SM Solar Panels

SPACEMIND

Design

SM-SP is a family of Solar Panels designed by NPC SPACEMIND in order to provide a modular and flexible solution for nanosatellite applications. The product is designed to be fully compliant with SM CubeSat Structures as well as with commercial of the shelf and custom-made CubeSat components.

As standard, SM Solar panels include thermal sensor and coarse sun sensor, with the possibility to add IMU9DOF and a user definable communication port. As option, embedded configurable magnetorquer providing up to 6 power levels (MTQ) can be included.

In case of specific mission requirement specific solutions can be realized both in terms of electrical performances and specific panels shape and cutout. For additional info spmtech@npcitaly.com

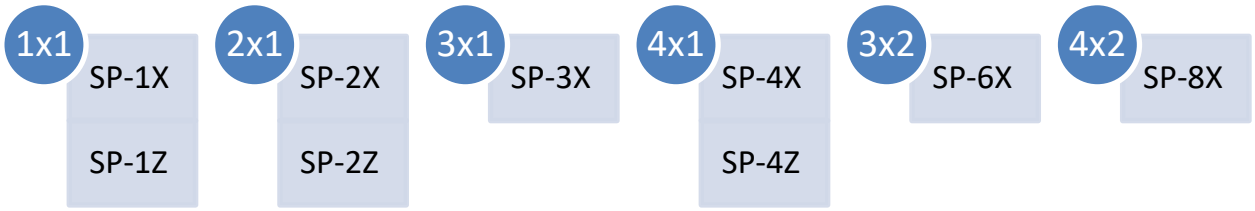
QUALITY ASSURANCE

NPC is a company certified ISO9001 for Quality management system. Qualification process has been pursued for each SM Solar Panels (QT). Product Assurance protocols are applied to each delivered SM Product (AT).

Qualification Test	QT	AT
Pre-production control	✓	✓
In-take quality control	✓	✓
Acceptance quality control	✓	✓
Vibration test	✓	-
Mechanical Shock	✓	-
TVAC Test	✓	-
Surface Treatment Test	✓	-
Functional and assembly test	✓	✓

Product configuration

SM Solar panels are directly compatible with SM Structures; nevertheless the design aims to ensure compatibility with a wide range of commercial components.



Custom form factor different than those presented in the document can be realized on the basis of customer specific requirements. For information contact spmtech@npcitaly.com

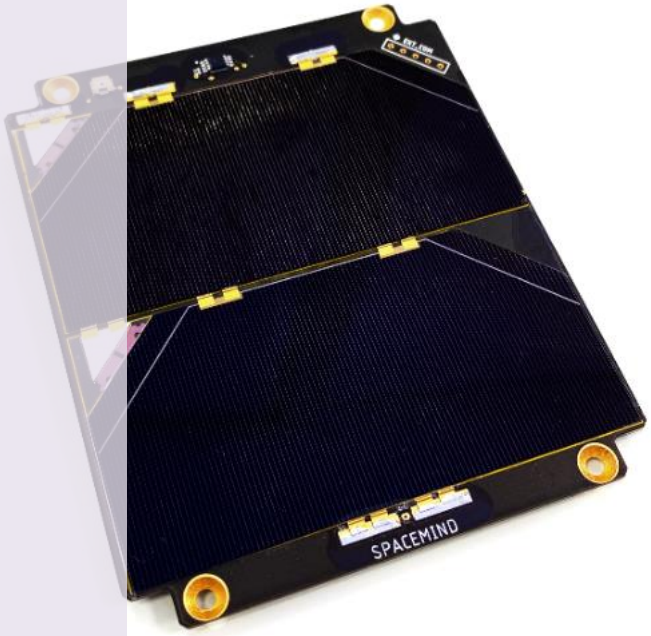
Available solar panels configurations are outlined in the compatibility table below:

Code	Form Factor	Side	MTQ	RBF	SENSORS	EXT COM	Compatible with
SM-SP1X	82.8x97.8 mm	XY	-	✓	✓	✓	1U
SM-SP1X-M	82.8x97.8 mm	XY	✓	✓	✓	✓	1U
SM-SP1Z	97.8x97.8 mm	Z	-	✓	✓	✓	1U/2U/3U/4U
SM-SP1Z-M	97.8x97.8 mm	Z	✓	✓	✓	✓	1U/2U/3U/4U
SM-SP2X	82.8x211.5 mm	XY	-	✓	✓	✓	2U
SM-SP2X-M	82.8x211.5 mm	XY	✓	✓	✓	✓	2U
SM-SP2Z	97.8x222.3 mm	Z	-	✓	✓	✓	6U/8U
SM-SP2Z-M	97.8x222.3 mm	Z	✓	✓	✓	✓	6U/8U
SM-SP3X	82.8x324.6 mm	XY	-	✓	✓	✓	3U/6U
SM-SP3X-M	82.8x324.6 mm	XY	✓	✓	✓	✓	3U/6U
SM-SP4X	82.8x438.1 mm	XY	-	✓	✓	✓	4U/8U
SM-SP4X-M	82.8x438.1 mm	XY	✓	✓	✓	✓	4U/8U
SM-SP4Z	222.3x222.3 mm	Z	-	✓	✓	✓	12U/16U
SM-SP4Z-M	222.3x222.3 mm	Z	✓	✓	✓	✓	12U/16U
SM-SP6X	208.8x325.3 mm	XY	-	✓	✓	✓	6U/12U
SM-SP6X-M	208.8x325.3 mm	XY	✓	✓	✓	✓	6U/12U
SM-SP8X	208.8x325.3 mm	XY	-	✓	✓	✓	8U/16U
SM-SP8X-M	208.8x325.3 mm	XY	✓	✓	✓	✓	8U/16U

SP1X

Product Code: SM-SP1X

- Solar panel for XY side
- Compatible with 1U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 35g
- 2.4 W Peak Power
- 494 mA Peak Current – 4.8 V
- 5,2 V Open circuit voltage
- 2 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available



Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

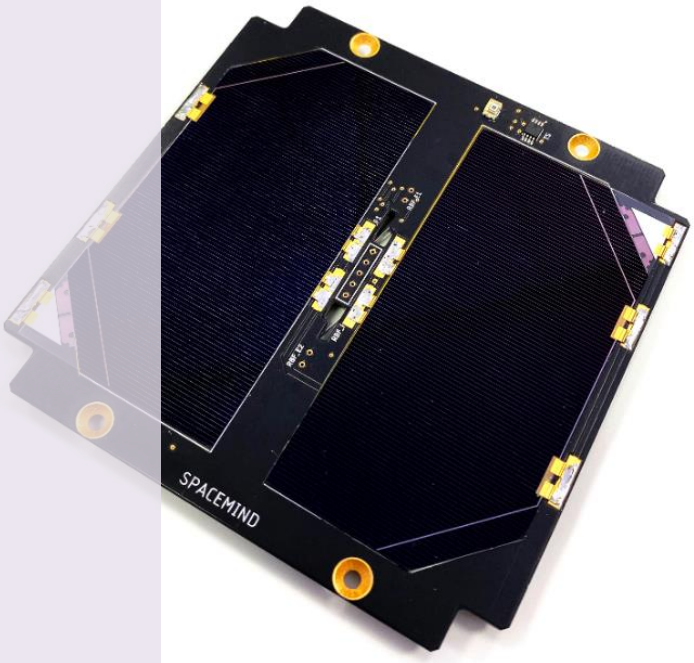
For integration with SM CubeSat Structure:

- SM01 – 1U CubeSat Structure

SP1Z

Product Code: SM-SP1Z

- Solar panel for Z side
- Compatible with 1U/2U/3U/4U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 35 g
- 2.4 W Peak Power
- 494 mA Peak Current – 4.8 V
- 5,2 V Open circuit voltage
- 2 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available



Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

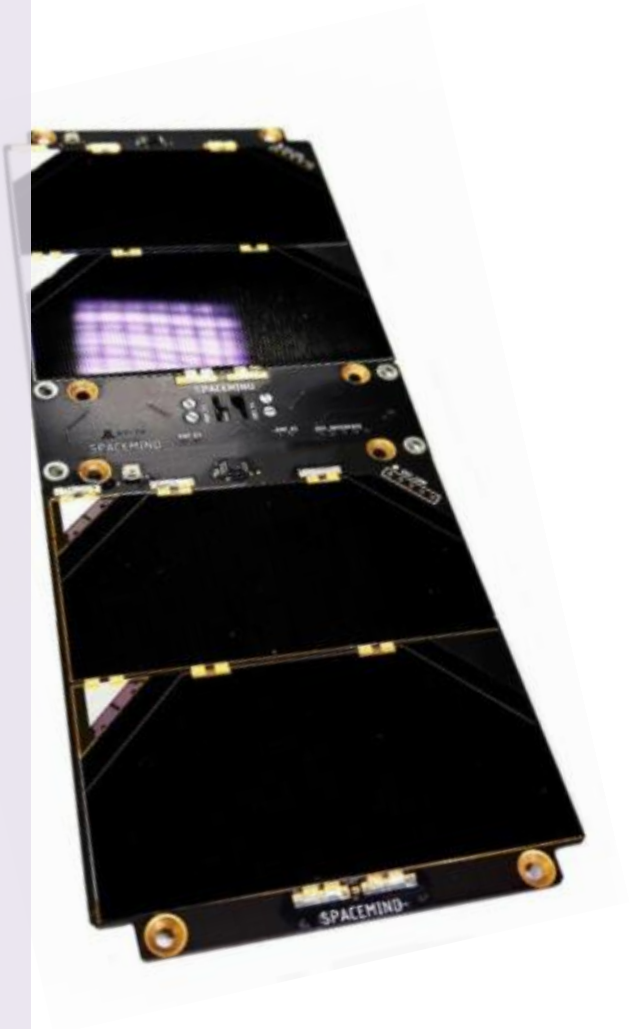
For integration with SM Cubesat Structure:

- SM01 – 1U CubeSat Structure
- SM02 – 2U CubeSat Structure
- SM03 – 3U CubeSat Structure
- SM04 – 4U CubeSat Structure

SP2X

Product Code: SM-SP2X

- Solar panel for XY side
- Compatible with 2U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 75 gr
- 4.8 W Peak Power
- 494 mA Peak Current – 9.6 V
- 10,4 V Open circuit voltage
- 2 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available



Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

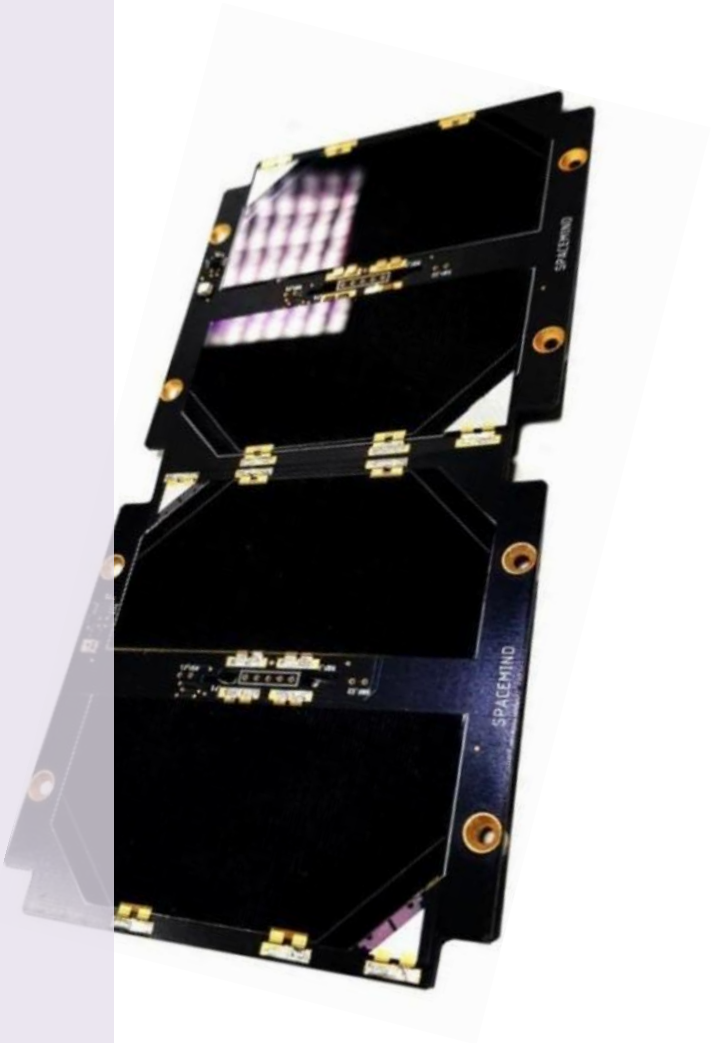
For integration with SM CubeSat Structure:

- SM02 – 2U CubeSat Structure

SP2Z

Product Code: SM-SP2Z

- Solar panel for Z side
- Compatible with 6U/8U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 75g
- 4.8 W Peak Power
- 500 mA Peak Current
- 10.4V Open circuit voltage
- 2 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available



Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

For integration with SM CubeSat Structure:

- SM06 – 6U CubeSat Structure
- SM08 – 8U CubeSat Structure

SP3X

Product Code: SM-SP3X

- Solar panel for XY side 3U CubeSat
- Compatible with 3U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 110 g
- 8.4 W Peak Power
- 500 mA Peak Current – 13.8 / 18 V
- 18.2 V Open circuit voltage
- 4 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available

Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

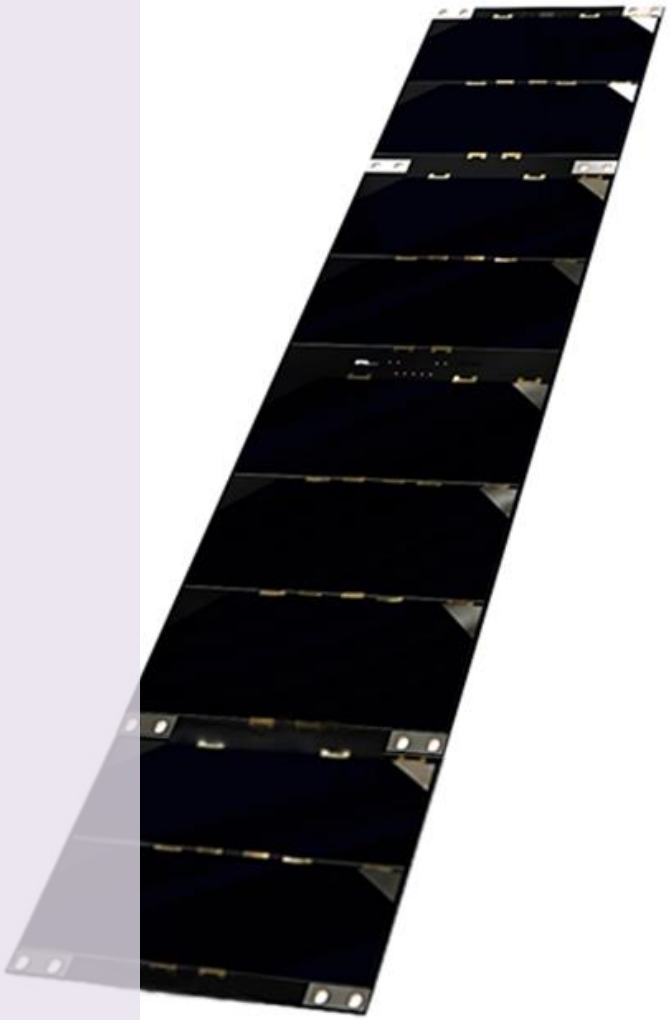
For integration with SM CubeSat Structure:

- SM03 – 3U CubeSat Structure
- SM06 – 6U CubeSat Structure

SP4X

Product Code: SM-SP4X

- Solar panel for XY side 4U/8U CubeSat
- Compatible with 4U/8U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 145g
- 12.6 W Peak Power
- 500 mA Peak Current
- 23.4 V Open circuit voltage
- 4 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available



Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

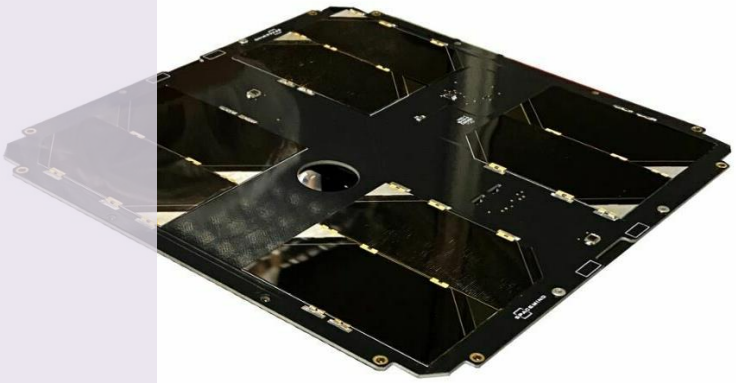
For integration with SM CubeSat Structure:

- SM04 – 4U CubeSat Structure
- SM08 – 8U CubeSat Structure

SP4Z

Product Code: SM-SP4Z

- Solar panel for Z side 12U/16U CubeSat
- Compatible with 12U/16U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 165g
- 9.6 W Peak Power
- 500 mA Peak Current
- 20.8 V Open circuit voltage
- 4 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available



Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

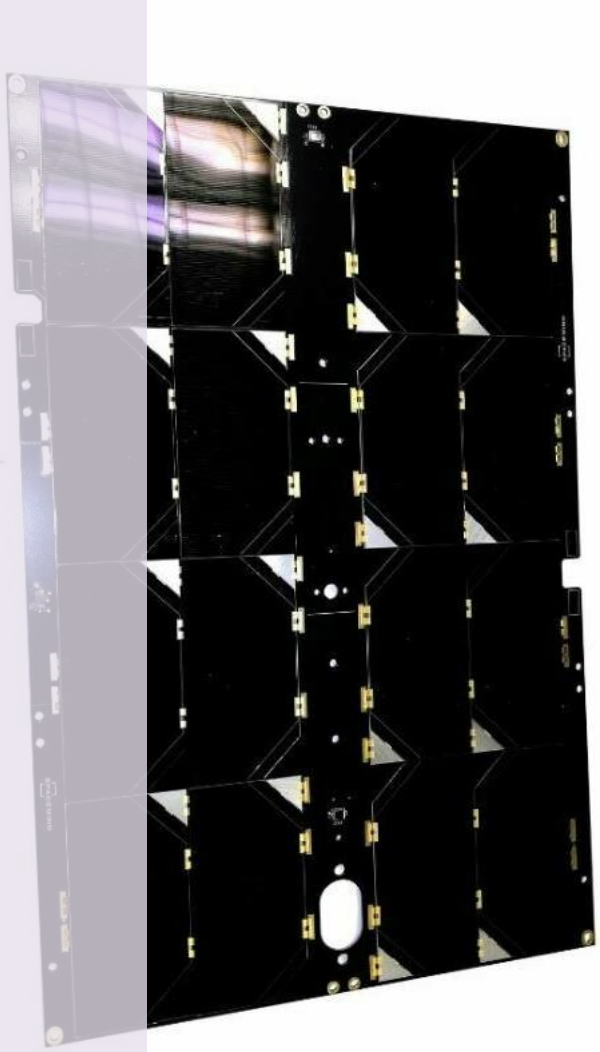
For integration with SM CubeSat Structure:

- SM12 – 12U CubeSat Structure
- SM16 – 16U CubeSat Structure

SP6X

Product Code: SM-SP6X

- Solar panel for Z side 6U/12U CubeSat
- Compatible with 6U/12U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 260g
- 19.2 W Peak Power
- 1000 mA Peak Current
- 20.8 V Open circuit voltage
- 4 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available



Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

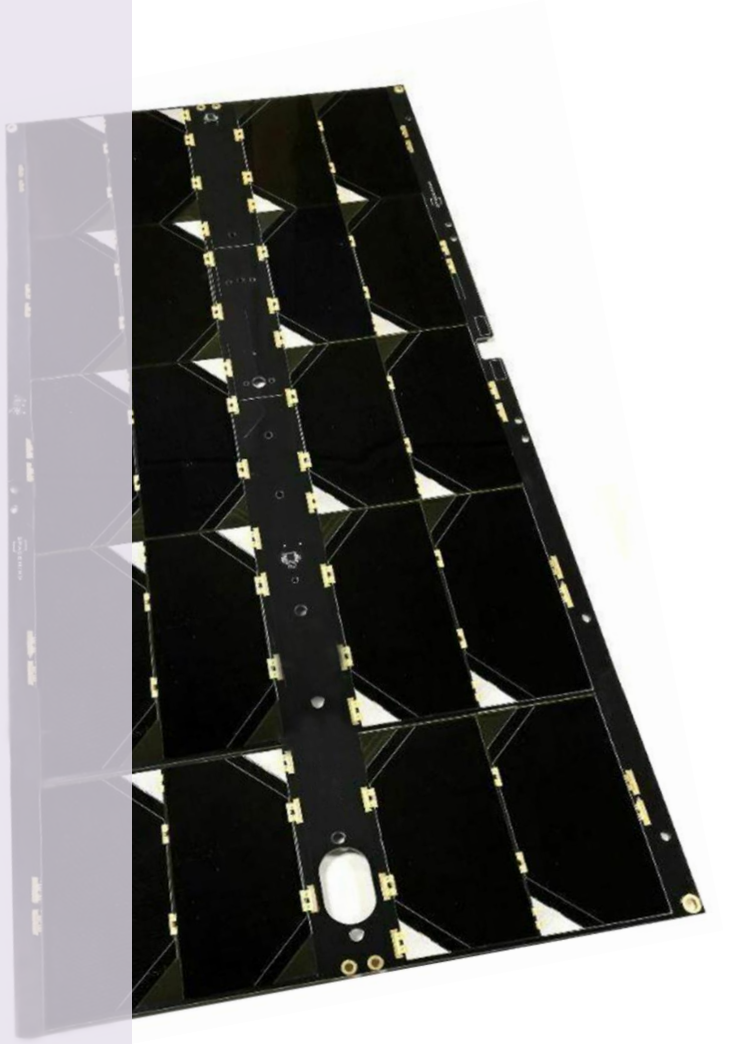
For integration with SM CubeSat Structure:

- SM06 – 6U CubeSat Structure
- SM12 – 12U CubeSat Structure

SP8X

Product Code: SM-SP8X

- Solar panel for Z side 8U/16U CubeSat
- Compatible with 8U/16U SM CubeSat structure
- High efficiency triple junction UTJ solar
- Mass: 350g
- 24 W Peak Power
- 1000 mA Peak Current
- 26 V Open circuit voltage
- 4 parallel picoblade power connectors
- Coarse sun sensors
- 2x Thermal sensor
- External Communication port
- Improved efficiency solar cells available



Options and customization

- IMU LSM9DS1 – 3xAcc/3xGyro/3xMag
- M - User configurable magnetorquer
- Custom cut-out and electrical performances

For integration with SM CubeSat Structure:

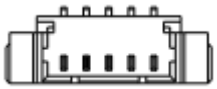
- SM08 – 8U CubeSat Structure
- SM16 – 16U CubeSat Structure

Product Features

In order to provide the customer with a performant and flexible solution, SM Solar panels include following subsystems:

- Solar Cells
- Sensor Package
- External Communication (where present)
- Magnetorquer (where present)
- Remove Before Flight (where present)

All product present identical connector type and pinout for the above mentioned subsystems. Data in this section are therefore applicable to all SM Solar panels provided that the relative subsystem is present on the product version and unless otherwise specified. Location of subsystem connectors is identical in each SM Solar Panels product version.

Horizontal Connector	Vertical Connector
 1 2	 1 2
 1 2 3	 1 2 3
 1 2 3 4 5	 1 2 3 4 5
 1 2 3 4 5 6	 1 2 3 4 5 6

SOLAR CELLS

SM panels integrate as standard triple junction solar cells 30% connected in series. Available on request SM panels can be configured with alternative parallel connection.

Each panel is equipped with two parallel power connectors (PWR-1 / PWR-2) in order to allow the possibility to combine different panels of the spacecraft in series or in parallel.

Below is reported pinout for solar cells power output:

Connector Label	Type	Pin	Connection
PWR	Picoblade pitch 1,25	1	V+ (solar cell P junction)
		2	V- (GND)

SENSORS PACKAGE

Thermal Sensor TMP126

General Data	
VDD Voltage supply [V]	3.3 V - [1.62 to 5.5 V]
Connector Type	6-pin Picoblade pitch 1,25 mm
Communication	SPI
Measuring Range	-55°C to +175°C
Measuring Accuracy	±0.75°C (maximum)
Data Output	14 bit

Sensor connector type and pin-out is outlined below:

Sensor Label	Type	Pin	Connection	
TS_CON	Picoblade pitch 1,25 mm	1	VDD	Voltage Supply
		2	SDI/SDO	Serial Data Input/Output
		3	ALERT	Alert open-drain output
		4	CS	Chip selector
		5	SCK	Serial Clock
		6	GND	Ground

Sun Sensor SFH 2401

Sun sensor	
Data Output	Photocurrent
Half angle [°]	60
Wavelength of max sensitivity [nm]	950
Spectral range of sensitivity [nm]	300 - 1100

Sensor connector type and pin-out is outlined below:

Connector Label	Type	Pin	Connection
CS	Picoblade pitch 1,25	1	CATHODE
		2	ANODE

EXTENDED SENSOR PACKAGE:

Extended sensor package includes IMU 9DOF with Accelerometer, Gyroscope, Magnetometer, Temperature sensor:

- ***NOTE**: LSM9DS1 – 9DOF inertial measuring unit is mounted on SM Solar panels. Users can refer directly to components datasheet provided by the OEM to retrieve detailed data and performance characteristics*

