

New Product Update

The use of radiation-validated power switches for satellite failure detection, isolation and recovery (FDIR)

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Agenda

- The importance of fault management in satellite architecture
- TI's solution for Failure Detection, Isolation and Recovery (FDIR)
 - Solution for latch-up protection
 - Solutions for power supply cold sparing
- Summary of radiation-validated power switches
- Additional resources

The importance of fault management in satellite architecture

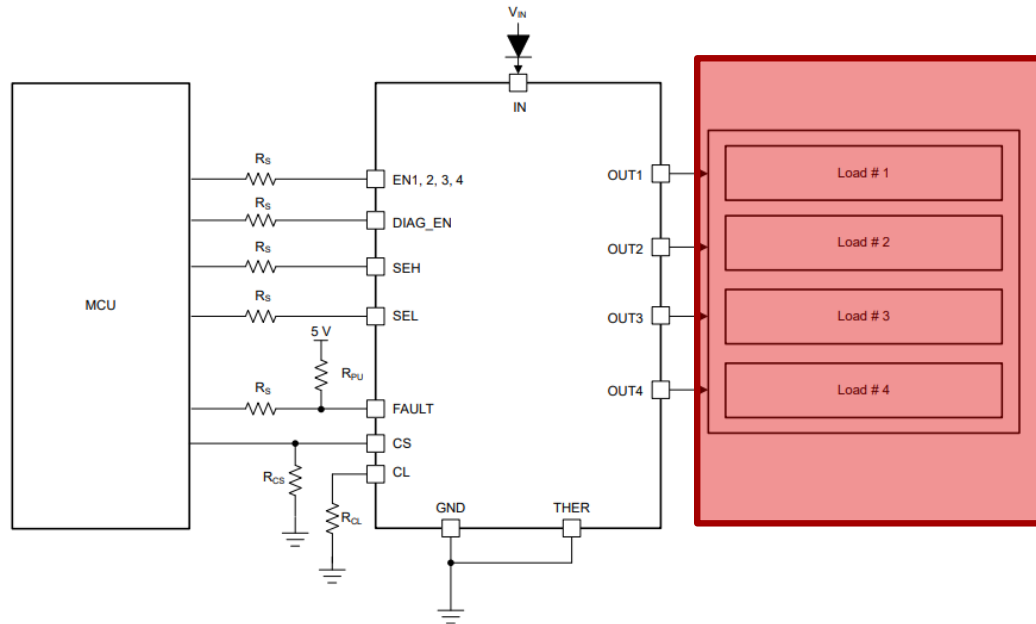
“Fault Management capability of a system or sub-system are consistently viewed **as essential for space mission success**, and is typically assessed at a high criticality level by satellite operators.” NASA

Fault Management is accomplished in several dimensions:

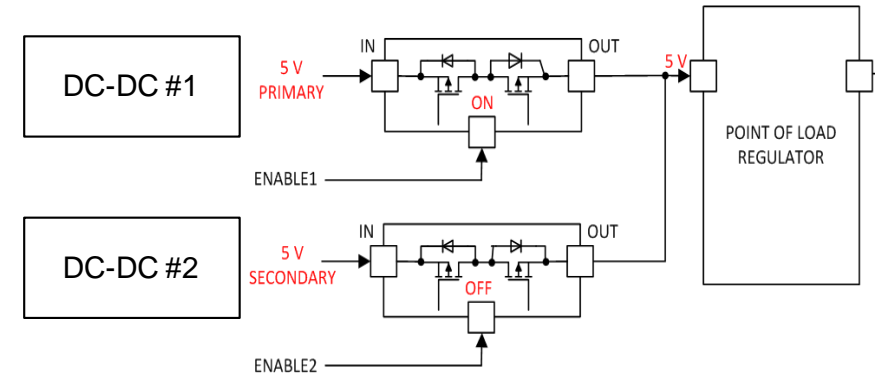
- Spacecraft Robustness, redundancy and margins
- Subsystem Hardware, Firmware and Software capabilities for Failure Detection Isolation and Recovery (FDIR)
- System-Level FDIR

TI's solution for failure detection, isolation and recovery (FDIR)

