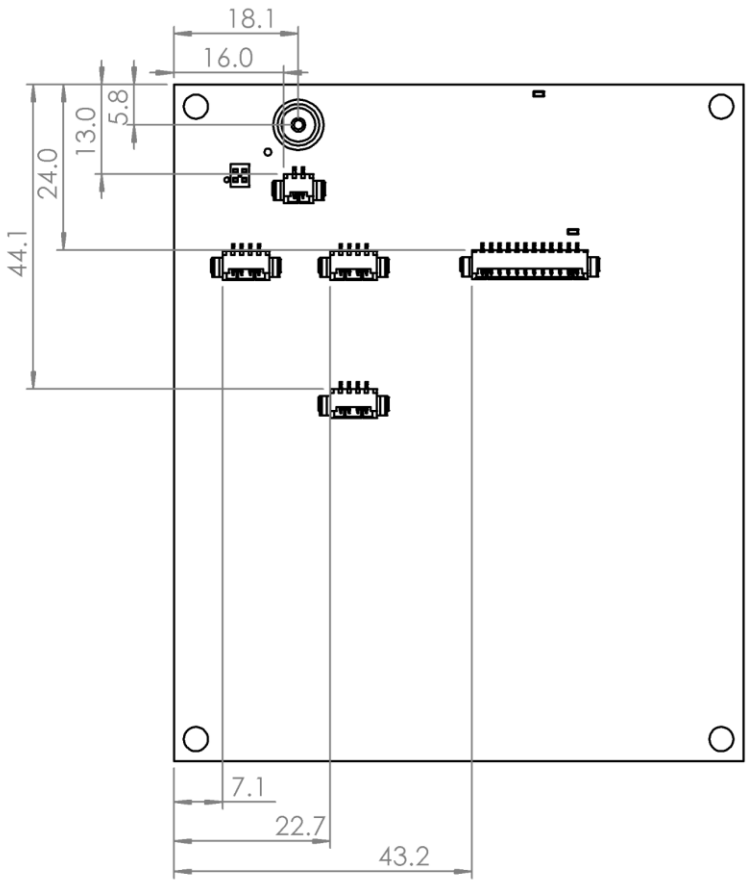


Figure 18: Solar panel X/Y RBF - Bottom View (connector location)

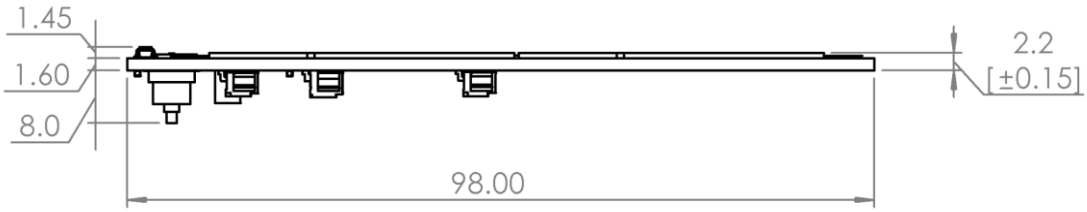


Figure 19: Solar Panel X/Y RBF - Side View

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

8.6 Tolerances

The outer edge dimensions of the 1U solar panels have a tolerance of ±0.1mm (±4mil).

The thickness of the 1U solar panels have a tolerance of ±0.15mm (±6mil).

9 CUSTOMIZATION

EnduroSat's 1U 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.

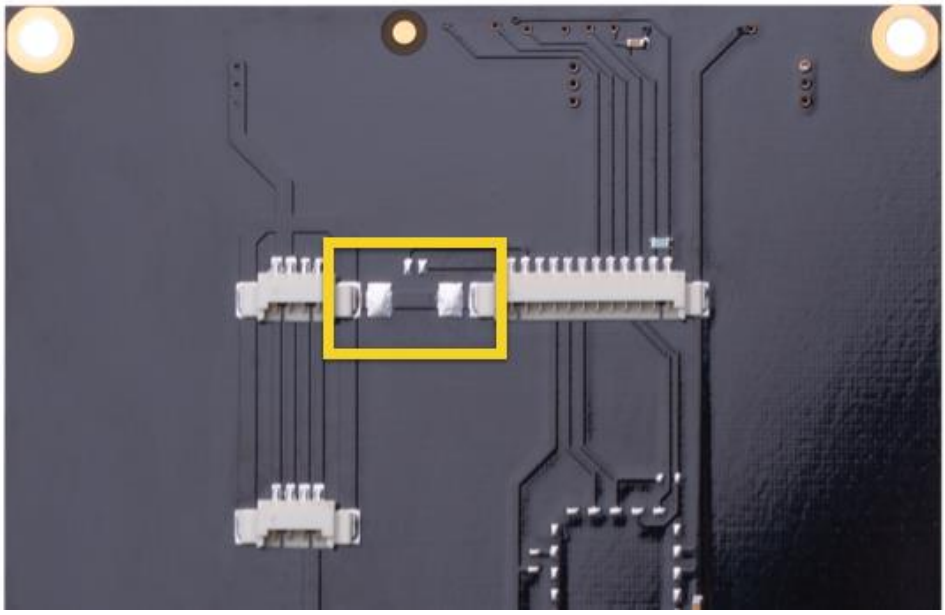


Figure 6: Solar Panel - Bottom Side (location of pads for the external magnetorquer connector)

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

10 MATERIAL AND ASSEMBLING

The solar panel's 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 ENVIRONMENTAL AND MECHANICAL TESTS

A full campaign of tests at qualification level was performed on the solar panel's qualification engineering model. Qualification test levels and duration follow the ESA standard ECSS-E-ST-10-03C and GEVS: GSFC-STD-7000A. Tests performed were:

- 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

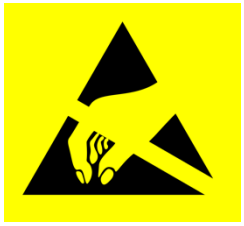
13 HANDLING AND STORAGE

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 as dust, oil, grease, fumes and smoke from any source.
- Do not touch the solar cells.
- Solar panels must be handled by touching the 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).

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.