General Data	
VDD Voltage supply [V]	1.9 < VDD < 3.6
Connector Type	5-pin Picoblade pitch 1,25 mm
Communication	I2C
IMU Model	LSM9DS1
IMU DOF	3x acceleration (X,Y,Z) 3x angular rate (X,Y,Z) 3x magnetic field (X,Y,Z)
Data Output IMU	16 bit
Current consumption acc/mag [mA]	0,6
Current consumption gyroscope [mA]	4
Operating temperature range [°C]	-40° < T < 85°

Sensor connector type and pin-out is outlined below:

Sensor Label	Type	Pin	Connection	
IMU_CON	**Picoblade pitch 1,25 mm**	1	VDD	Voltage Supply
		2	SDI	SDA/SDI/SDO
		3	SC	Serial Clock
		4	CS	Ground
		5	SCK	Not Used

MAGNETORQUER

Embedded magnetorquer are available for all SM Panels as selectable option. Embedded magnetorquers are designed to allow the user to configure it according to the mission requirements: 3 available functional regimes can be obtained properly soldering the configuration pattern on the back of the board (HP configuration standard provided if not specifically requested). Customer can require the pattern pre-soldered in the required configuration. Magnetorquer can be supplied with 3,3V and 5V according to performance requirements.

SP4Z

Configuration	Dipole/Power (@3.3V)	Dipole/Power (@5V)
LP - Low Power	0,096 Am^2 / 0.06 W	0,146 Am^2 / 0.13 W
MP - Mid Power	0,193 Am^2 / 0,76 W	0,292 Am^2 / 1.15 W
HP - High Power	0,386 Am^2 / 0.92 W	0,585 Am^2 / 2.16 W

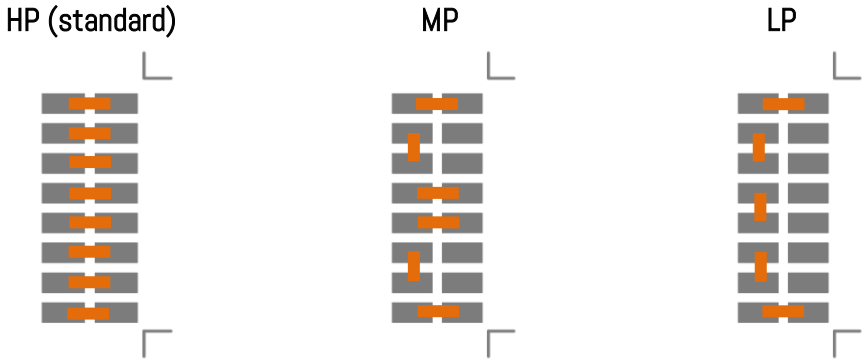
SP8X

Configuration	Dipole/Power (@3.3V)	Dipole/Power (@5V)
LP - Low Power	0,118 Am^2 / 0.04 W	0,179 Am^2 / 0.09 W
MP - Mid Power	0,236 Am^2 / 0,15 W	0,359 Am^2 / 0.35 W
HP - High Power	0,473 Am^2 / 0.61 W	0,717 Am^2 / 1.40 W

Magnetorquers connection can be alternately switched inverting the direction of the current loop. Pinouts indicate the connection that generate an outgoing (+Z) resulting dipole.

Connector Label	Type	Pin	Connection
MTQ	Picoblade pitch 1,25	1	V+
		2	V-

In the table below are provided configuration patterns for HP-MP-LP configurations obtainable by welding the tin bridges as indicated by the orange lines. LP and MP configurations are useful for low power dissipation.



A redundant configuration with two separate parallel circuits is optionally available. This configuration allows to achieve the HP and MP connections, selecting the parallel or series configuration for the two loops in each circuit.

REMOVE BEFORE FLIGHT

RBF add-on includes inhibition circuit accessible from the outside while satellite is integrated into the deployer. Due to the variety of available deployers and differences in access ports, RBF are included both in XY and Z side panels for all product versions. RBF are implemented by enclosed pin jumpers activated from the external face of the panel by means of physical plugs that shall be removed to inhibit the circuit.

Label	Pin	Connection	
RBF_P#	Picoblade pitch 1,25 mm	1	COM
		2	NO
		3	NC
RBF_E#	Picoblade pitch 1,25 mm	1	CONTROL_G
		2	OUTPUT POWER_RET_D
		3	INPUT POWER_S

OPERATING DATA

Following operating data are applicable to all SM Solar panels.