Solutions for detecting and isolating issues in the downstream circuitry

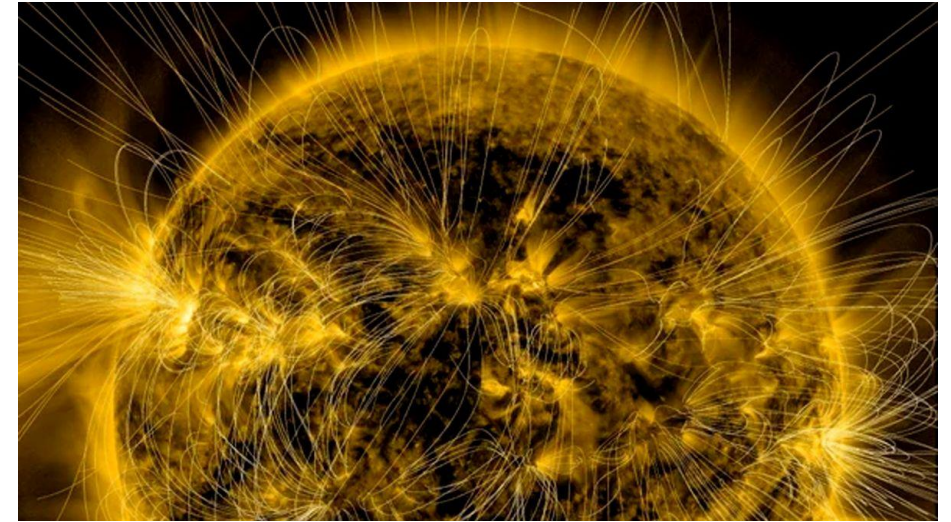


Solutions for detecting and isolating issues in the upstream circuitry



Radiation-validated protection IC to maximize mission assurance

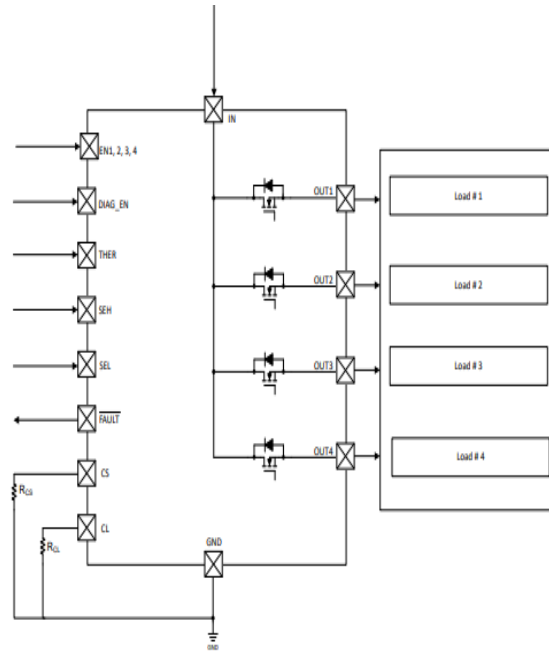
- There are many many challenges that need to be overcome to achieve a successful space mission.
- Focusing down on a subsystem's fault detection, isolation and recovery functions. This needs to be designed to operate to the maximum expected radiation as this function can not fail due to radiation as this is the last level of protection.



Fault response recovery

MCU controlled recovery

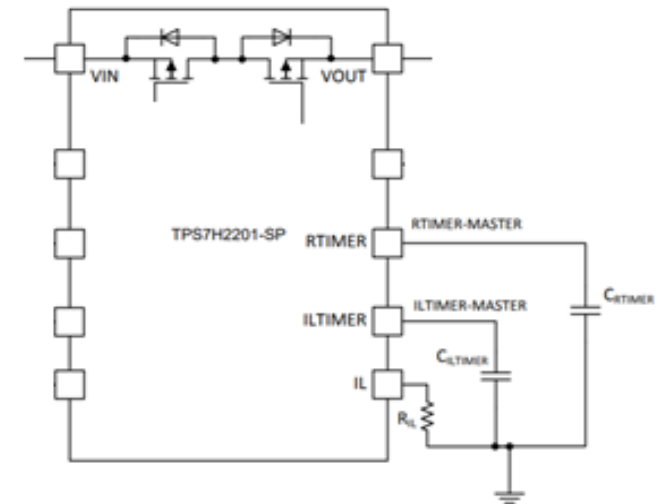
- Set programmable current limit
- When current limit threshold on any channel is exceeded a flag is set to record the channel and the FAULT pin is taken low to alert the MCU
- The MCU identifies the channel via internal flag and disables that channel
- Then the MCU can assert the ENx pin to re-activate the channel



