NanoPower
Deployable Solar Panel

Datasheet
Deployable solar panel for 3U or 6U satellite

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Product name: NanoPower DSP

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Approved by: PHK

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Confidentiality Notice

1 Table of Contents

Document Change Log

Revision	Date	Name	Description
2.0	04-02-2020	KAME	Released version 2.
2.5	08-04-2021	KAME	Added description about J105
2.6		RABN	Clarified explanation of variants under Highlighted features. Clarified explanations about the mounted sensors and GSSB PCBs available on the various variants.
3.1	23-02-2024	FIHA	An overhaul including CESI and ASUR cells support on new dual cell module.

2 Overview

The GomSpace NanoPower DSP (Deployable Solar Panel) is designed to give maximum energy for the small formfactor GomSpace Nanosatellites.
The deployable panel design is composed of three panels connected side by side with the ability of being folded together for minimum space occupation during transport and launch.
A DSP can be mounted on either a 3U or a 6U structure – see examples in section 4.1. The same DSP unit is designed to be installed on either side of a structure. On a 6U structure the panels can only be mounted on the 3U sides. On a 3U structure they can be mounted on all four 3U sides.
On the panel mounted on the body of the satellite the NanoSense Fine Sun Sensor (FSS) can be mounted, canted 6° outwards.
The DSPs comes in three versions, a *135° version*, a *90° version*, and a *135° reverse version*. The CAD below in Figure 2-1, shows the 135° version and the 90° version DSP variants. The difference between 135° reverse version and the 90° version is the deploy angle only.

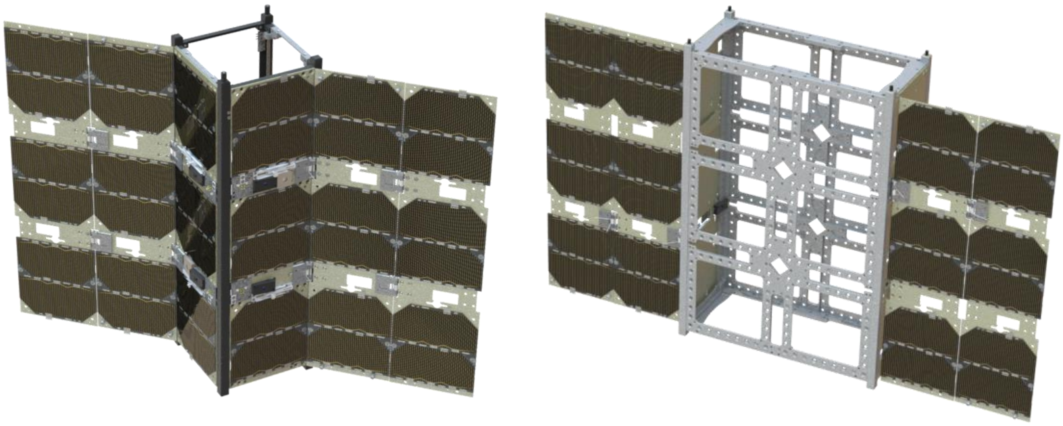

Figure 2-1: Two 135° versions on a 3U structure left, and two 90° versions on a 6U structure right.

The 135° version has 3 strings each with 6 solar cells arranged in series.
The 135° reverse and the 90° versions have 3 strings each with 4 cells arranged in series.
Each DSP has two deployable panels and one body mounted panel.

2.1 Highlighted Features

General:

- 135° version, three panels with 6 solar cells each and including:
  - 2 x Coarse sun sensor and 2 x temperature sensors.
  - 2 x Fine Sun Sensors (FSS).
  - 2 x GSSB modules for interconnection of above-mentioned sensors.
- 90° version, two panels with 6 solar cells each.
- 135° reverse, two panels with 6 solar cells each.
- Redundant panel release mechanism.
- Temperature sensors:
  - Internal temperature sensor range is -40° C to +85° C.
  - External temperature sensor range is -55° C to +175° C.

Solar cells:

- Two solar cell variants to mitigate lead time:
  - AzurSpace 3G30A Triple Junction Solar Cell GaInP/GaAs/Ge on Ge.
  - CESI CTJ-LC Triple Junction Solar Cells InGaP/GaAs/Ge.
- Space qualified triple junction solar cell assemblies.
- 30 cm^2 effective area per solar cell.
- 28-30% solar panel efficiency.
- Up to 1.2 W per cell in LEO.
- Cover glass included.

3 Warnings

Handling

This product uses advanced solar cells that are fragile. Do not touch solar cells.

Only handle solar panels without touching solar cells or their tabs

Never place anything on solar cells!

ESD

This product uses semiconductors that can be damaged by electrostatic discharge (ESD). When handling, care must be taken so that the devices are not damaged. Use appropriate precautions.

4 Graphical Overview

The illustration below – see Figure 4-1 – labels the different parts of a DSP and illustrates how the release mechanism and the FSS goes through the holes in the panels in the stowed configuration. The FSS only goes through the first panel, and is partly hidden by the last panel, hence it cannot be used for precise sun alignment until the panels are deployed. Instead, the FSS is used as solar panel deployment detection.

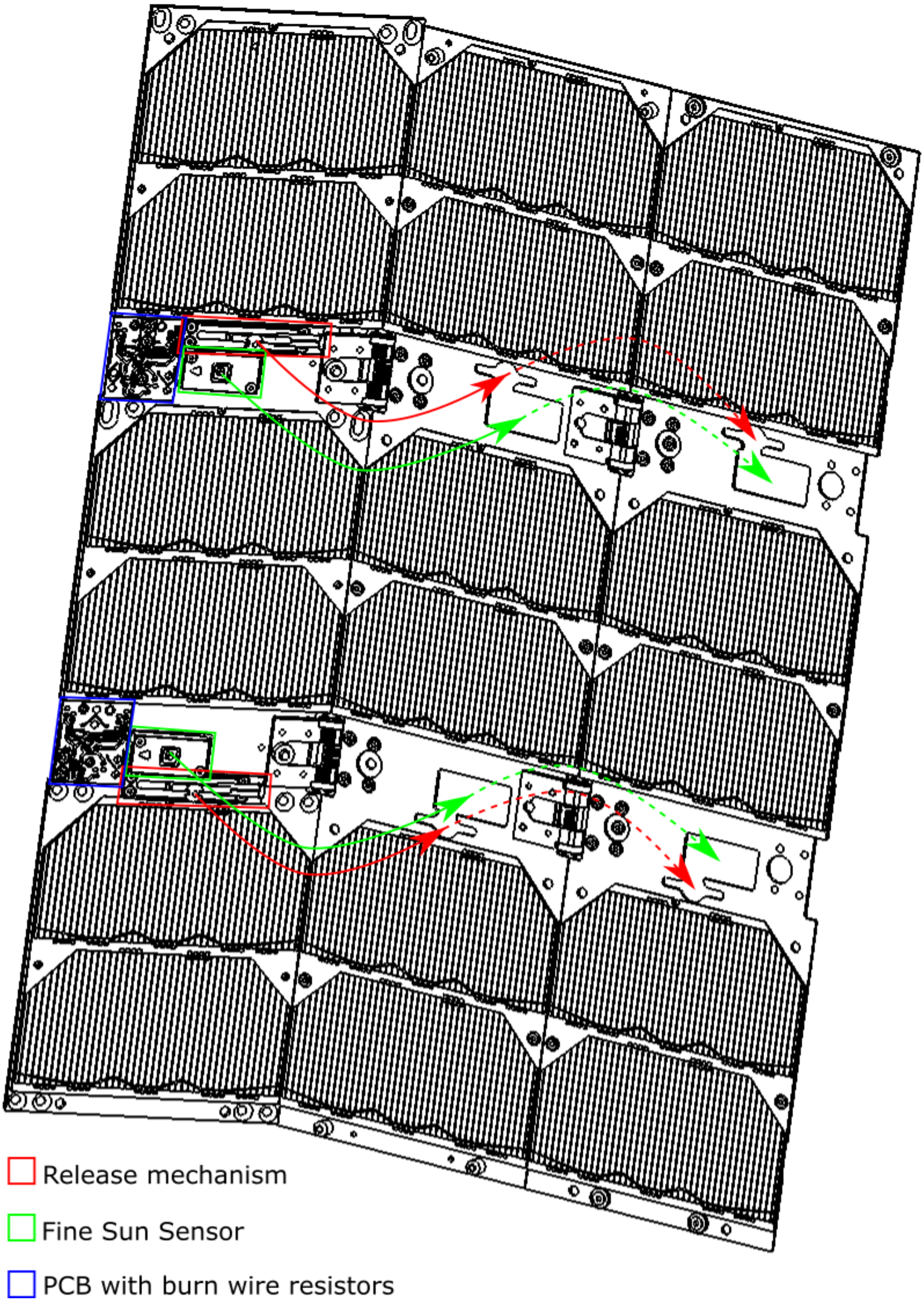

Figure 4-1: The 135° solar panel.

4.1 Solar Panel Configuration Examples

Below are shown different mounting configurations with both one and two DSP's – see Figure 4-2.

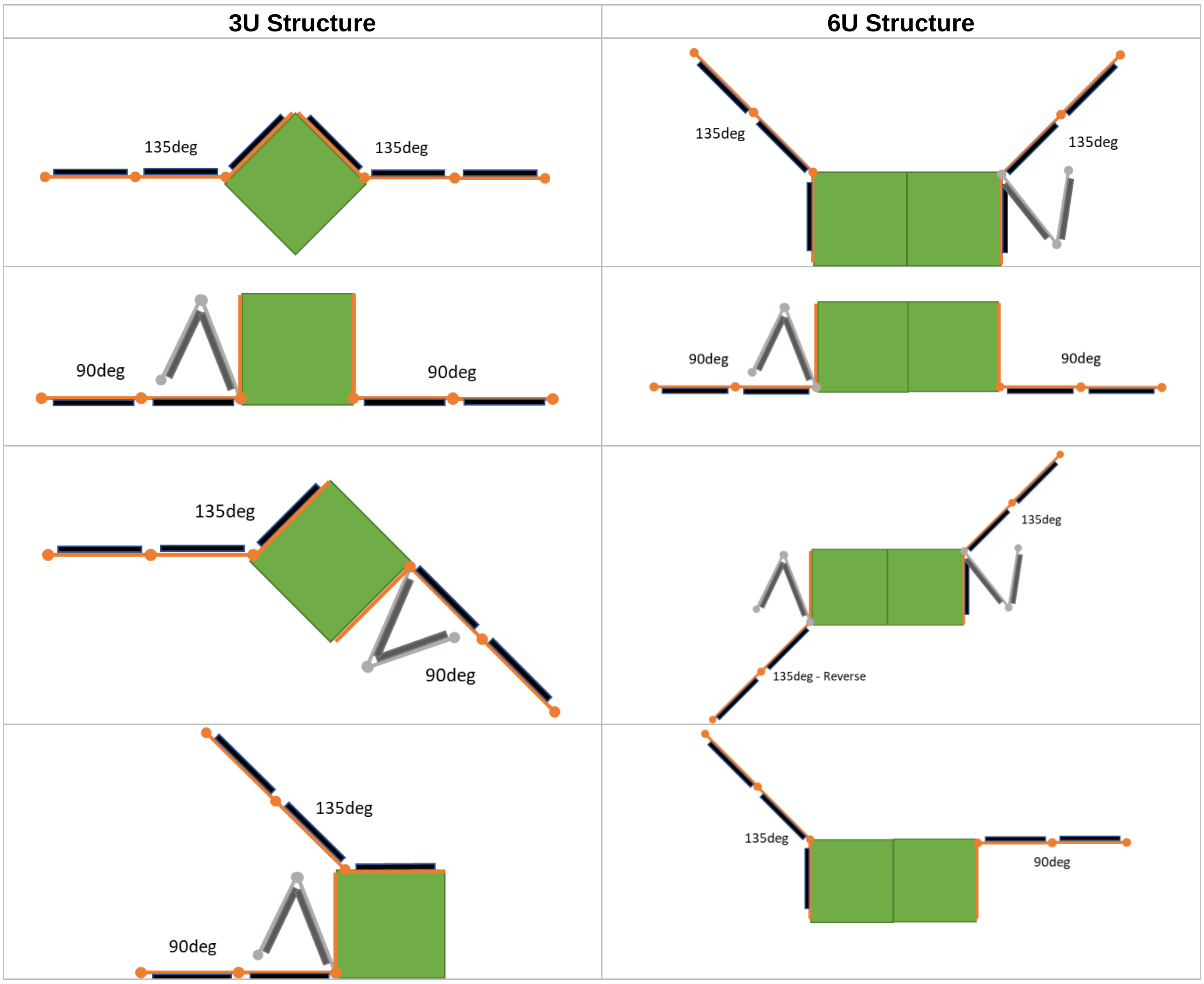

Figure 4-2: Examples of solar panel configurations.

All configurations shown are top view of the satellite. Eight configurations are shown but many more configurations can be made.

Black indicates the solar cells, and the orange is the aluminium back plate.

5 Block Diagrams

To illustrate the deployable solar panel system power flow, the sensors, and the release system, do visit the block diagrams in the following.

5.1 NanoPower DSP 135 deg MK2 (111286)

The 135° solar panel is arranged in 3 strings each with 3 dual cells series connected with flex PCBs and are ending in either in an S2C or P2C interface boards – see Figure 5-1.

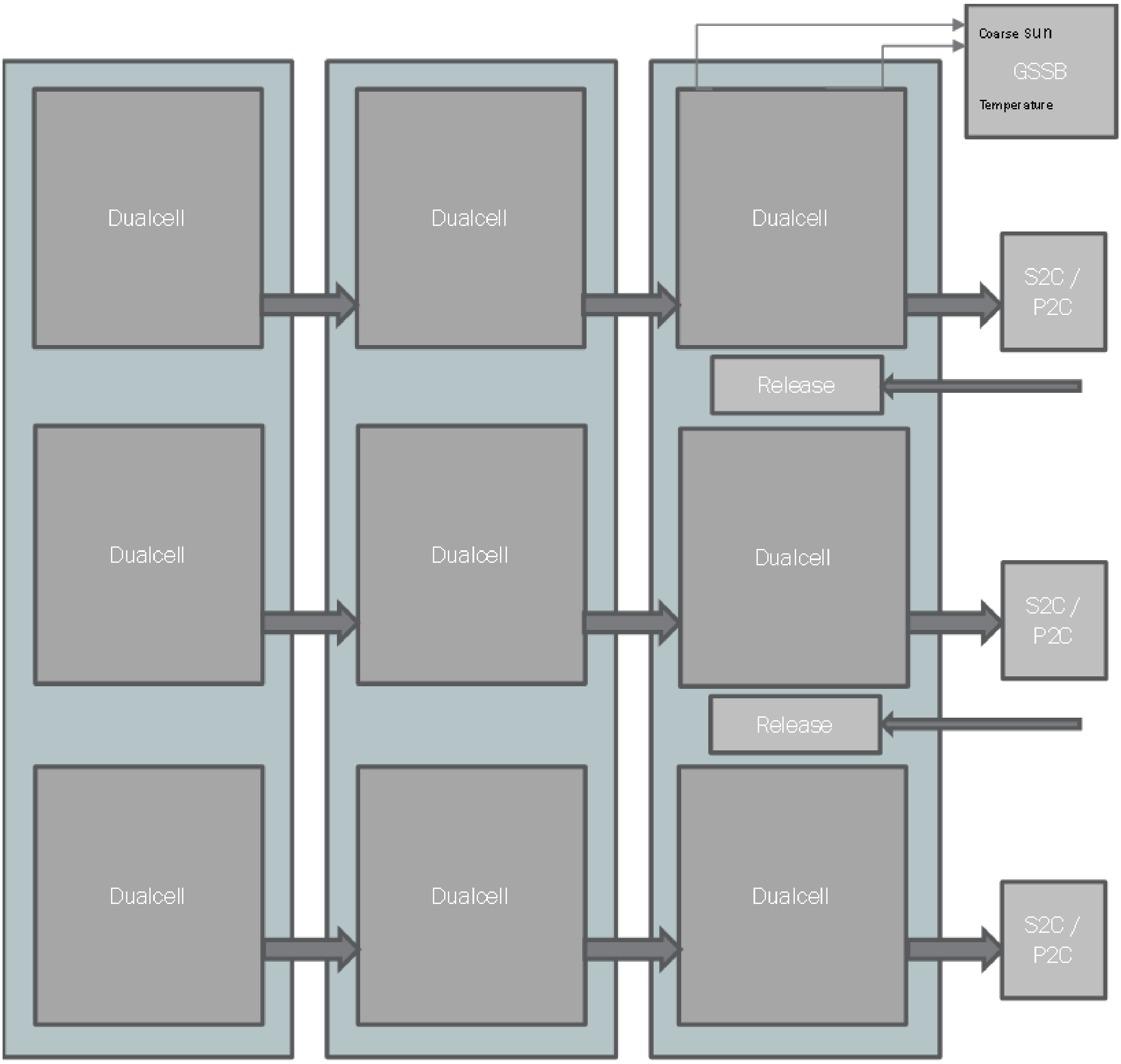

Figure 5-1: NanoPower DSP 135 deg MK2 (111286).

The P2C interface board enables the three strings to be connected in parallel and only one cable needs to run to the EPS. If higher voltage is required, the S2C board can be used instead.
The 135° version has two GS GSSB modules for enabling a fine sun sensor for alignment and two times an internal and an external temperature sensor – and two coarse sun sensors for detection if illuminated or if in shadow.

More information can be found in section 7.

5.2 NanoPower DSP 90 deg MK2 (111287), and DSP 135 deg MK2 – reverse (111288)

The 90° and the 135° reverse panels are both arranged in 3 strings each with 2 dual cells series connected with flex PCBs and are ending in either in an S2C or P2C interface boards – see Figure 5-2.

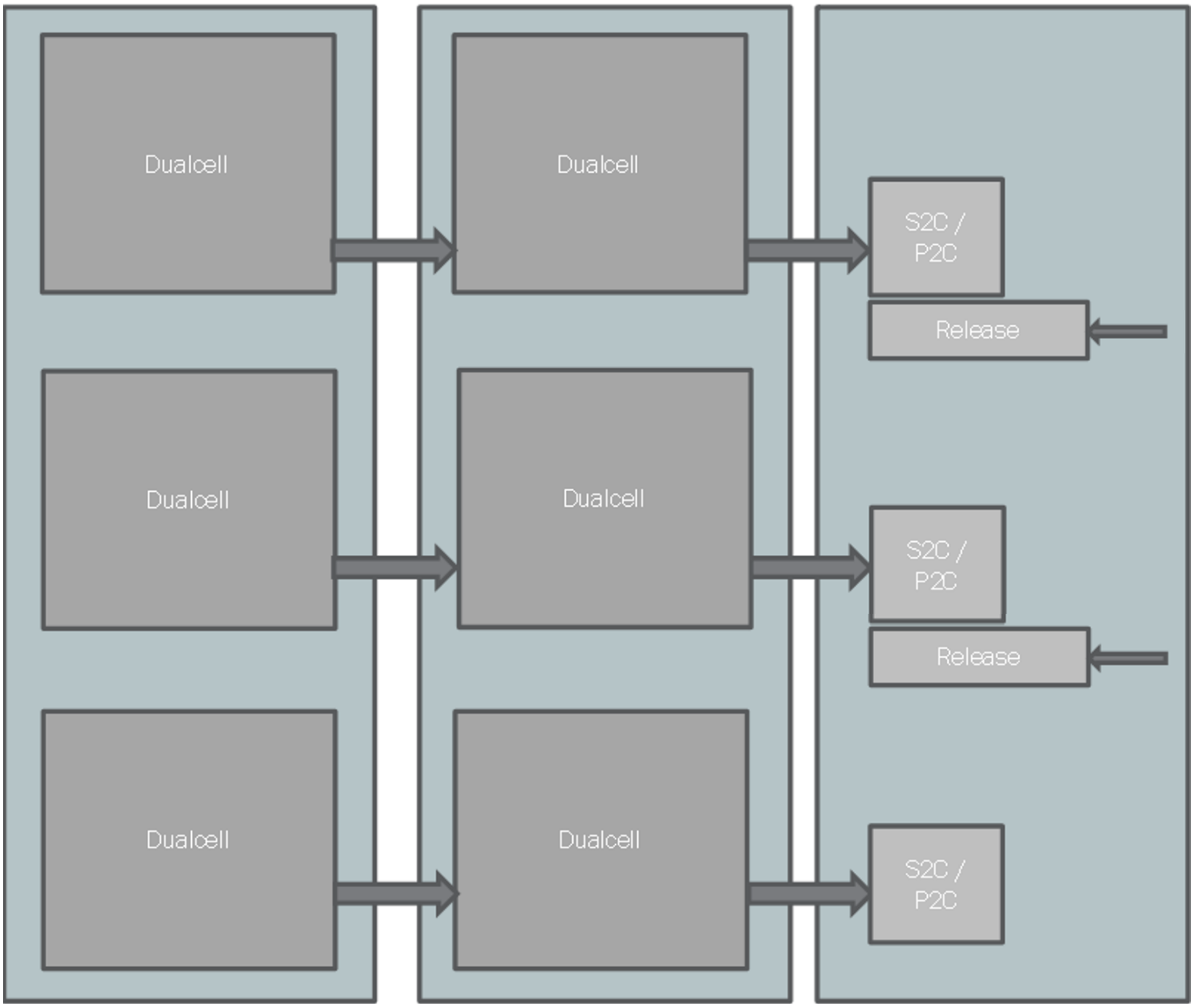

Figure 5-2: 90° version and 135° reverse version.

The P2C interface board enables the three strings to be connected in parallel and only one cable needs to run to the EPS. If higher voltage is required, the S2C board can be used instead.
No GS GSSB modules are used per default.

More information can be found in section 7.

6 Submodule Descriptions

6.1 The Dual Cell Module (108256, 108300, 111274, 111294)

The main components in the DSP are the solar cells, components transforming incoming sunlight into electric energy. GomSpace use a few vendors that provides highly efficient solar cells designed for use in space. There are variants depending on the component availability and use case.

The modules have a PT100 as external temperature sensor and a coarse light detection diode (sun sensor). The external temperature sensor range is -55 to +175°C. The coarse sun sensor found on the dual cell module, is a simple detector if that senses if the solar array is illuminated or is in the shadow.

On a Dual Cell Module, the two solar cells are always arranged in series – and includes two bypass diodes, one parallel to each solar cell that will conduct if the parallel cell performs poorly – see Figure 6-1.
The individual dual cell modules are combined in series using a flex PCB, and each string can be interfaced through a P2C board found on the body mounted panel, see e.g. Figure 7-1 and Figure 8-1.

All solar cell panels require minimum one MSP-GSSB board enabling use of internal and external temperature sensor – and the coarse sun sensor.

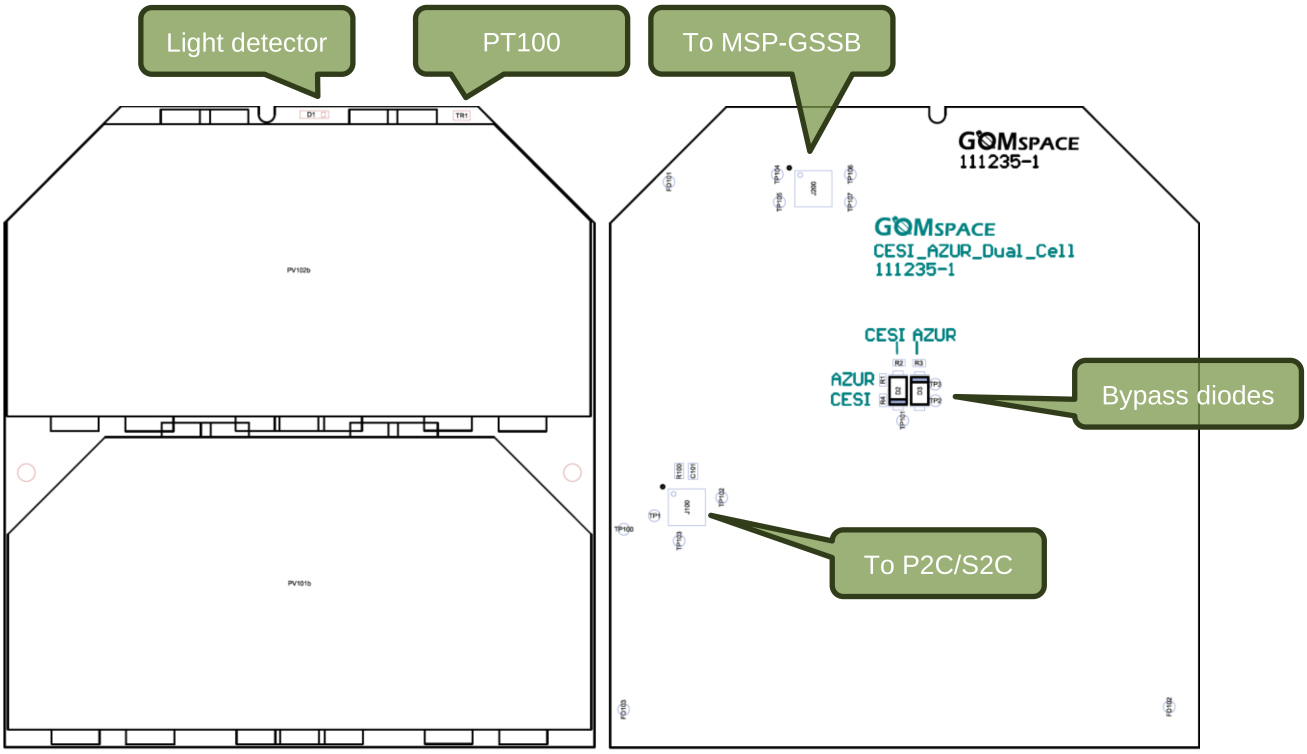

Figure 6-1: Dual Cell Layout - cells side left and rear right.

The output from one dual cell module is in best case 4.8V 2.3W (0,5A * 2.4V pr. cell). For detailed information please request datasheet.

6.2 Gomspace Sensor System Bus Module, GSSB (108258)

The MSP-GSSB module is placed on the solar array backside, directly connected to the solar array via a soldered connection.

The MSP-GSSB module includes the internal temperature sensor and reads the external sensors: fine sun sensor, coarse sun sensor, and the external temperature sensor.
Data is routed to the system via the I²C bus using an onboard processor.

External temperature sensor range is -55°C to +175°C and internal temperature sensor range is -40 to +85°C.

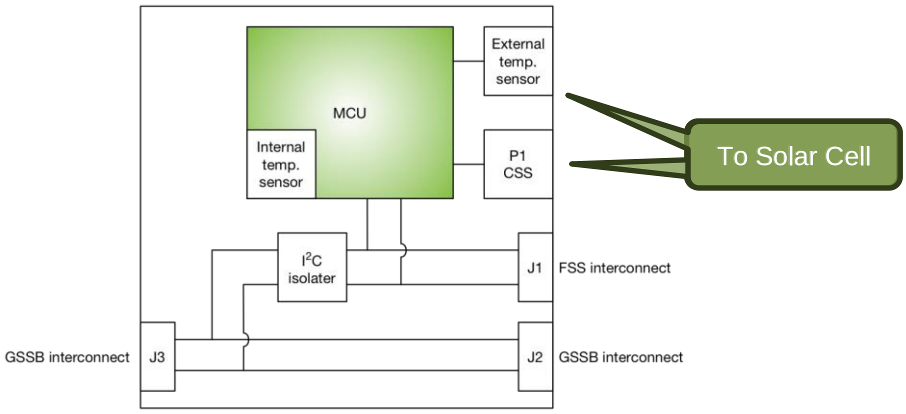

Figure 6-2: MSP-GSSB block diagram.

6.2.1 GSSB Connector Interface

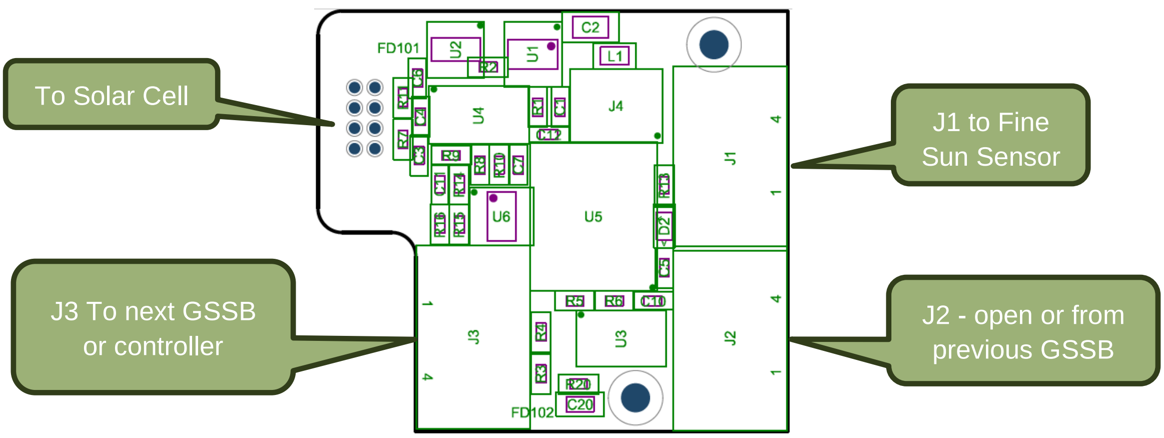

Figure 6-3: MSB-GSSB component placement.

6.2.2 J2 – GSSB IN

Molex Pico-Lock 1.50 mm pitch, right angle, 504050-0491.

Pin	Description
1	GND
2	GSSB_SCL
3	GSSB_SDA
4	GSSB_VCC

6.2.3 J3 – GSSB OUT

Molex Pico-Lock 1.50 mm pitch, right angle, 504050-0491.

Pin	Description
1	GSSB_VCC
2	GSSB_SDA
3	GSSB_SCL
4	GND

The pins on connector J2 and J3 are connected back-to-back. This is to avoid split harness and the sensor bus can be routed through the GSSB module.
Communication on GSSB is I²C 3.3V level. Pull up resistors are not present on GSSB module.

6.3 P2C Module (108242)

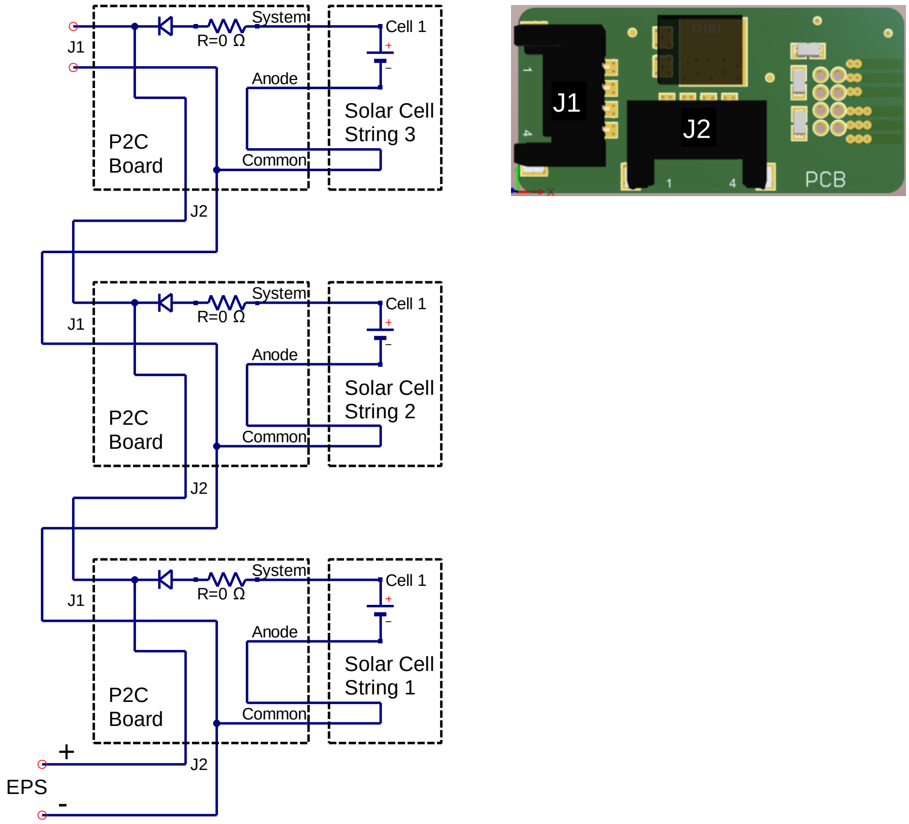

Figure 6-4: Schematic with three strings left, and P2C layout right.

The P2C module can be used to connect dual cells strings in parallel.
The implemented blocking diode ensures that a poorly performing cell string does not consume the power of a better performing string when these are connected in parallel.
The blocking diode is a low loss Schottky SS10P4.

6.3.1 J1 and J2 – Connector pinout.

J1 and J2 are parallel and can be used as best practice.

Pin	Description
1	Cathode
2	Cathode
3	Anode
4	Anode

Molex Pico-Lock 1.50 mm pitch, right angle, 504050-0491.

Please see appendix for connection examples.

6.4 Interstage, Release controller (108289, 108288, 108295, 108294)

The Deploy Release Controller, DEPR, is a two-part PCB, divided in a controlling part and an executing part. The controlling part is located inside the satellite and the executing part can be placed where feasible.

The controlling part include all intelligence and communicate with the satellite system.
The executing part is a simple PCB with a few resistors for burning the wire.
The controlling part exists in four versions: “DSP Deploy Interstage“ – see Figure 6-5, and “DSP V2 Deploy Interstage Reverse” – see Figure 6-6.

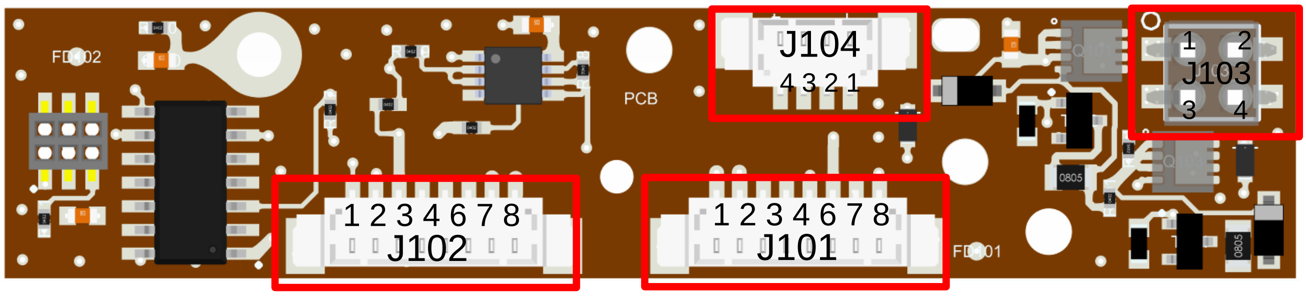

Figure 6-5: Interstage, Release Controller (108289, 108288)

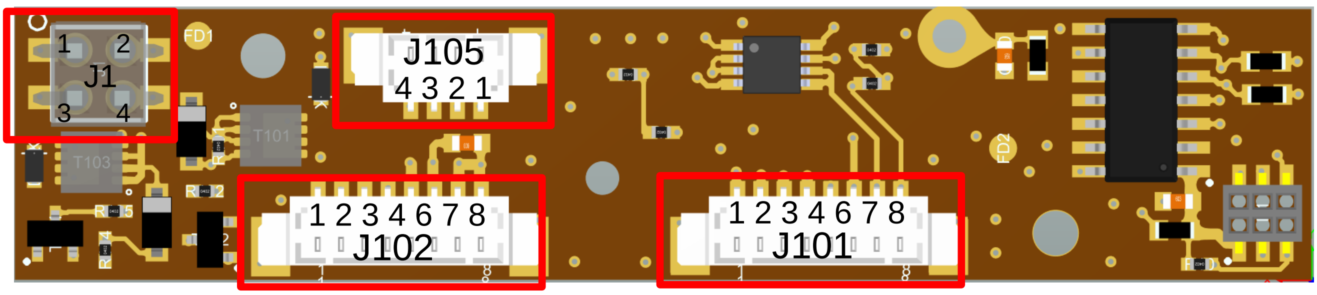

Figure 6-6: Interstage Reverse, Release Controller (108295, 108294)

Both controllers exist in two versions depending on the connectors is angled or straight.

6.4.1 J103/J1 – Connector to Deploy Burn PCB

Mouser 89898-302LF
In this connector the burn PCB is direct inserted.

Pin	Description
1	B1_OUT
2	BURN_GND
3	B2_OUT
4	Burn Release IN (internal communication)

6.4.2 P1 - Programming

This connector is used for internal programming of the PCB. For updating the firmware.

6.4.3 J101 and J102 – GSSB Serial Connector (Gomspace Sensor Satellite Bus)

Molex PicoBlade 053398-0871 or 05326-10871.

The pins on connector J101 and J102 are configured to fit into the rest of the GomSpace GSSB using products, like e. g. GomSpace Interstage GSSB.

Pin	Description (J101)
1	BURN_GND
2	BURN_GND
3	BURN_B1
4	BURN_B1
5	GSSB_GND
6	GSSV_VCC
7	GSSB_SCL
8	GSSB_SDA

Pin	Description (J102)
1	GSSB_SDA
2	GSSB_SCL
3	GSSB_VCC
4	GND
5	BURN_B1
6	BURN_B1
7	GND
8	GND

Burn voltage depends on the actual system design. GSSB_VCC is 3V.; I^{2}C level is 3V3:

6.4.4 J104/J105 Cross burn function

Mouser 538-53398-0471
This connector is used to connect 2 release controllers for obtaining the release functionality.

Pin	Description
1	GND
2	BURN_POWER (input)
3	BURN_POWER (output)
4	GND

6.5 Burn PCB versions (108274 … 108285)

Second part of the DEPR is the burn PCB, which function is to burn the hold wire.
The PCB is used in many positions, therefore having 8 optional resistor positions; only 2 resistors are mounted – see Figure 6-7.

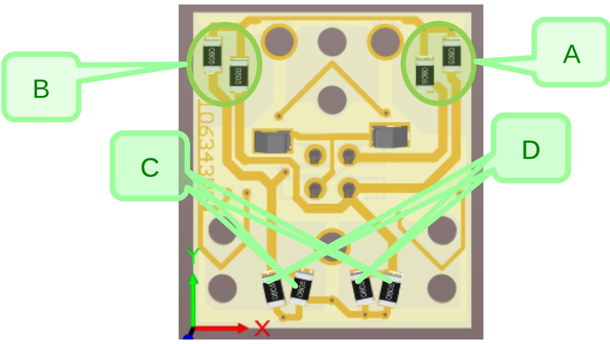

Figure 6-7: Burn PCB

This PCB is directly inserted into Interstage PCB, J1/J103 (Release controller).

More versions exist depending on resistor position (A, B, C, or D) and burn voltage (5, 16, or 32 Volts) – see Table 6-1 for part numbers.

	A	B	C	D
5 V	108274	108275	108276	108277
16 V	108278	108279	108280	108281
32 V	108282	108283	108284	108285

Table 6-1: Burn PCB Versions

6.6 Fine Sun Sensor Module (107475)

The fine sun sensor can – when the mission allows it – be used to optimize the satellite alignment (solar cells) for best sun energy harvesting.
The sensor is a segmented Si photodiode (4 diodes) where the alignment offset cause an offset in the current generation in the diodes. Best alignment will then be when the current generation is equal in all diodes.
The current generated in the diodes are loaded with a resistor and the resulting voltage is measured with an ADC and collected by a small microprocessor. Using measurement calibration, accuracy can be down to 0.5°. Measurement results can then be read via an I²C bus routed to the connectors off the FSS PCB – see Figure 6-8.

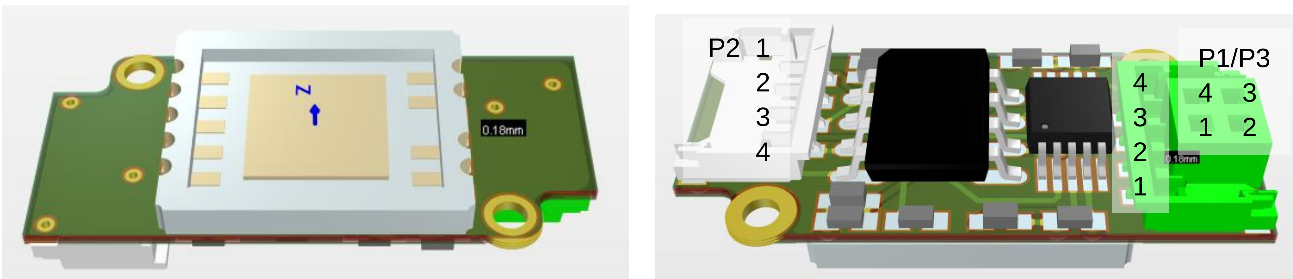

Figure 6-8: FSS Layout, top with sensor shown left, and bottom shown right.

Pin	Description (P1, P2, P3)
1	VCC
2	GND
3	I²C SDA
4	I²C SCL

7 Deployable Solar Panel (DSP) System Schematic

The following describes the 135° panel – see Figure 7-1 – which have: 9 pcs Dual Cell Modules, 2 pcs GSSB modules, 2 pcs FSS modules, and 3 pcs P2C modules. The 135° reverse and the 90° are smaller versions – still with 3 strings, but only two Dual Cells modules per string and without FSS and GSSB modules.

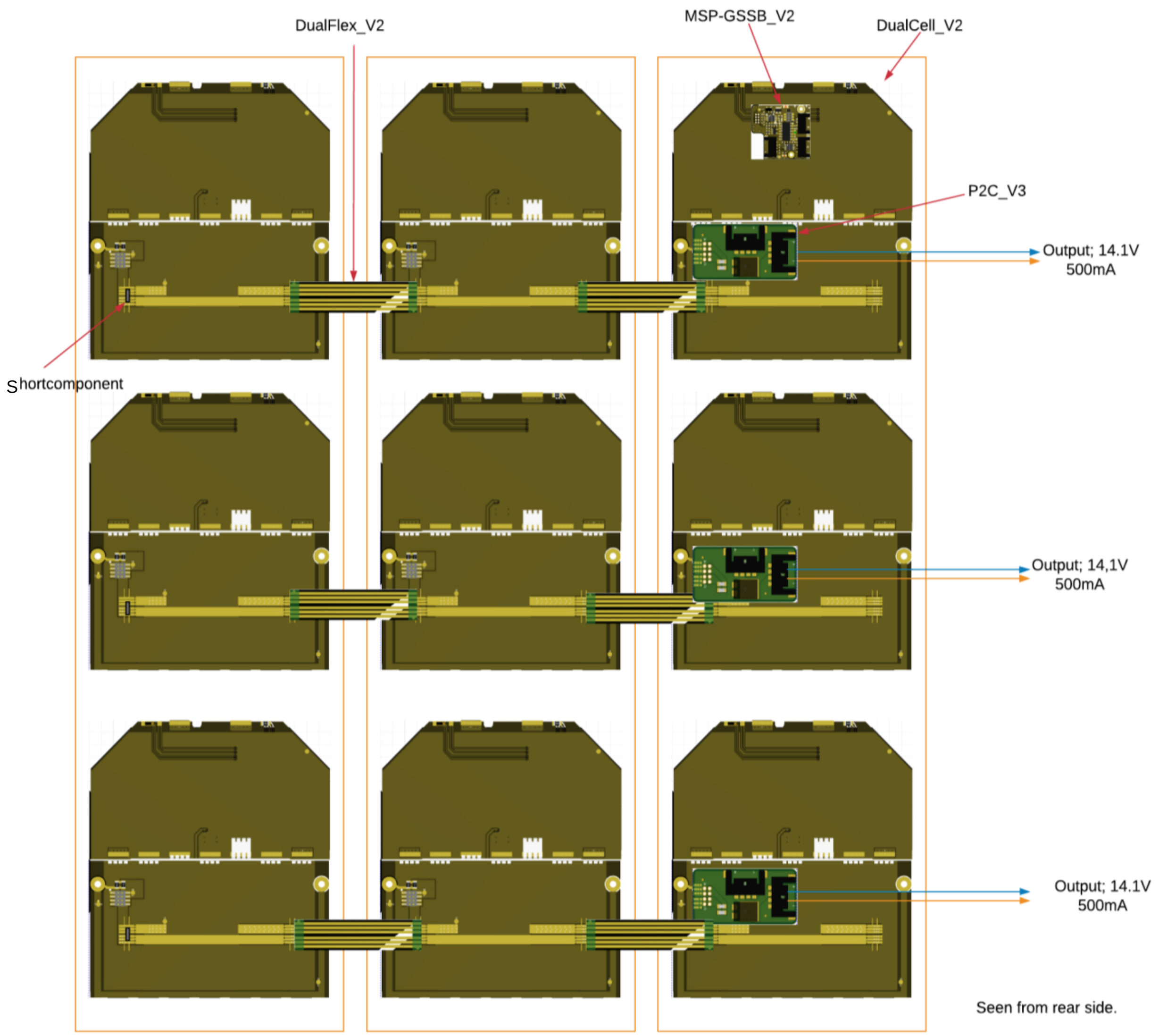

Figure 7-1: The 135° System Schematic.

The 135 panel consists of 18 solar cells combined in 3 rows each with 6 cells arranged in serial. These rows can be configured into serial or parallel; default is parallel.
The panel is built on 3 aluminium plates (Columns). On every plate, 3 dual cells are placed.
From left to right: The dual cell is connected electrically to the middle dual cell via a flex PCB, Dualflex, and again from the middle dual cell to the right dual cell via another Dualflex. Combined this gives 6 cells in serial.
The serial connection is per default ending in a P2C module, to enable combination of the 3 outputs in parallel and have only one cable from the DSP to the charger unit.
Having three strings connected in parallel the output will be up to (14.1V (3* 500mA)) = 14.1V 1.5A. 21.15W
All calculations are for a maximum illuminated cell in beginning of solar cell life, BOL.

8 Hardware Layout

The panel mounted on the structure (main panel) has the following connectors.

8.1 Back side of DSP - Connectors

Below is shown a drawing with the connector group names – see Figure 8-1. Each of the three P2C (PCB to cable) groups are the same and each of the DEPR (Deploy Release) and GSSB groups are the same. On the 135° version, the FSS are mounted on the other side of the DEPR PCB. The same can be done on the 90° and 135° reverse versions if the FSS are procured separately.
The two DEPR’s are connected using a harness that works as a redundant panel release mechanism.

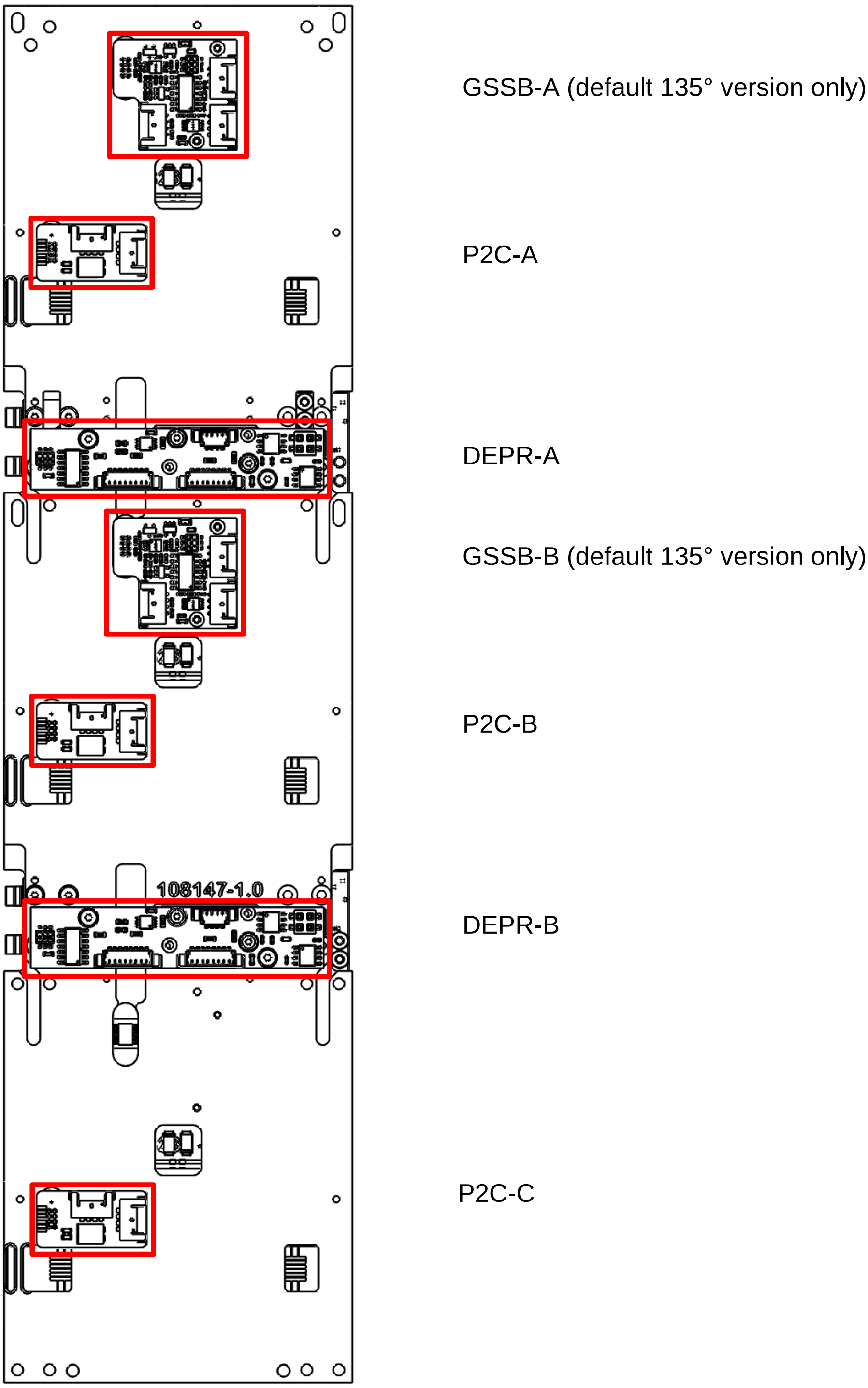

Figure 8-1: The main panel rear side.

8.2 Front side of DSP – Sensor Positions

The main panel of the 135° version is fixed to the satellite body and holds a coarse sun sensor (green) and an external temperature sensor (red) – see Figure 8-2.

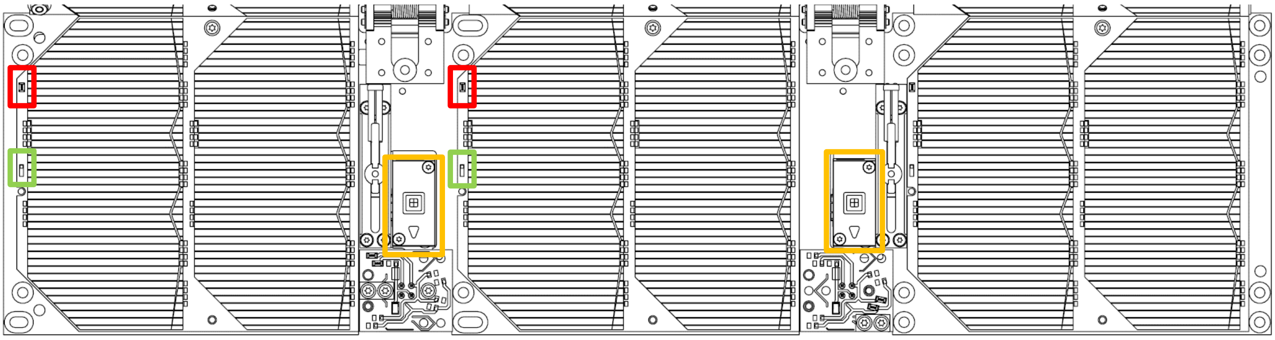

Figure 8-2: Main panel of the 135° version.

The two pairs of sensors are connected to the GSSB A and B modules on the rear side inside the satellite, and their readings can be accessed through the GSSBs I²C bus.

8.3 Fine Sun Sensor on the DSP 135º Version

The 135° Version have two NanoSense FSS modules – see Figure 8-2 (orange).
The NanoSense FSS is a vector sun-sensor designed especially for CubeSats with an I²C interface with high ADCS requirements. They are connected to the GSSB PCB.

Figure 8-3: Fine Sun Sensor (FSS)

Both FSS's comes mounted and connected to the GSSB PCBs (A and B) shown in in Figure 8-1.
Additionally, the two GSSB PCBs are interconnected.
The FSS is placed a 6° canted block directly onto the DEPR boards to prevent the 135° deployed panels to shadow the FSS.

8.4 Sensors on DSP 135° and DSP 90°

The FSSs and GSSB PCBs are not included in the 90° version and the 135° reverse version since the deployed panels will interfere with the sensor field of view.
Also note, that the coarse sun sensors and temperature sensors are also not connected as they are found only on deployed panels, and connectivity for these are not included in the panel-to-panel connections.
However mounting interface for the FSS is incorporated into the DEPR board. The FSS and a GSSB module can be bought as a standard module at GomSpace.

9 Release Mechanism

The panel is held in stowed position by a Berkley Nanofil 0.28 mm wire (burn wire) with strength 8.4 kg. Release is done by heating the burn wire until it breaks due to the force of the release springs build into the hinge assembly – and the panel unfolds – see Figure 9-1 and Figure 9-2.

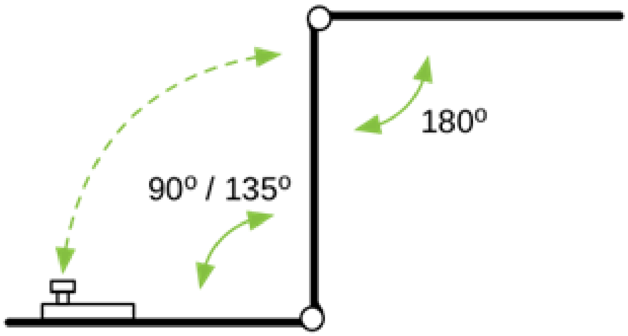

Figure 9-1: Release Movement

Deploy angle is controlled by stops in the hinges.

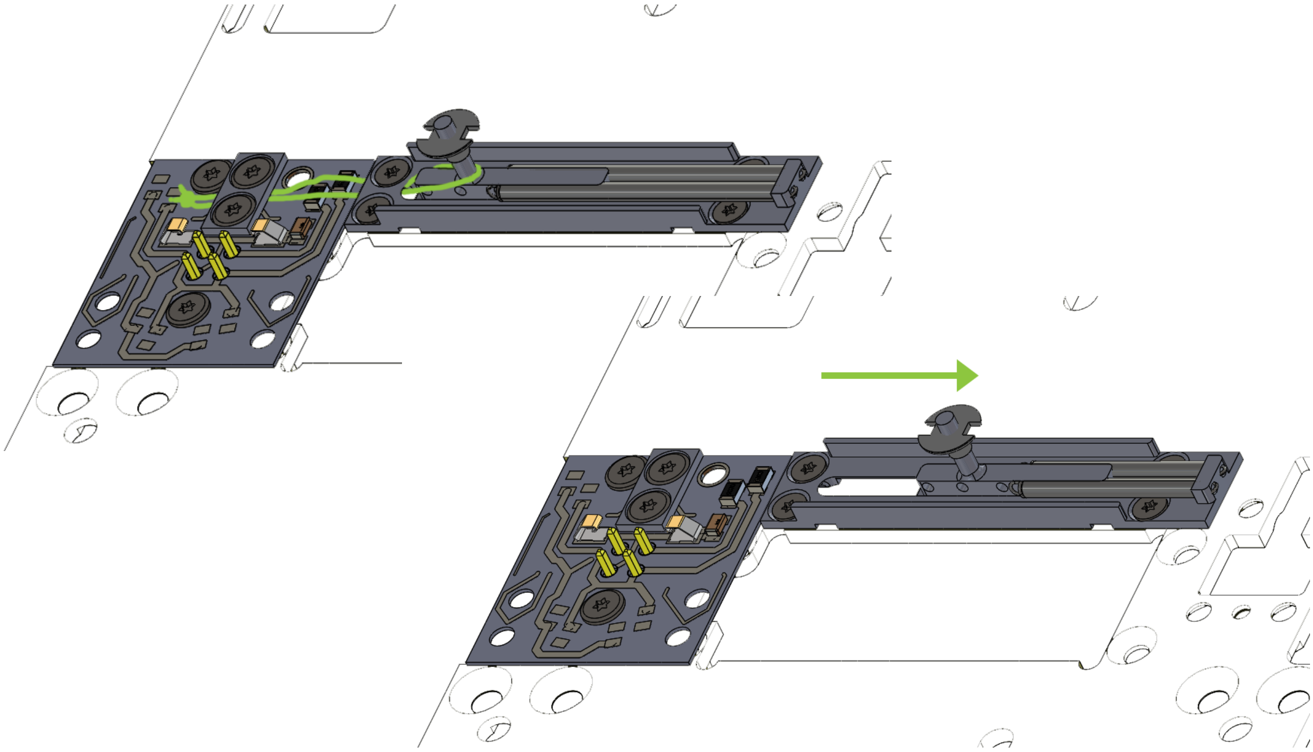

Figure 9-2: Release Mechanism

The burn wire is routed over the burn resistors on the burn PCB – see Figure 9-2 (green).

10 Redundancy Release System

The two DEPR PCBs are connected through a harness. Each burn PCB contains two burn resistors (R1 and R2), each controlled from a different DEPR. View the illustration below.

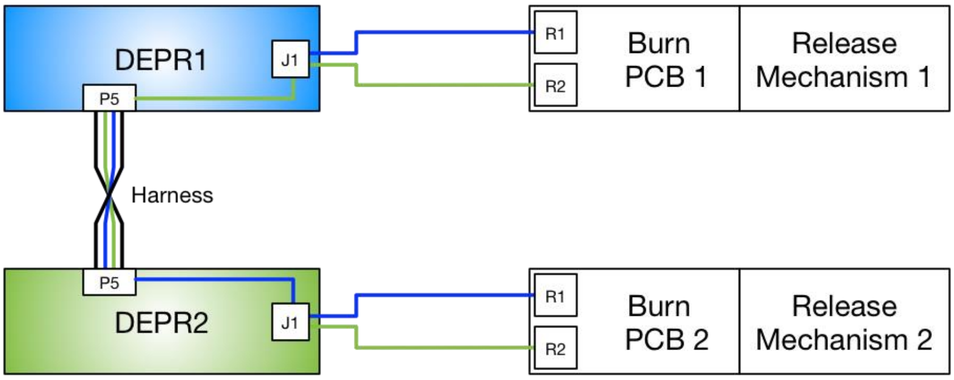

Figure 10-1: Schematic of redundant release system.

Blue DEPR1 has access to the two R1's and green DEPR2 has access to the two R2's.

11 Thermal Ratings

Thermal environments beyond those listed under Thermal Ratings may cause permanent damage to the DSP. Exposure to thermal rating conditions for extended periods may affect the reliability.

Symbol	Description	Min.	Max.	Unit
$T_{SolarCell}$	Temperature on the solar cell*	-150	+150	°C
$T_{nonOperational}$	Most extreme non-operational temperature tested (1000 thermal cycles, solar cell modules only, both dual and single cell)	-77	+104	°C
$T_{Operational}$	Electronics operating temperature	-40	+85	°C

* Data from CESI

12 Electrical Characteristics

Parameter	Condition	Min	Typ.	Max	Unit
Single Solar Panel	Full sunlight in LEO, BOL				
• Voltage	Optimal voltage	2.32		2.42	V
• Current	Current at optimal voltage	490		508	mA
• Power	Maximum power	1135		1200	mW
• Efficiency		29.8	30	30.2	%
GSSB_VCC		3.1	3.3	3.5	V
GSSB_I_idle			2.6		mA
BURN_B1	Connect to VBAT through switch on FPP**	5		32	V
Course Sun Sensor					
• Current	Short current at 1367 W/m^2		930		µA
• Cosine error			1.85	3.5	º
Temperature Sensor External					
• Range		-75		+175	ºC
• Resolution				3.5	%
Temperature Sensor Internal					
• Range		-40		85	ºC
• Resolution		-10		10	%

** Burn resistors aligned to VBAT through option sheet.

13 Physical Characteristics

Panels are made of AL6082 T651.

Description	Typical value	Unit
Mass - 90º and 135º reverse	390	g
Mass - 135º	449	g
Size	View Mechanical drawings in chapter 14	mm

14 Mechanical Drawings

All dimensions in mm.

14.1 90 º and 135 º Reverse Stowed

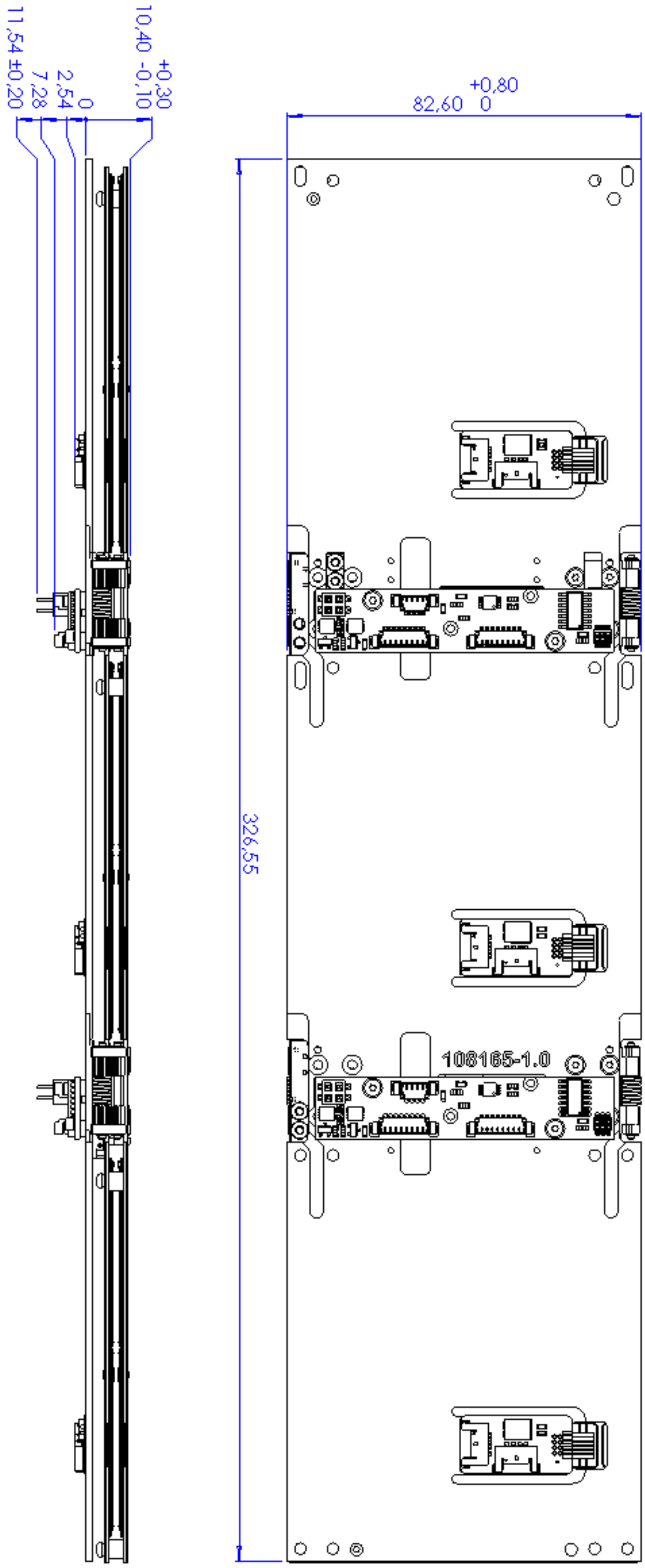

Figure 14-1: Layout of 90° and 135° stowed.

14.2 90 º Deployed

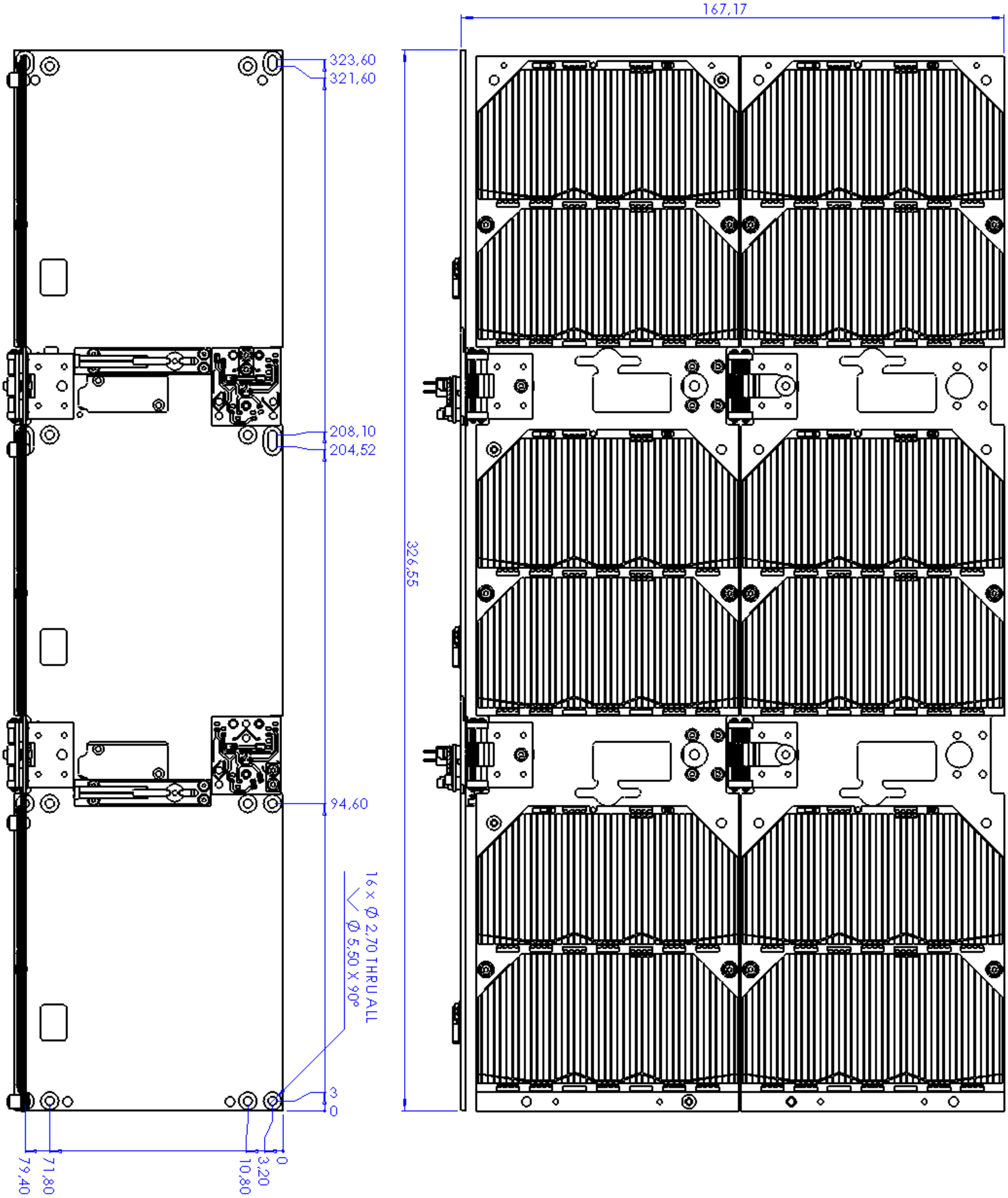

Figure 14-2: Layout of 90° deployed.

14.3 135 ° Reverse Deployed

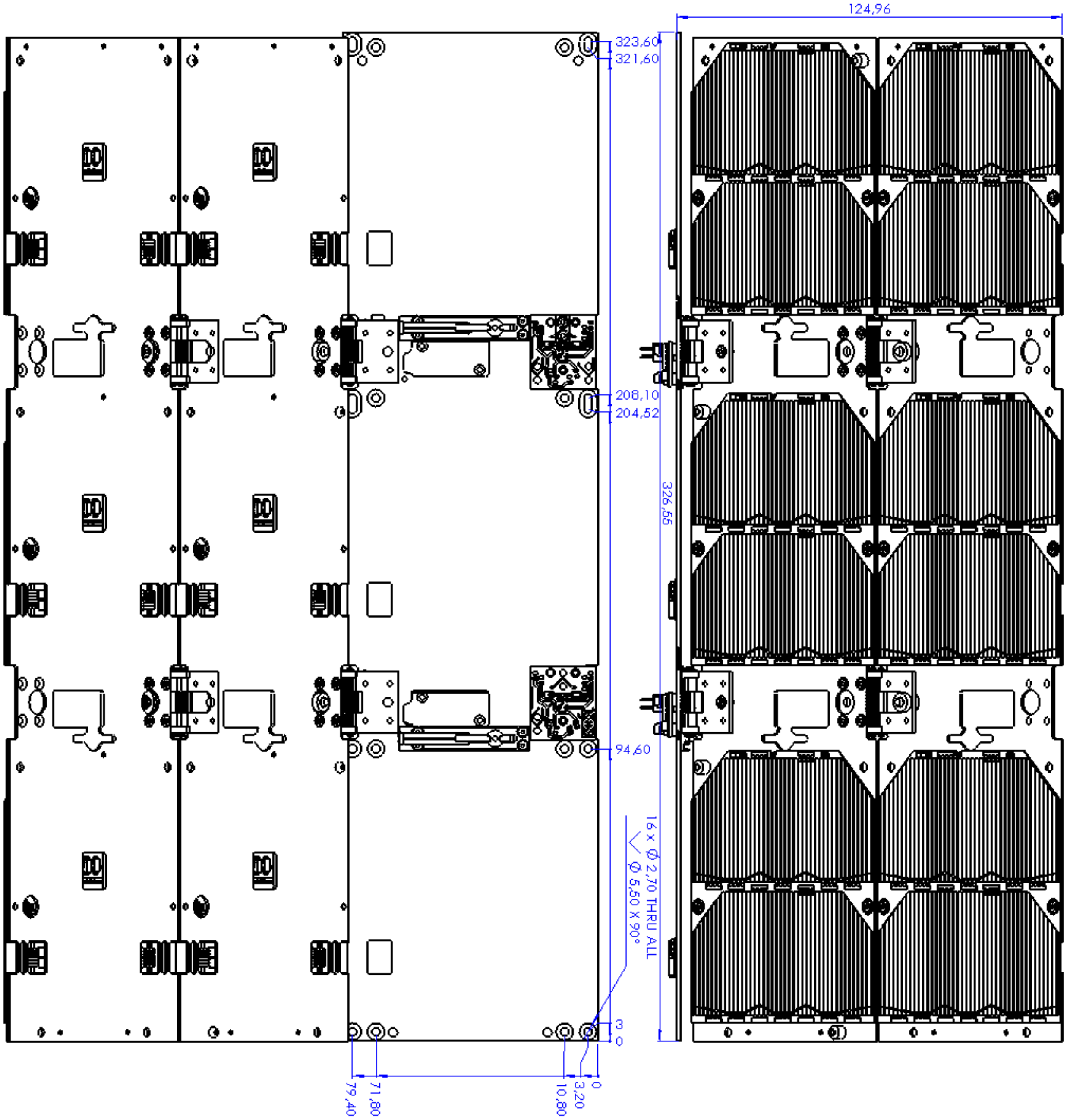

Figure 14-3: Layout of 135° reverse deployed.