- Mechanical qualification: NASA GEVS
- Operating temperature: -30°C +100°C
- Qualification temperature: -50°C +130°C

Product Features

SM Solar Panels are conceived to allow the customer to create its own set according to mission requirements: this ensures multiple solutions in terms of platform layout, compatibility different launch provider interfaces, etc.
As example, complete mission solar panel sets for 1U, 2U and 3U including full functionalities is provided.

RBF/COM Access on XY panel

1U Suggested set

- X+: SP1X
- Y+: SP1X
- X- : SP1X-M
- Y- : SP1X-M
- Z+: SP1Z
- Z- : SP1Z-M

2U Suggested set

- X+: SP2X
- Y+: SP2X
- X- : SP2X-M
- Y- : SP2X-M
- Z+: SP1Z
- Z- : SP1Z-M

3U Suggested set

- X+: SP3X
- Y+: SP3X
- X- : SP3X-M
- Y- : SP3X-M
- Z+: SP1Z
- Z- : SP1Z-M

PRODUCT LAYOUT

In this section a layout of each product version is provided indicating location of subsystem connectors. For pinout description user can refer to section….
In this section is reported product layout with indication of connectors positioning and labelling and overall layout. For reasons of brevity and document simplicity, the layout of the version with all the add-ons is reported. Other versions without add-ons maintain the same measurements and layout net of subsystems and related connectors not present.

HARNESS

Solar Panels shall be cabled exploiting molex picoblade 1.25 pitch connectorized cables:

- 125V – 1A rated cable is suggested.
- Picoblade connectors shall be plugged/unplugged smoothly In order to avoid damages to the item
- Plugged connectors might be secured with bonding epoxy material prior to flight (Araldite)

ASSEMBLY

Solar Panels shall be assembled directly on SM Structure:

- M2,5 Screws are used to fix the panels to the structure – see SM Structure Datasheet and User Manual.

ENVIRONMENTAL TESTING

Environmental tests are carried out on SM Solar Panels in accordance with JX-ESPC-101133-B and ECSS-E-ST-10-03C.

STRUCTURAL REQUIREMENTS

SM Solar Panels are designed in compliance static and dynamic requirements, in order to guarantee the functionality and the capability to withstand severe loading conditions.
Detailed FEM analysis have been carried out to verify margins of safety, displacements and identify load paths.
A summary of main structural requirements taken into account for design are provided in the table below. Bolt fail safe analysis has been carried out considering complete CubeSat model and different loading conditions, in order to assess the structural compatibility also in case of bolt failure.

Structural Requirement Table

Requirement	Value	Reference to specifics
Quasi-static acceleration	18,1 g	Orbital Cygnus
Stiffness	100 Hz	JX-ESPC-101133-B
Random vibration	14.1 GRMS	NASA-GEVS

STORAGE AND HANDLING

PACKAGED PRODUCT

- SM Solar Panels are provided in a Antistatic Envelope in a rigid box.
- Each panel is provided equipped with a protective plexi-glass panel to avoid contact with the cells surfaces
- Eventual accessories and cable assembly is provided in labelled envelope.

UNPACKING

- Unpacking should be made in a particles-free environment (class according to requirements) in presence of electrostatic discharge protection systems (In any case no dust, oil, grease, fumes and chemicals shall be present)
- Particular attention shall be paid to avoid any damage to product parts during the unpacking.
- Small parts such as screws and special inserts are easy to get lost during the unpacking phase: always check compliance with the Bill of Material provided for each product.
- Each product parts should be handled using PVC, latex, cotton (lint free) or nylon gloves not to deposit any trace of skin grease on the part.

HANDLING

- Each product parts shall be handled in presence of electrostatic discharge protection systems.
- Each product parts should be handled using PVC, latex, cotton (lint free) or nylon gloves not to deposit any trace of skin grease on the part.
- In case of wrong handling parts can be cleaned with isopropyl alcohol 99% -
- Cells might be cleaned with dry microfiber tool; Do not clean cells with isopropyl alcohol 99%

STORAGE

- Parts must be stored away from humidity and contaminant in electrostatic protective envelopes.
- Storage shall not compromise in any case structural shapes and shall not stress the parts structurally, thus avoiding any elastic / plastic deformation.

TOOLING LIST

- Torque wrench (up to 2,5 Nm torque);
- List of screws/ inserts: