cleansat

Isolation of solar array within PCDU

TAS-Belgium

27/05/2016

Agenda

1. Context of the study
2. Scope & Objectives
3. Main requirements
4. Passivation Solutions
    1. PCDU Description
    2. Solutions Proposed
5. Future Steps. Main challenges

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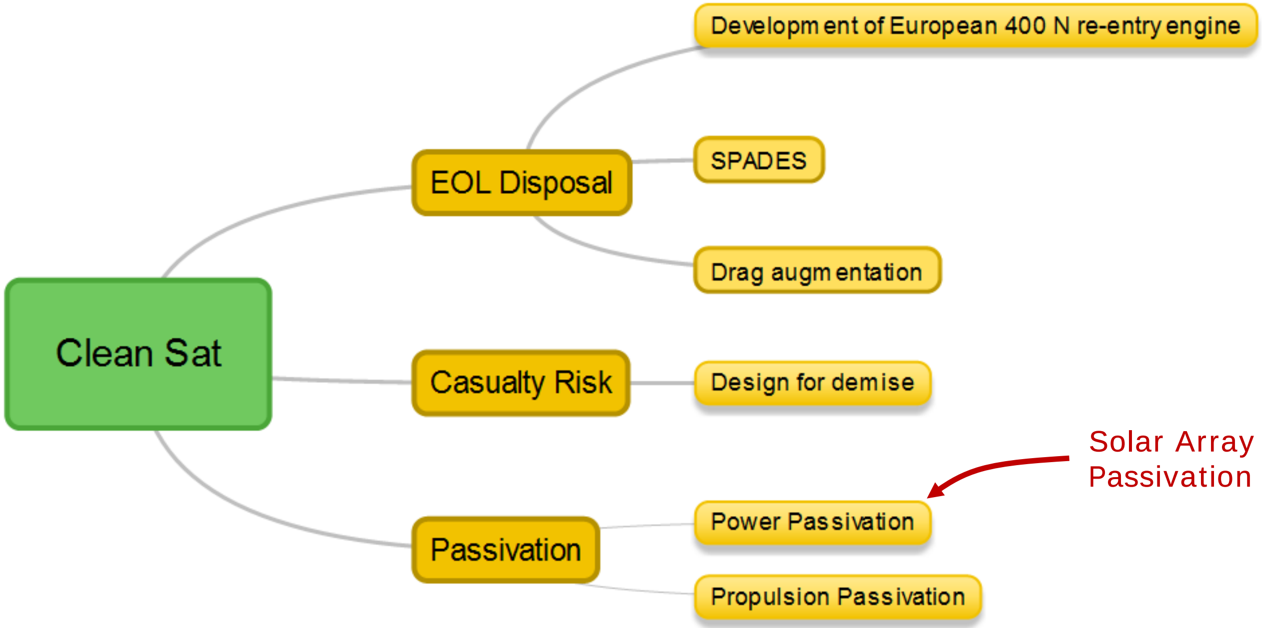
1. Context of the Study

This activity is performed in the frame of the ESA's CleanSat program to comply with the SDM requirements by developing common building blocks for different platforms and architectures.



It implies the co-engineering of main Satellite Large Integrators (OHB, ASD & TAS)

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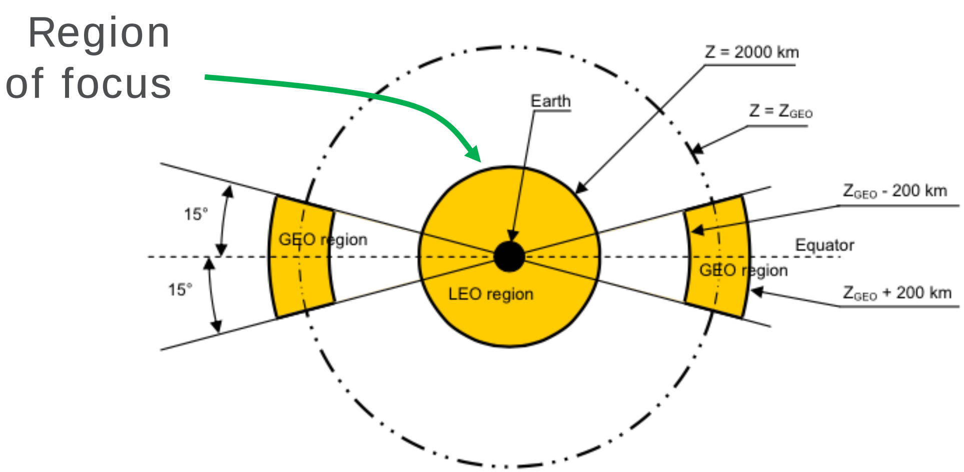
2. Scope and Objectives

Scope: Spacecrafts without capability to manoeuvre into a controlled re-entry.

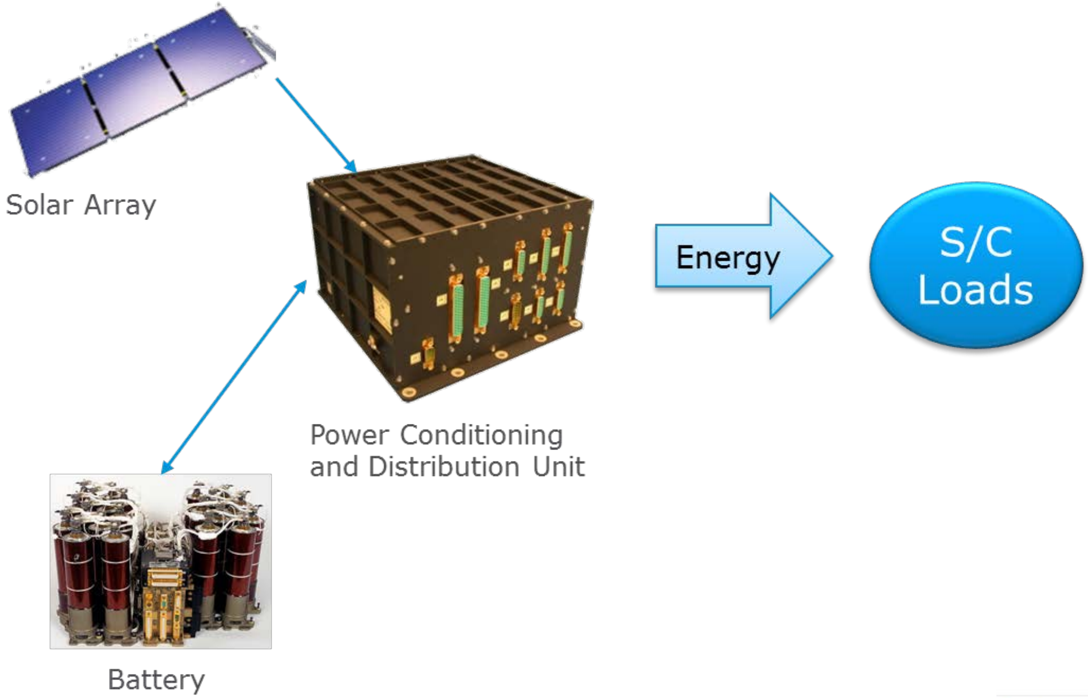


For these S/C, a **passivation of all sources of energy** is mandatory to reduce risk of debris generation during disposal phase. The passivation shall guarantee no reactivation during all disposal phase (25 years).

2. Scope and Objectives

This study refers to the electrical power system passivation by definitely interrupting the flow of energy from the Solar Array.

Once the Solar array power is no longer available to recharge the battery, the battery will be depleted by the remaining active loads, by some additional load or by its own self-discharge (out of scope)



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3. Main Requirements 1/2

After iteration with SLI following main requirements have been identified:

Functional Requirements
Isolation of Solar Array in PCDU shall provide a SA passivation capability by short-circuiting or open-circuiting all SA sections.
Isolation of Solar Array in PCDU shall remain active even in case of a main power bus powered down to 0V.
Two independent commands shall be used for passivation, one arming and one confirmation command.
The passivation shall be **reversible** upon the reception of a single command.
The SA isolation function shall be applicable to both regulated and unregulated bus architectures.
Performance Requirements
The passivation shall be compatible with a maximum Solar Array voltage of **150V**
The passivation shall be compatible with a maximum Solar Array current of **5A** per section

3. Main Requirements 2/2

After iteration with SLI following main requirements have been identified:

Reliability Requirements
The probability of un-intentional Isolation of Solar Array in PCDU shall be lower than **1E-4** over the specified operational lifetime.
The reliability of activating the passivation at the end of the operational lifetime shall be at least 0.99.
The reliability of keeping the SA isolated during disposal period shall be at least 0.95.
Environmental Requirements
LEO missions present a maximum TID at PCDU component level of **15kRad** at the end of disposal phase. The solution shall be compatible with this value.
MEO missions present an average value at component level of 50kRad. Compliance with this level is desirable
The solution shall be able of keeping the SA isolation in the temperature range of **-50 °C to 80°C** during the disposal phase.
The solution shall be able to withstand **15 thermal cycles per day between 60°C and 80°C** during the disposal phase

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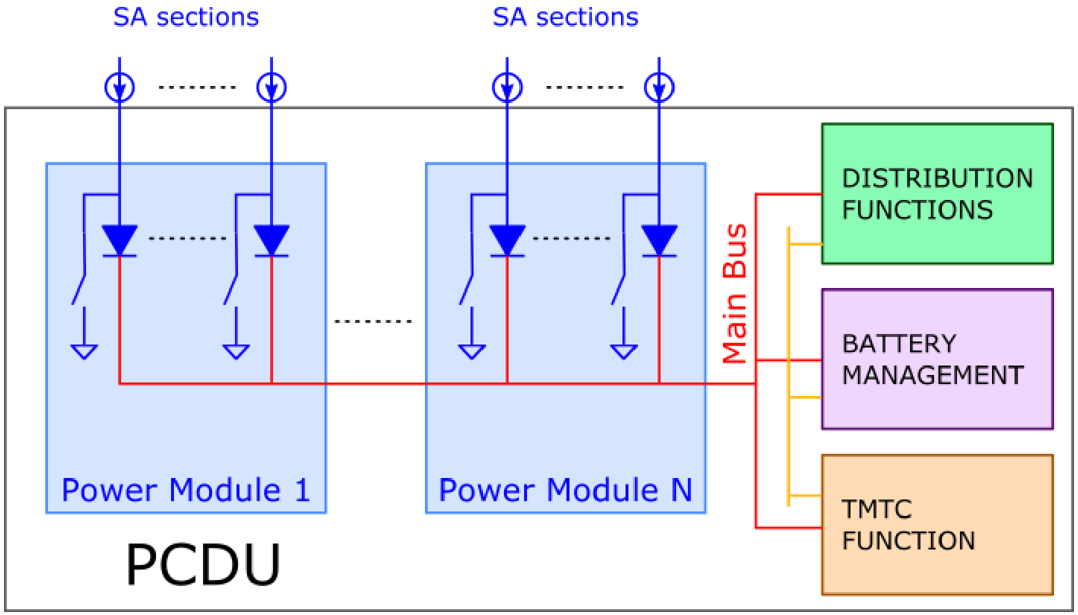
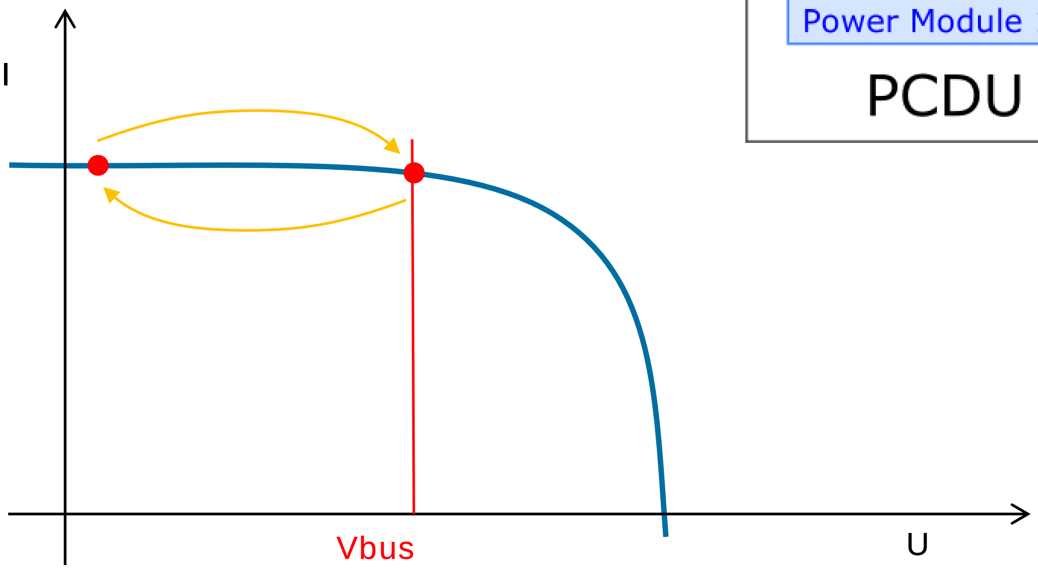
4.1. Passivation Solutions.
PCDU Description

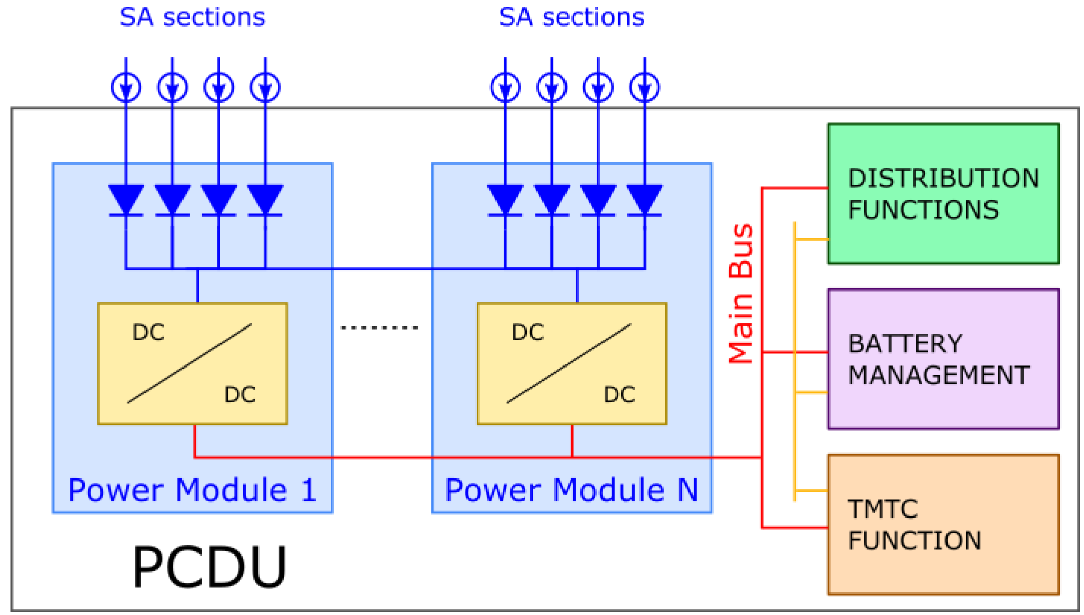
Two different architectures of Solar Array interfaces: S3R and MPPT

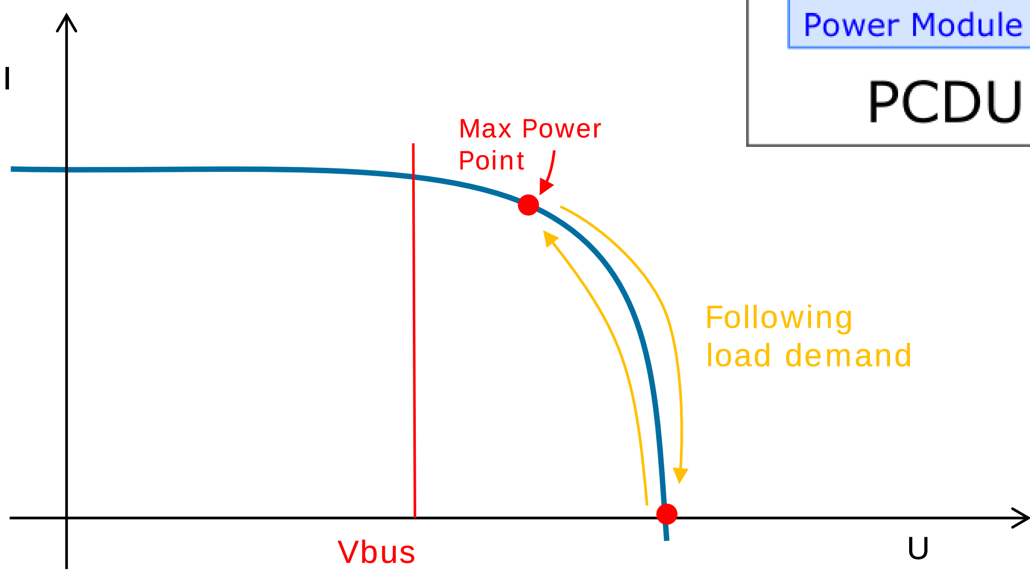




4.1. Passivation Solutions. PCDU Description

Two different architectures of Solar Array interfaces: S3R and MPPT





SA behavior for buck converter

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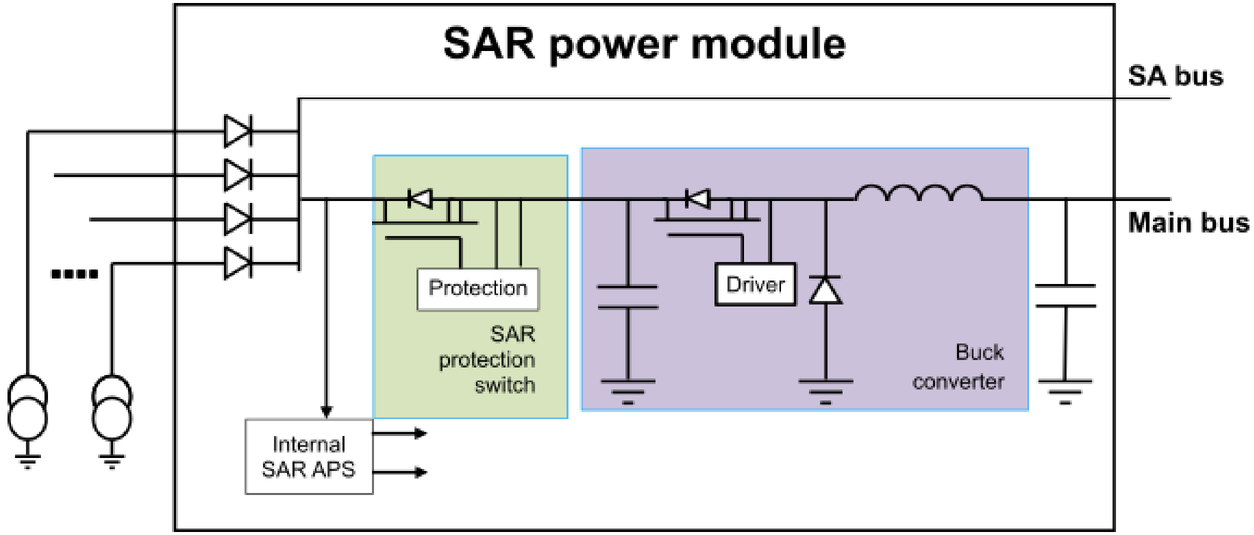
4.2 Solutions Proposed. Electronic Switch

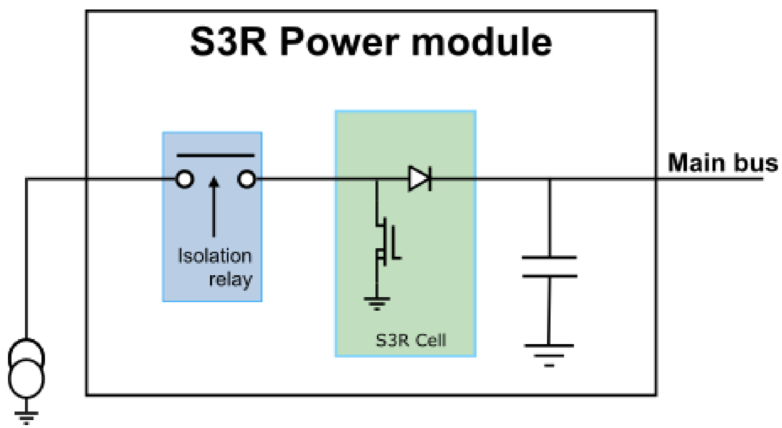
Passivation is achieved by opening the native protection of the DC/DC converter

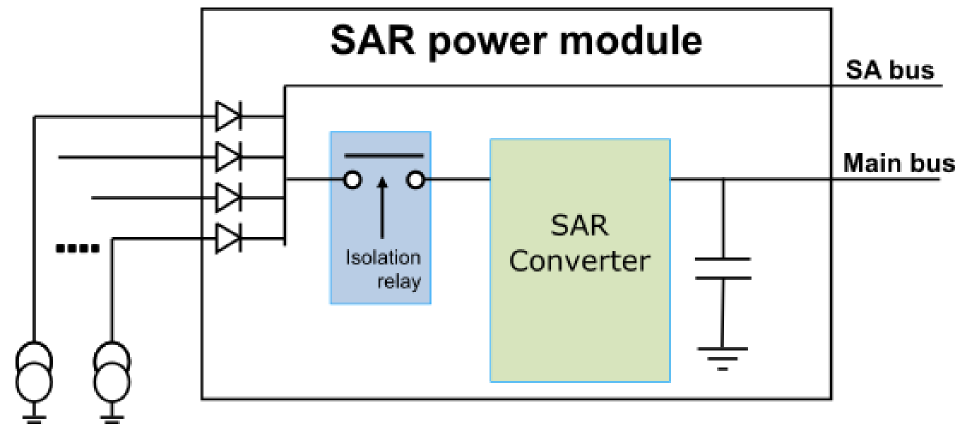


Advantages	Drawbacks
✓ No impact on Operational lifetime	✗ Valid only for MPPT Architectures ✗ Sensitive to radiation

4.2 Solutions Proposed.
Series Relay

Passivation is achieved by opening an added relay on the line of the solar array

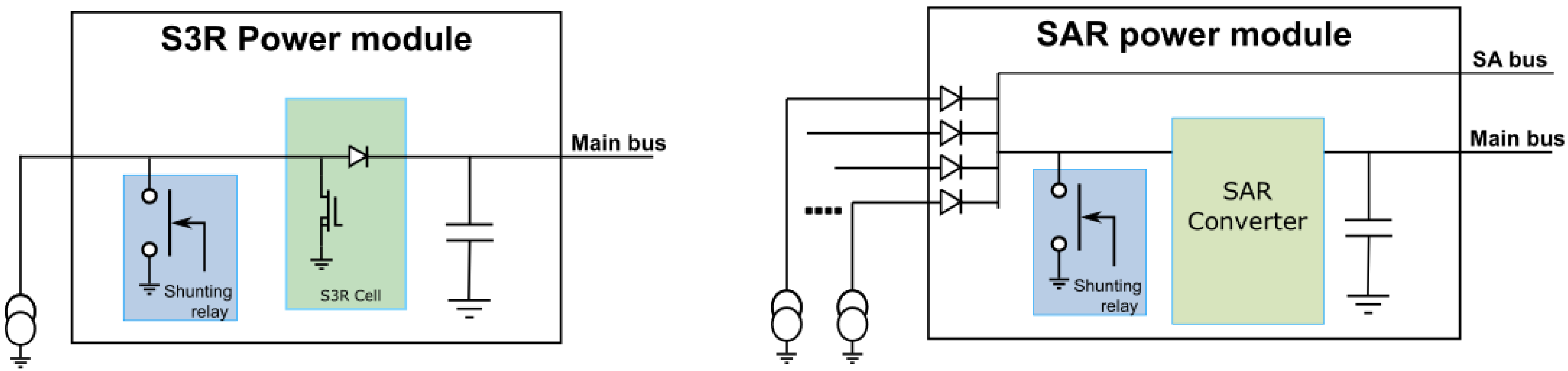




Advantages	Drawbacks
✓ Valid for all architectures ✓ Low sensitivity to environment	✗ Several power relays added (more in S3R) ✗ Operational efficiency impacted

4.2 Solutions Proposed. Shunting relay

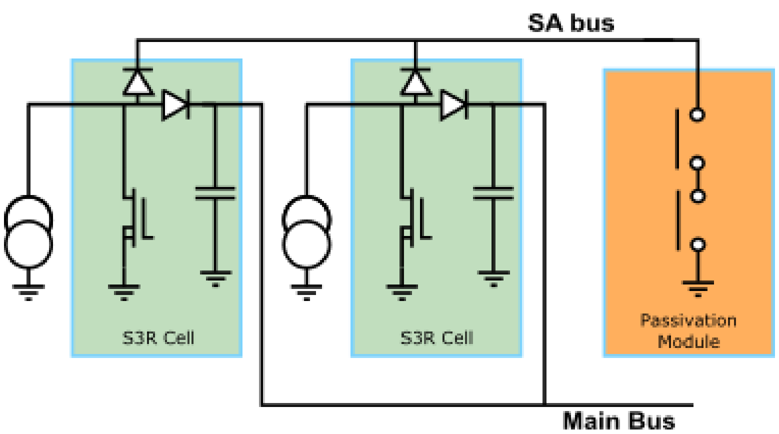
Passivation is achieved by closing a shunt relay in each section line to put the all solar array sections in short circuit

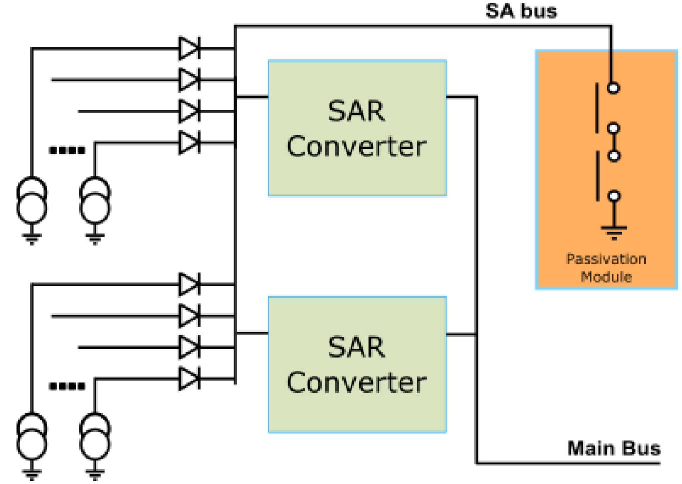


Advantages	Drawbacks
✓ Valid for all architectures ✓ Low sensitivity to environment ✓ No efficiency impact	✗ Several power relays added (more in S3R) ✗ Current flow through passivation during disposal phase

4.2 Solutions Proposed. Common shunting relay

Passivation is achieved by closing a shunt relay to put the all solar array sections in short circuit through a single relay

