ELECTRICAL PASSIVATION - PCDU UPGRADE FOR POWER PASSIVATION

FINAL PRESENTATION

ESA CONTRACT 4000123809/18/NL/AF

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SCOPE AND OBJECTIVES OF THE ACTIVITIES

/// Objective : Isolation of the solar arrays from the main bus in the PCDU

- Trade-off between passivation solutions
- Identification of the components involved in the isolation of the solar array during the disposal phase.
- Manufacturing of technological breadboards and technological test evaluations
- Develop and manufacturing of the breadboard with the selected solution
- Test of the BB

❑ **The work is organized in 2 phases as follows.**

- ➢ **Phase 1** – Passivation technique trade-off and technological tests
- ➢ **Phase 2** – Design, development and test of electrical breadboard

MAIN REQUIREMENTS

A2. Specific requirements

A2-010	The isolation of the solar array shall be designed to be implemented within the Power Conditioning (and Distribution) Unit.
A2-020	The isolation of solar array shall remain active even in case of a main power bus powered down to 0V as by a depleted battery.
A2-030	The isolation of solar array shall provide a SA passivation capability by short-circuiting or open-circuiting all SA sections, so that SA power is no more transferred to the main bus and battery charge becomes impossible.
A2-040	Two fully independent commands shall be used for passivation (for example arming command and firing command). At least one of the commands shall be a direct command from ground (HV-HPC as per AD10).

MAIN REQUIREMENTS

<table>
<tr><td>A2-240</td><td>During the satellite operational phase the following temperature range at TRP shall be considered:
<table>
<tr><th>°C</th><th>Min Op</th><th>Max Op</th><th>Min Non-Op</th><th>Max Non-Op</th><th>Min Start up</th></tr>
<tr><td>Design Temperature limits</td><td>-20</td><td>+50</td><td>-30</td><td>+60</td><td>-30</td></tr>
<tr><td>Acceptance Temperature</td><td>-25</td><td>+55</td><td>-35</td><td>+65</td><td>-30</td></tr>
<tr><td>Qualification Temperature</td><td>-30</td><td>+60</td><td>-40</td><td>+70</td><td>-30</td></tr>
</table></td></tr>
<tr><td>A2-250</td><td>During the satellite operational phase the solution shall be able to withstand 15 thermal cycles per day between 20°C and 40°C.</td></tr>
<tr><td>A2-260</td><td>During the disposal phase the solution shall be able of keeping the SA isolation considering a temperature range of -50 °C to 80°C.</td></tr>
<tr><td>A2-270</td><td>During the disposal phase the solution shall be able to withstand 15 thermal cycles per day between 60°C and 80°C.</td></tr>
<tr><td>A2-280</td><td>The passivation function shall be testable during the AIT phase at satellite level without the use of any specific test command.</td></tr>
</table>

PHASE 1 ACTIVITIES

PASSIVATION TECHNICS TRADE-OFF

TRADE-OFF RESULTS

Trade-off results for Isolation of the solar array in the PCDU:

- S3R : shunting solution
- S2R : opening solution
- MPPT : opening/shunting solution

65V (un)regulated bus plateform		Passivation reliability	Mission reliability	Market coverage	Mass	Price	Efficiency	
Weight		10	40	10	15	15	10	Results
S3R	Commun Relay Shunting	9	10	8	2	0	10	714
	Shunting Relay (1 contact per section)	10	10	6	3	5	10	762
	Series Relay	10	7	10	1	3	7	606
	Relays passivation main bus regulation	7	7	2	10	7	10	722
	MOSFET D-G S/C	3	7	3	10	7	10	684
	Serial Electronic Switch	1	4	10	9	0	0	401
S2R	Serial Relay	10	7	10	4	6	6	684
	Serial Electronic switch	1	10	10	9	5	10	811
MPPT	Serial Relay	10	7	10	9	10	1	770
	Common SA shunt	10	10	8	8	10	10	939
	Electronic input switch	9	10	10	10	9	10	976
	1 buck per SA section	9	10	3	10	9	10	906
	Galvanic Insulation	6	5	3	0	1	0	296
Passivation module		10	10	10	0	0	10	700

Table 66 - Tradeoff summary for 65V (un)regulated bus platform

This platform 65V is an average between small and large platform with 5kW SA input power.

TECHNOLOGICAL TEST EVALUATION RESULTS

TECHNOLOGICAL TESTS – TESTED COMPONENTS

/// List of packages submitted to technology evaluation

- SMD2 MOSFET
- SMD05 MOSFET
- SMD1 DIODE
- TO258 DIODE
- POWER RELAYS
- HIGH POWER TRANSFORMER
- LOW LEVEL RELAY
- FP14 COMPARATOR

TECHNOLOGICAL TESTS - TESTS DESCRIPTIONS

/// Mechanical tests

/ VIBRATIONS

- High level sine vibrations
- Random vibrations

/ SHOCKS

/// Thermal cycling tests file

/ MISSION PHASE

/ DISPOSAL PHASE

Electrical monitoring performed on all components during all the thermal cycling with low current (100 mA)

Mission phase :

	Components on PCB	Components on SOCS
Temperature range	-55 °C / +110 °C	-55 °C / +110 °C
Number of cycles	1337	2741

Disposal phase :

	Components on PCB	Components on SOCS
Temperature range	-55 °C / +110 °C	-55 °C / +110 °C
Number of cycles	1217	2050

/// Power cycling tests file

/ MISSION PHASE

/ DISPOSAL PHASE

Electrical monitoring performed with specific test set-up depending of mission or disposal phase

Parameters :

- SA current
- V0C
- VBus

All the tests were performed in order to cover mission and disposal phase needs in term of ageing, electrical functionality, mechanical and thermal stress

TECHNOLOGICAL TESTS - TESTS RESULTS

/// Power components

	Component to evaluate	Mounting	Quantity & quality definition	result
Power relay	EL415	on PCB	4 : thermal cycling, EM grade 4 power cycling, grade 3+	Succeed
	EL215	on PCB	4 : thermal cycling 4 : power cycling	Succeed
Power diode	SMD1	on SOCS	10 : thermal cycling, grade 1 6 : power cycling, grade 1	Succeed Succeed
	TO-258	on PCB (mechanical structure + flex)	10 : thermal cycling, grade 1 6 : power cycling, grade 1	Succeed Succeed
Electronic switch	SMD2	on SOCS	10 : thermal cycling, EM grade 6 : power cycling, grade 1	Succeed Succeed
	SMD05	on SOCS	10 : thermal cycling, grade 1 6 : power cycling, grade 1	Failed Succeed
Galvanic isolation	ETD transformer	on mechanical structure	2 2	Succeed
Low level component	Resistors, capacitors, comparators	On PCB	-	Succeed except the resistor RM2010

CONCLUSION OF PHASE 1

/// All the technological test evaluation are done successfully except SMD05 mosfet.

PHASE 2 ACTIVITIES

PASSIVATION SELECTED TECHNIC AND ITS IMPLEMENTATION

PASSIVATION SELECTED TECHNIC

/// Based on the trade-results and use of S3R topology for the futur programs Copernicus, ARIEL…, it agreed between all parties (ESA, TAS-F and ADS) to implement the reliable topology S3R and passivation technic based on relay for each section.