High voltage eFuse
4.5V to 32V, 5.4A
TPS7H2140-SEP

Self recovery

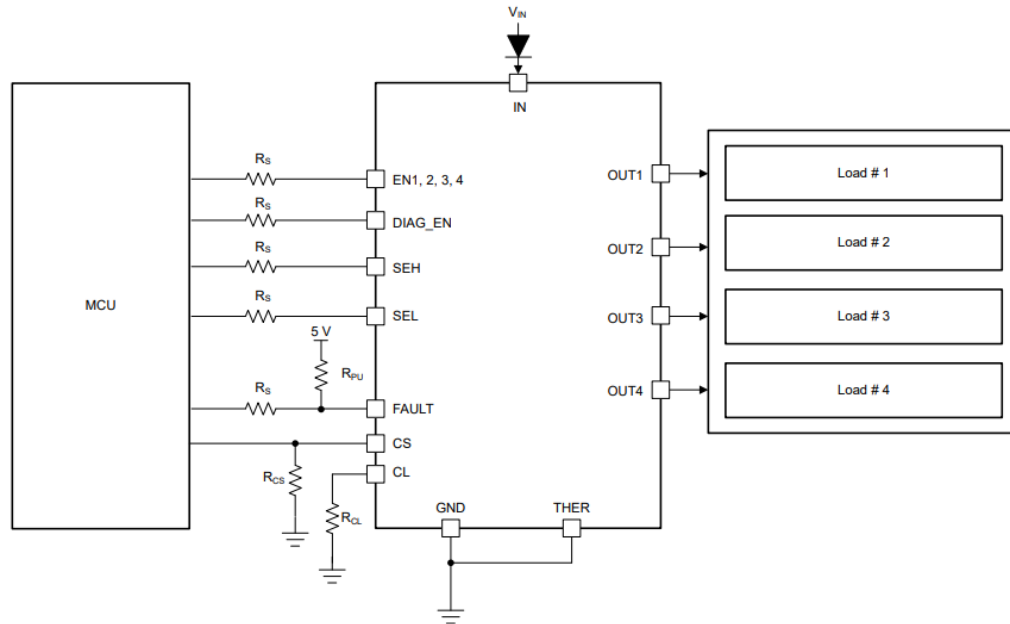
- Set the current limit threshold based on resistor value.
- The programmable current limit fault time is defined by the capacitor at the ILTIMER pin
- The capacitor connected to the RTIMER pin defines how long the device stays in retry mode
- Min off time of 20μsec before going into retry mode



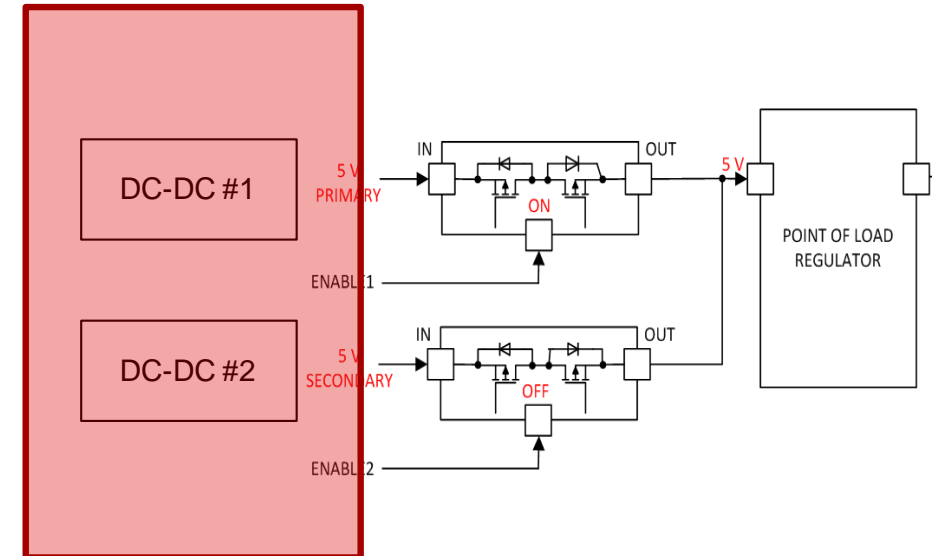
High current eFuse
1.5V to 7V, 6A
TPS7H2201-SP &
TPS7H2201-SEP

TI's solution for Failure Detection Isolation and Recovery (FDIR)

Solutions for detecting and isolating issues in the downstream circuitry

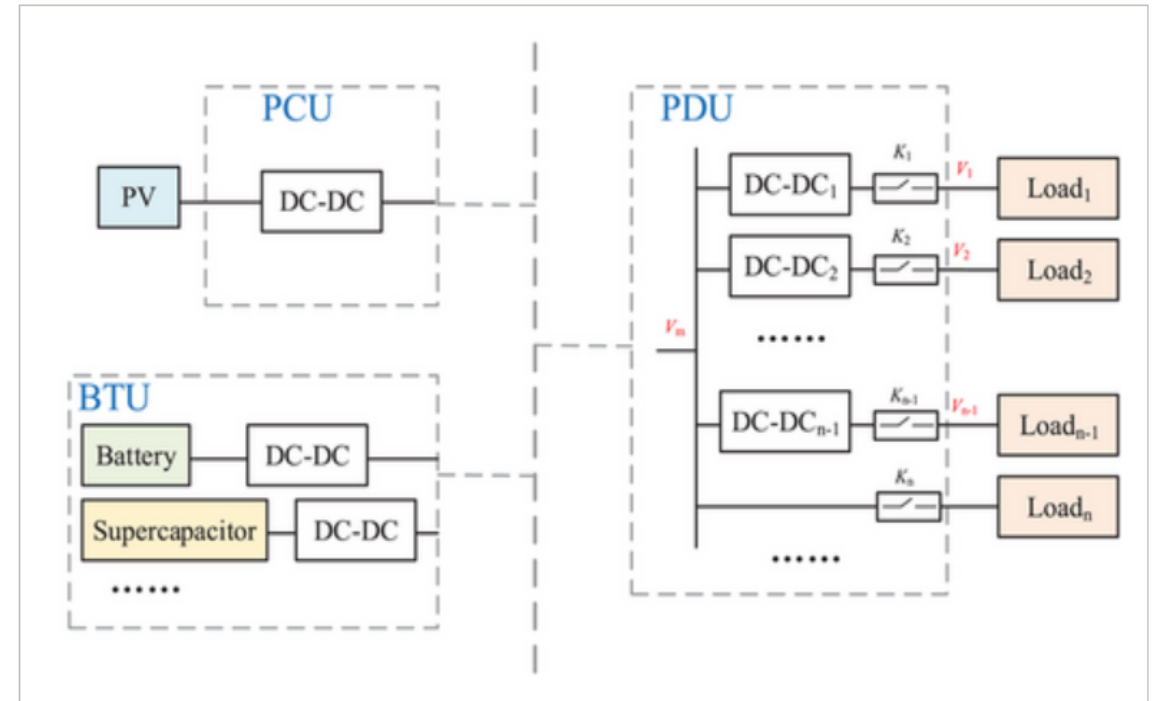


Solutions for detecting and isolating issues in the upstream circuitry

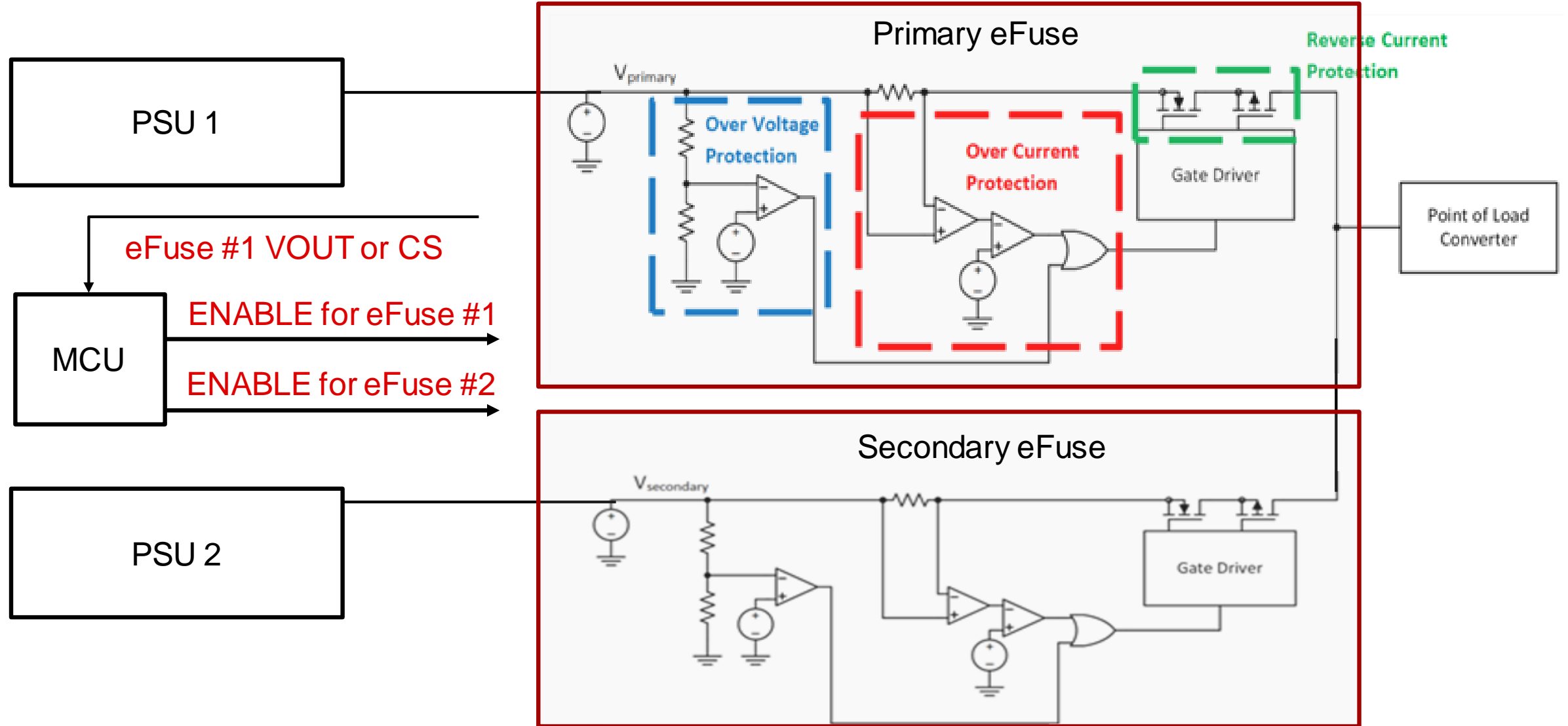


Redundancy. . . minimize single point of failure

- There is a lot of redundancy in a satellite's electrical power subsystem (EPS)
 - Numerous independent solar strings
 - Number of battery cells, number of battery packs, & configuration of battery subsystem
 - Redundant power supplies in the power distribution subsystem (PDU)



Power Supply Cold Sparing



Paralleling devices for higher current subsystems

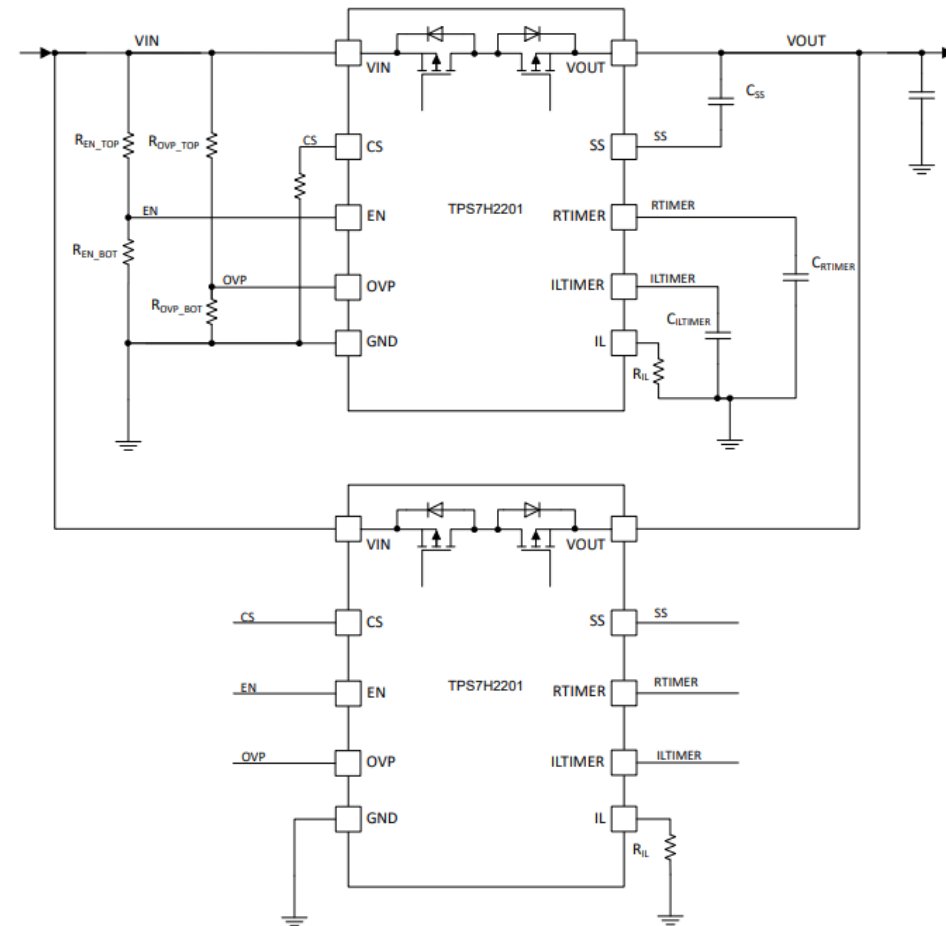
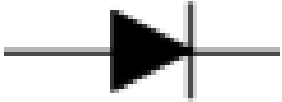


Figure 9-6. Parallel Configuration to Reduce Resistance or Increase Current Capability

Reverse current protection approaches

Diode



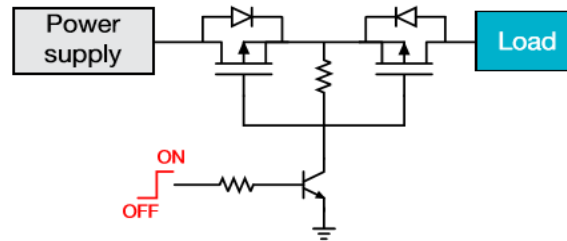
Advantages

- Simple
- Low cost and BOM count

Disadvantages

- Highly inefficient due to large voltage drop across the diode

Back-to-back MOSFETs



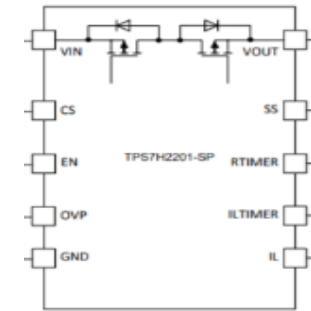
Advantages

- Current blocking in both directions
- Higher power efficiency

Disadvantages

- Larger solutions size and BOM count
- Only provides reverse current protection
- Increased $R_{ds(on)}$ value due to dual FETs

TPS7H2201-SP/-SEP TPS7H2211-SP/-SEP



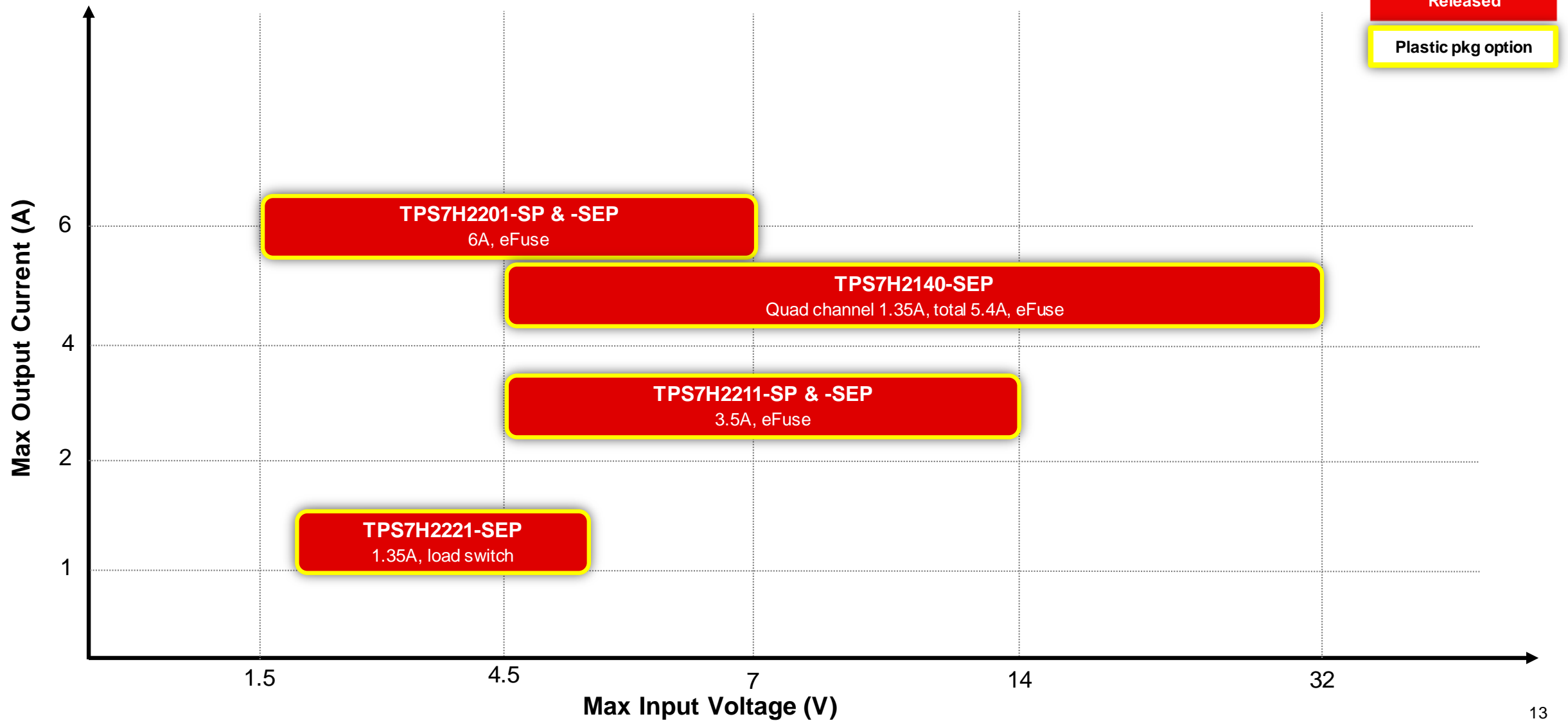
Advantages

- One chip solution, reduced board space
- Integrated back-to-back MOSFETs for reverse current protection in a small solution size
- Added protection features