14.4 135 º Stowed

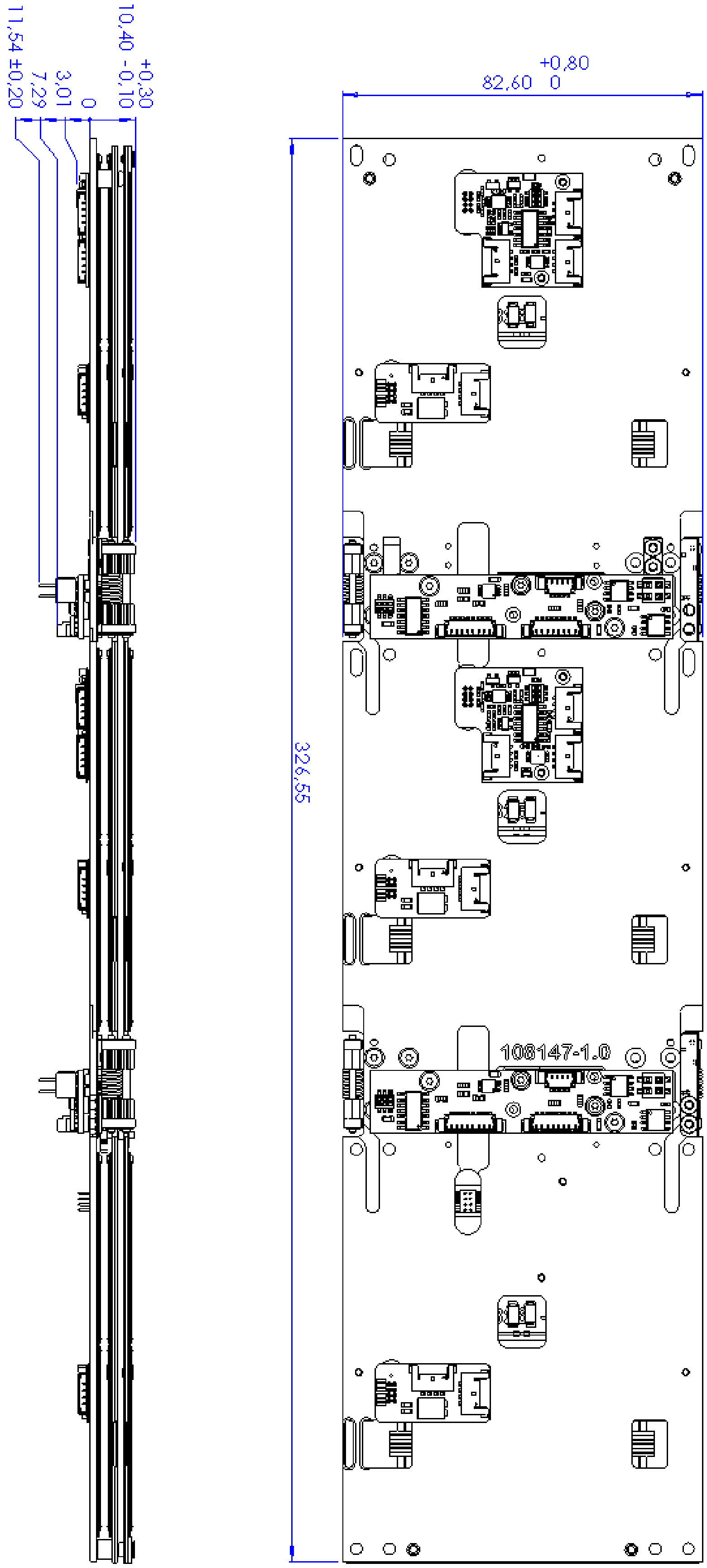

Figure 14-4: Layout of 135° stowed.

14.5 135° Deployed

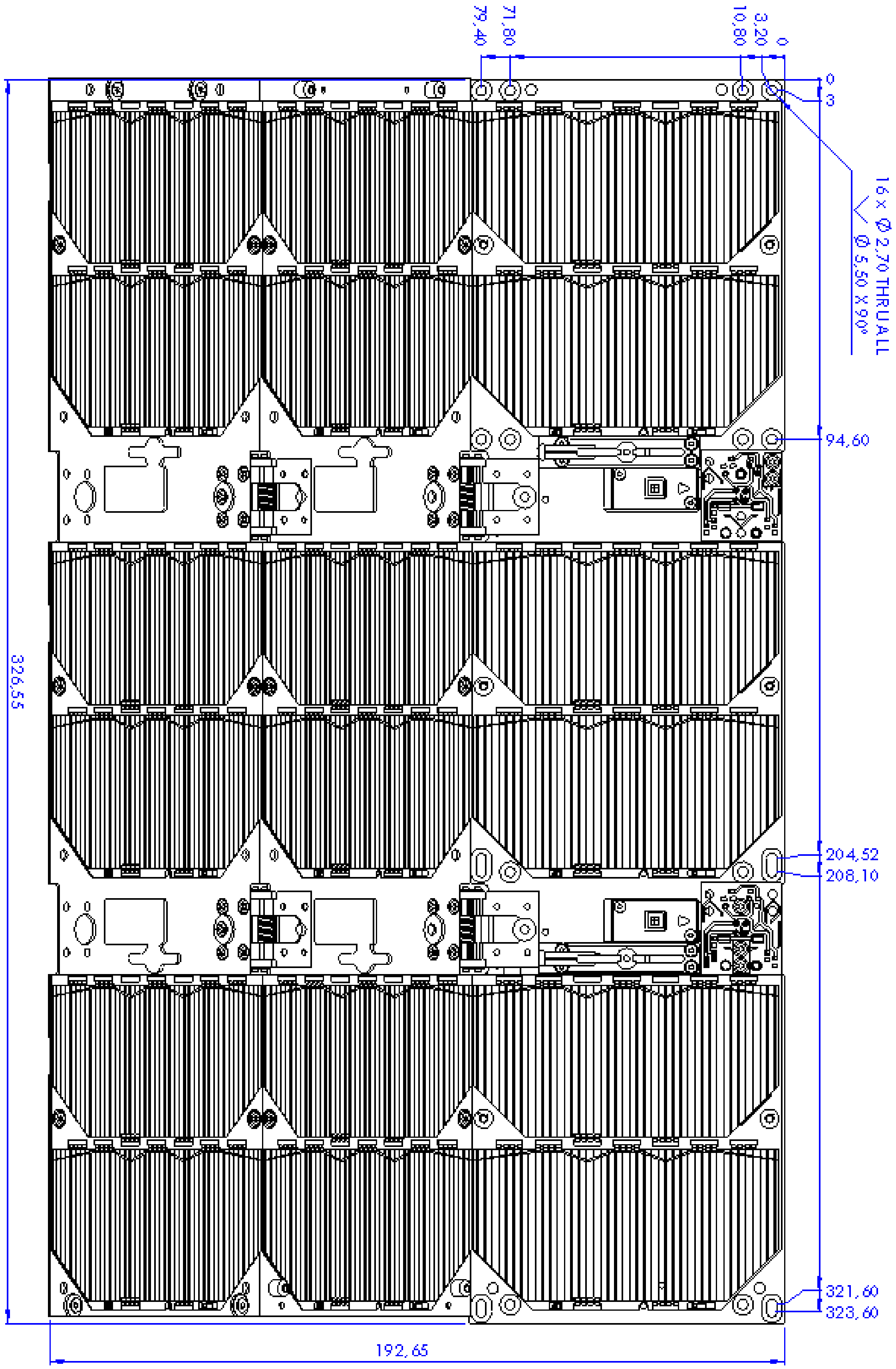

Figure 14-5: Layout of 135° deployed.

15 Appendix

15.1 Solar cells in serial connection (S2C with diode: 108246 and without diode 108248)

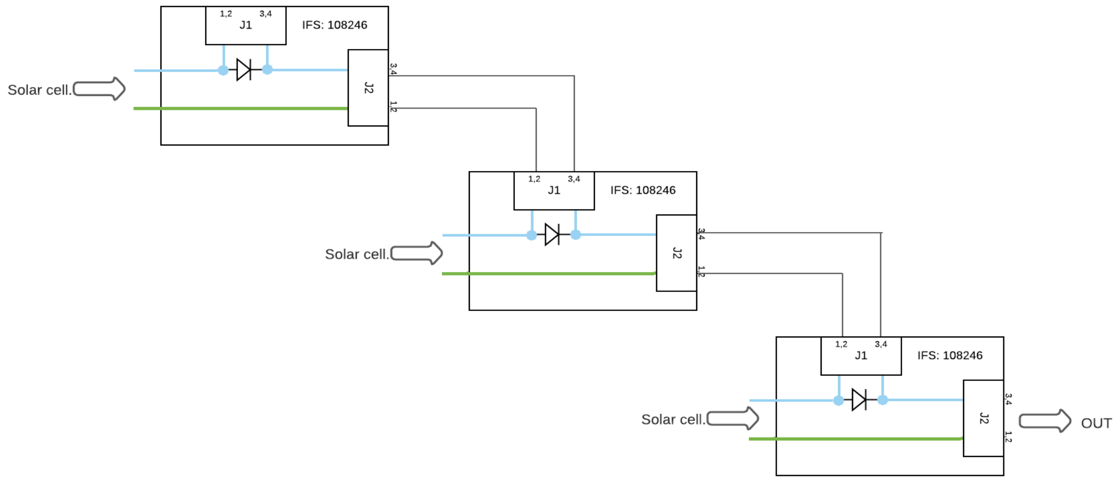

Figure 15-1: Schematic of serial connected solar cells.

15.2 Solar cells in parallel connection (P2C: 108242)

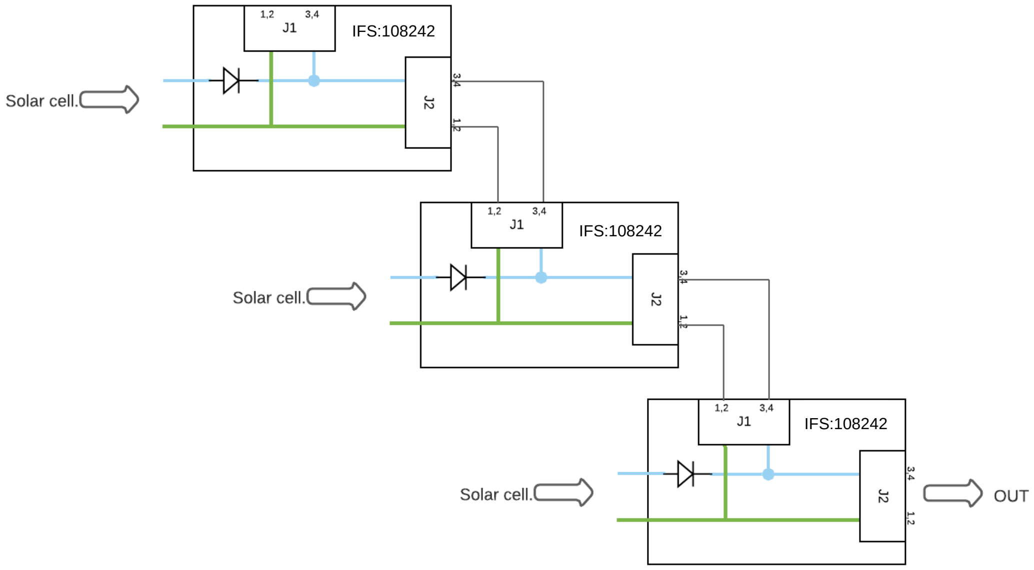

Figure 15-2: Schematic of parallel connected solar cells.

16 Disclaimer

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