Arming : through 1553 command
Firing: through discrete command

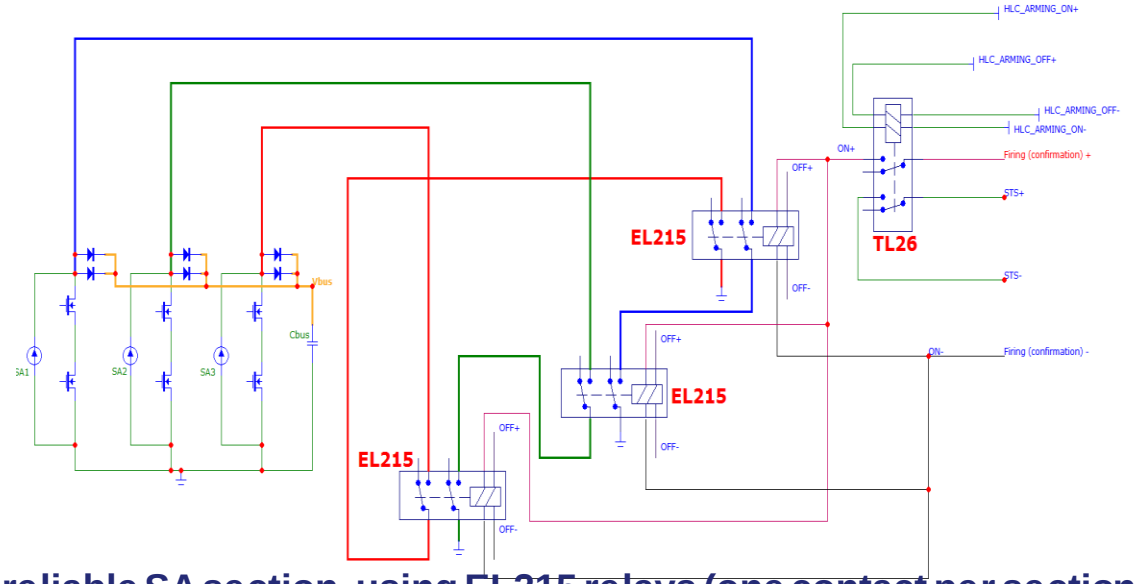


Figure 1 - Shunting reliable SA section using EL215 relays (one contact per section)

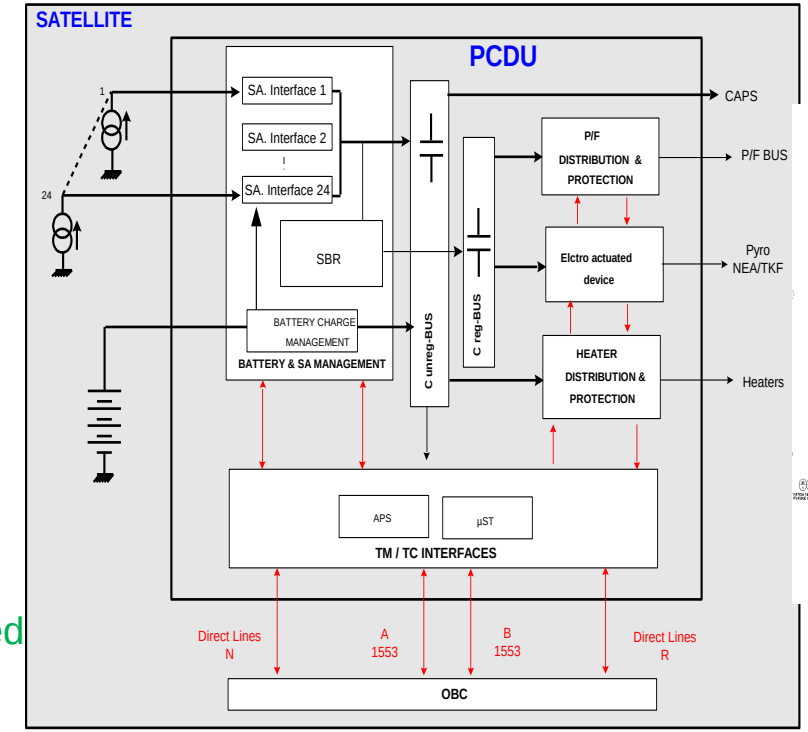
IMPLEMENTATION OF THE PASSIVATION TECHNIC IN THE PCDU

///PCDU block diagram

- ❑ Modular concept
- SUN Power module (battery and Sa interfaces)
- Distribution Module (distribution through LCL)
- SBR Module (secondary bus regulator)
- HDRM Module (Hold-Down & Release *Mechanisms* for *actuators*)
- TMTC Module

(1553 interface and PCDU regulation)