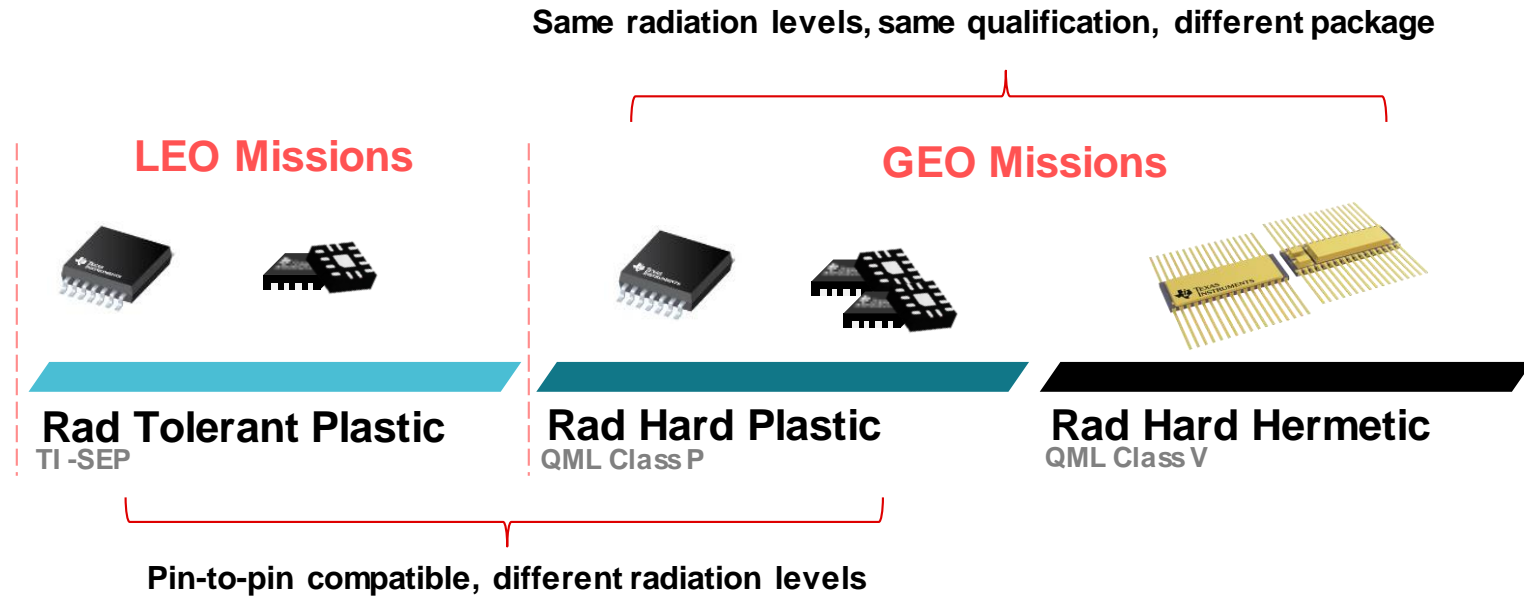
Disadvantages

- Increased $R_{ds(on)}$ value due to dual FETs
- Increased cost

Radiation validated power switches



TI Space product grades



Packaging	Plastic	Plastic	Ceramic / Metal Can
Mil. Spec	VID	SMD	SMD
Burn-in	No	Yes	Yes
TID Char	30 – 50 krad(Si)	< ----- 50krad(Si) – 300 krad(Si) ----- >	
TID RLAT	20, 30, or 50 krad(Si)	< ----- Non-RHA, 50, 100, or 300 krad(Si) ----- >	
SEL	43 MeV·cm ² /mg	< ----- ≥ 60 MeV·cm ² /mg ----- >	

Overview of space-rated power switches

Device	V _{in}	I _{out}	Size	Feature capability
<u>TPS7H2201-SP</u> <u>TPS7H2201-SEP</u>	1.5V – 7V	6A	Ceramic: 9.6 x 11mm Plastic 6.1 x 11mm	Highly integrated switch with reverse current protection, programmable current limit, OVP, and retry timers
<u>TPS7H2211-SP</u> <u>TPS7H2211-SEP</u>	4.5V – 14V	3.5A	Ceramic: 9.6 x 11mm Plastic: 6.1 x 11mm	Highly integrated switch with higher input voltage for 12V rail, reverse current protection, and integrated OVP
<u>TPS7H2140-SEP</u>	4.5V – 32V	1.35A x 4	Plastic: 4.5 x 9.8mm	High voltage eFuse to interface with bus voltage supporting programmable current limit and flexibility for switching independent channels or paralleling for higher current
<u>TPS7H2221-SEP</u>	1.6V – 5.5V	1.35A	Plastic: 2 x 2.1mm	Smallest form factor load switch

Getting started

- You can start evaluating these devices leveraging the following:

Content type	Content title	Link to content or more details
Selection Guide	TI Space Products Guide	https://www.ti.com/lit/sg/slyt532i/slyt532i.pdf
Application Note	Failure Containment in Spacecraft Point-of-Load Power Supplies	https://www.ti.com/lit/pdf/slvaeq6
Parametric Table	List of Space Rated Power Switches	https://www.ti.com/power-management/power-switches/products.html#1498=Space&

Visit www.ti.com/npu

For more information on the New Product Update
series, calendar and archived recordings



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