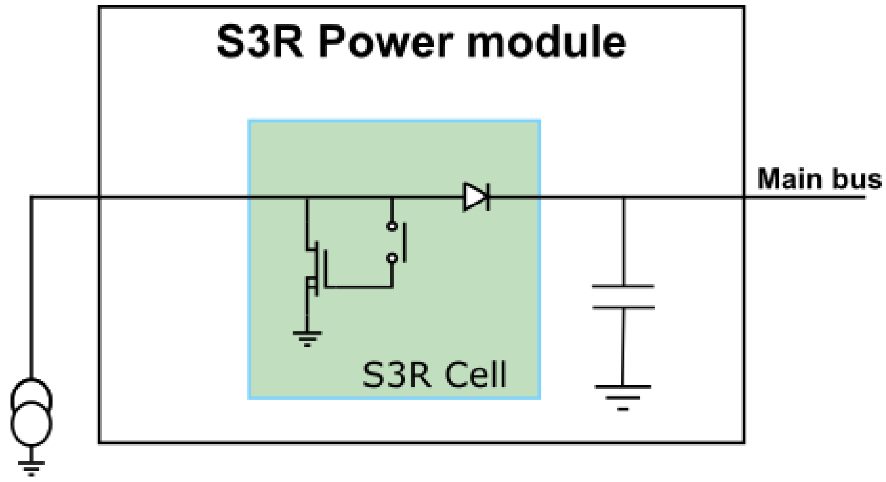




Advantages	Drawbacks
✓ Common solution for all architectures ✓ No efficiency impact	✗ Additional reliable module required (mass and size) ✗ Additional reliable bus in S3R architecture required

4.2 Solutions Proposed. Permanent Shunt of S3R

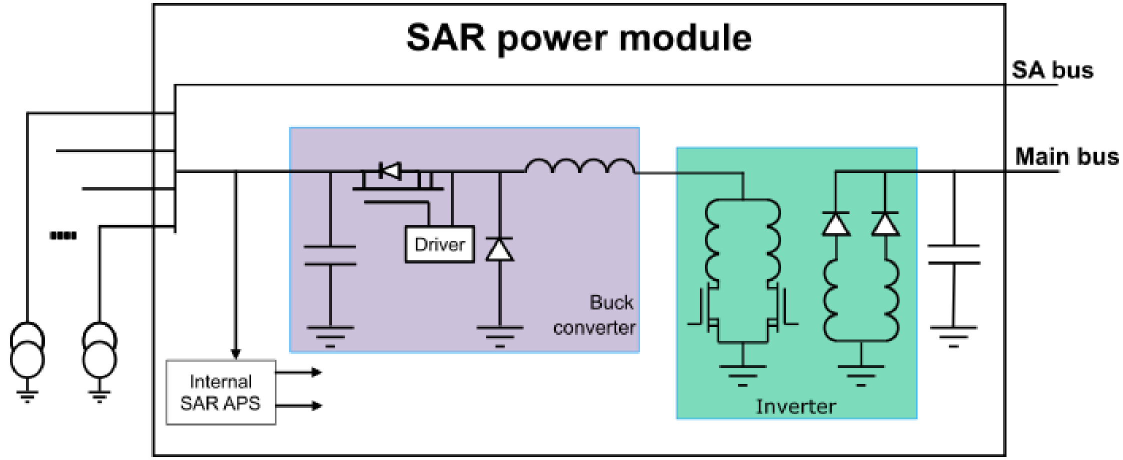
Passivation is achieved by forcing each S3R section to shunt state



Advantages	Drawbacks
✓ No additional power components	✗ Mosfets in high dissipation mode ✗ Solar Array not at zero volts ✗ Valid only for S3R architecture

4.2 Solutions Proposed. Galvanic Isolation

Passivation is achieved at the moment the trafo is not excited at the appropriate frequency



Advantages	Drawbacks
✓ Robust against environment ✓ Relief of protection diodes	✗ Only compatible with MPPT architectures ✗ Only applicable to isolated topologies

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5. Future Steps

- A set of requirements for the isolation of the Solar Array within the PCDU has been agreed with the SLI. Open Points to be fixed

- Environmental constrains defined. Risks at component level to be identified.

- Trade-off initiated. To identify the most promising solution(s)