➢ Passivation will be implemented in each SUN POWER Module



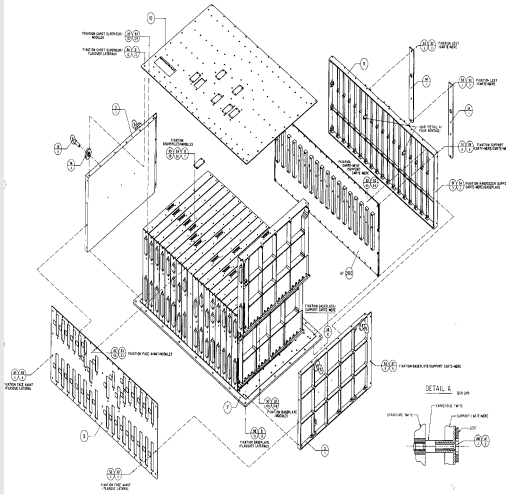
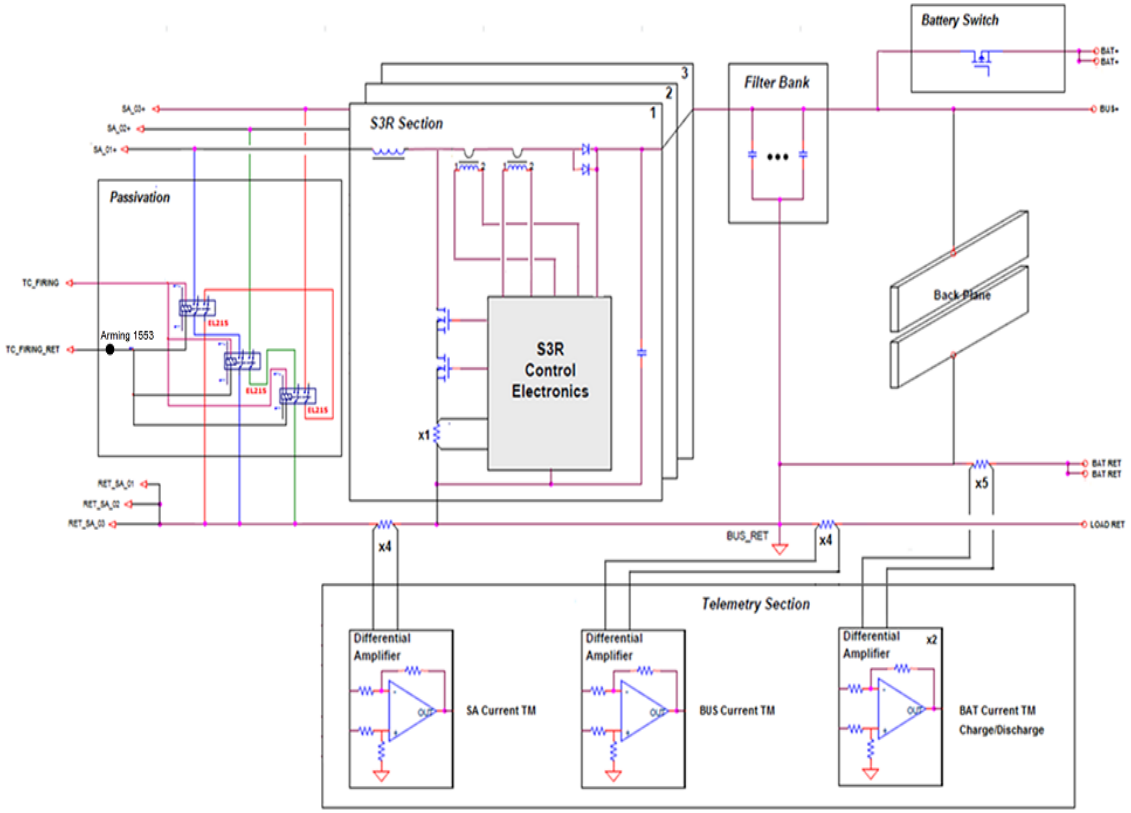


Figure 1 – PCDU block diagram

IMPLEMENTATION OF THE PASSIVATION TECHNIC IN THE PCDU

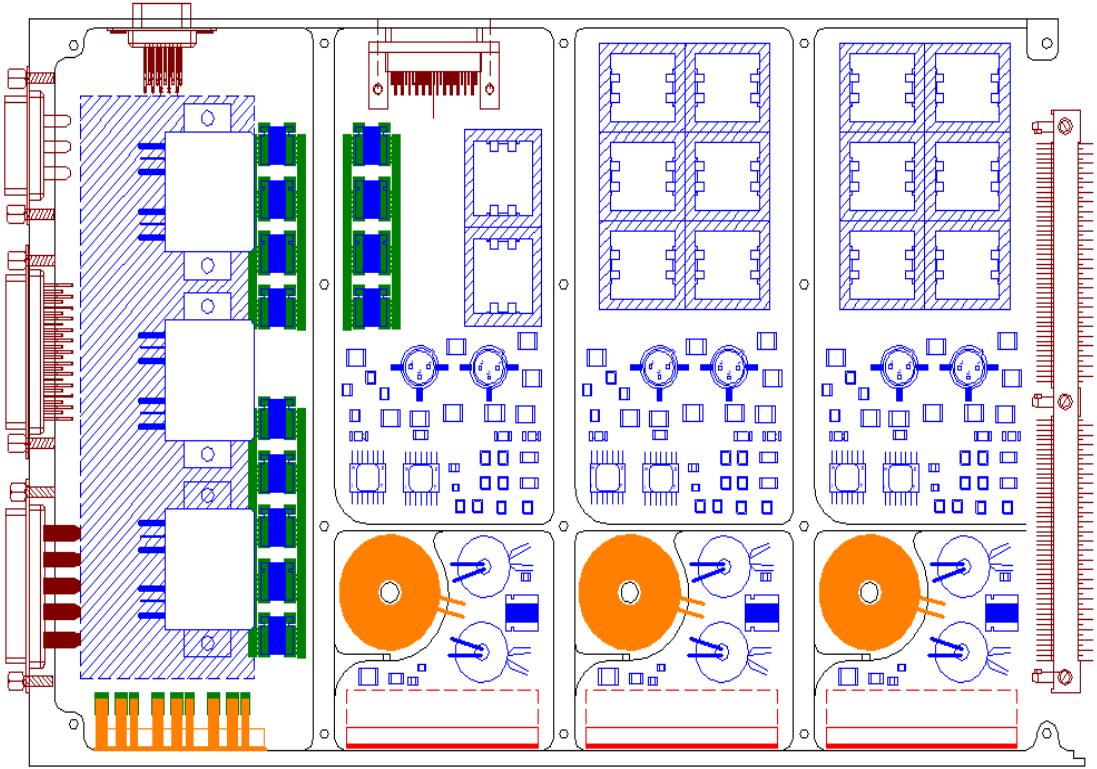
/// Sun Power module description and block diagram

Features	Configuration
Part of CBUS	Use of self-healing capacitors
3 reliable S3R cells	Up to 11A per cell for unregulated bus of 52V (fsw <3khz) Up to 11A per cell for regulated bus of 28V and 50V(fsw>3.5Khz) Up to 10 A for unregulated bus of 67V (fsw <3khz) compatible with launch-OFF interfaces
SA & BUS current monitoring	1 SA current TLM per group of 3 S3R cells 1 BUS current TLM per module
Battery interface	Battery current TM Battery isolation switch
Passivation interface	Passivation by shunting the SA by relay • Use of 3 power relays EL 215 • 1 low level relay TL26 • Arming & firing interface
Connectors	1 25SD for SA 1 3W3 for unprotected output BUS 1 5W5 for BAT+ and BUS_RET 1 15HD for LLC passivation commands (on the top) 1 micro-comp for test purpose



IMPLEMENTATION OF THE PASSIVATION TECHNIC IN THE PCDU

/// Sun Power module Implementation



IMPLEMENTATION OF THE PASSIVATION TECHNIC IN THE PCDU

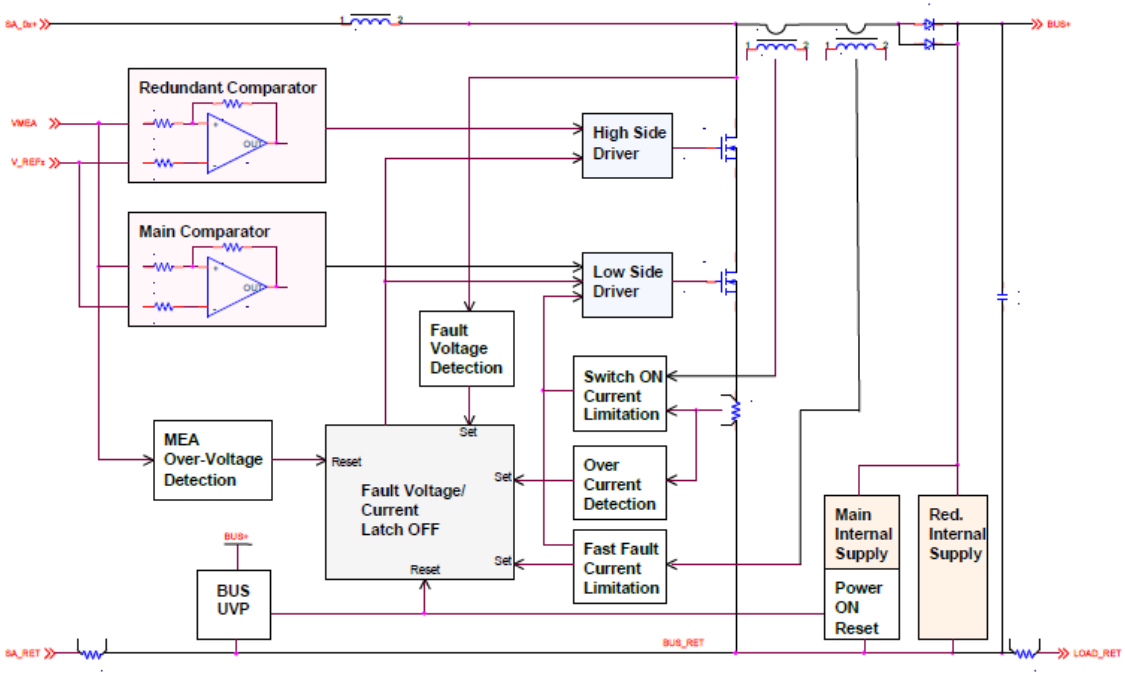
/// Reliable S3R detailed description

❑ Several protections

- Over current protection
- Reverse current protection
- Current limitation
- Undervoltage protection

❑ Regualtion by the MEA

- Regulation of each switch
- MEA ladder



PASSIVATION SEQUENCES AND OBSERVABILITY

/// Due to the presence of the SA parasitic capacitor and to avoid the relay stress during the passivatin activation (shunting the SA): the following procedure shall be adopted prior passivating:

1. We command the TMTC to change the End-of-Charge Voltage to a value much lower than the present state-of-charge at the moment of passivation. This will have as an impact the BCM to go high and authorize shunting of all S3R sections in the SUN module.

2. We check the status telemetry for each section and we verify that they are all in shunted mode.

3. If telemetry (status os each S3R section) indicates that all sections are shunted, the passivation sequence can be started by sending the two commands : arming (MIL 1553 command and get dry status) and Firing (discrete command and get dry status). Passivation then can safely happen knowing the SA parasitic capacitor is discharged.

4. If telemetry indicates that the protection latch in a module is tripped and the status of a section indicates BUS mode operation, then the passivation for this module shall not proceed up to identify the root cause by following the step 5

5. In night mode, the TC_LATCH_RESET command can be sent to reset the latch, if the Latch status indicates:

- “non-triggered” , then the passivation can be activated
- « triggered »; the passivation of this module shall not activated

EBB TEST RESULTS

IMPLEMENTATION OF THE PASSIVATION TECHNIC IN THE PCDU

/// BB definition

/// The objective of the EBB is to validate electrically the correct working of the passivation technic coupled to SA interface (S3R cell) including the low level sub functions required for arming, firing, TM and protection. The EBB electrical performances is qualified under the three temperatures.

/// the BB includes the following function to be close as possible to the flight SUN Module

- 3 SA section of 10A
- 1 Reliable S3R cell
- 3 Power relays EL 215
- Complete SA passivation interface of one module
- The needed connectors (SA, passivation , battery and user)
- PCB with same rooting and sizes as for the future SUN BBK Module

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IMPLEMENTATION OF THE PASSIVATION TECHNIC IN THE PCDU

///BB Test Results

Test conditions:

- Main bus of68V,
- CSA of 2.2uF,
- Lh of 1uH,
- Fsw of5KHz,

Passivation of the Sa during sun mode

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The measured current overshoot is 76.2A considering

SAS current during switching mode

The SA peak current is limited to 29A during the switching mode in order to limit the Sa Isa Rms current.

CONCLUSION

/// All the technological test evaluation are done successfully except SMD05 mosfet.

/// All the identified passivation technics can be implemented for all topologies: S3R, S2R and MPPT

/// The selected solution based on power relay:

- is compliant with ESA-LSI requirements
- Insure the passivation by shunting the solar array in the PCDU
- Allows passivation of set of 3 SA sections per module (modular concept)