Texas Instruments

New Product Update

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

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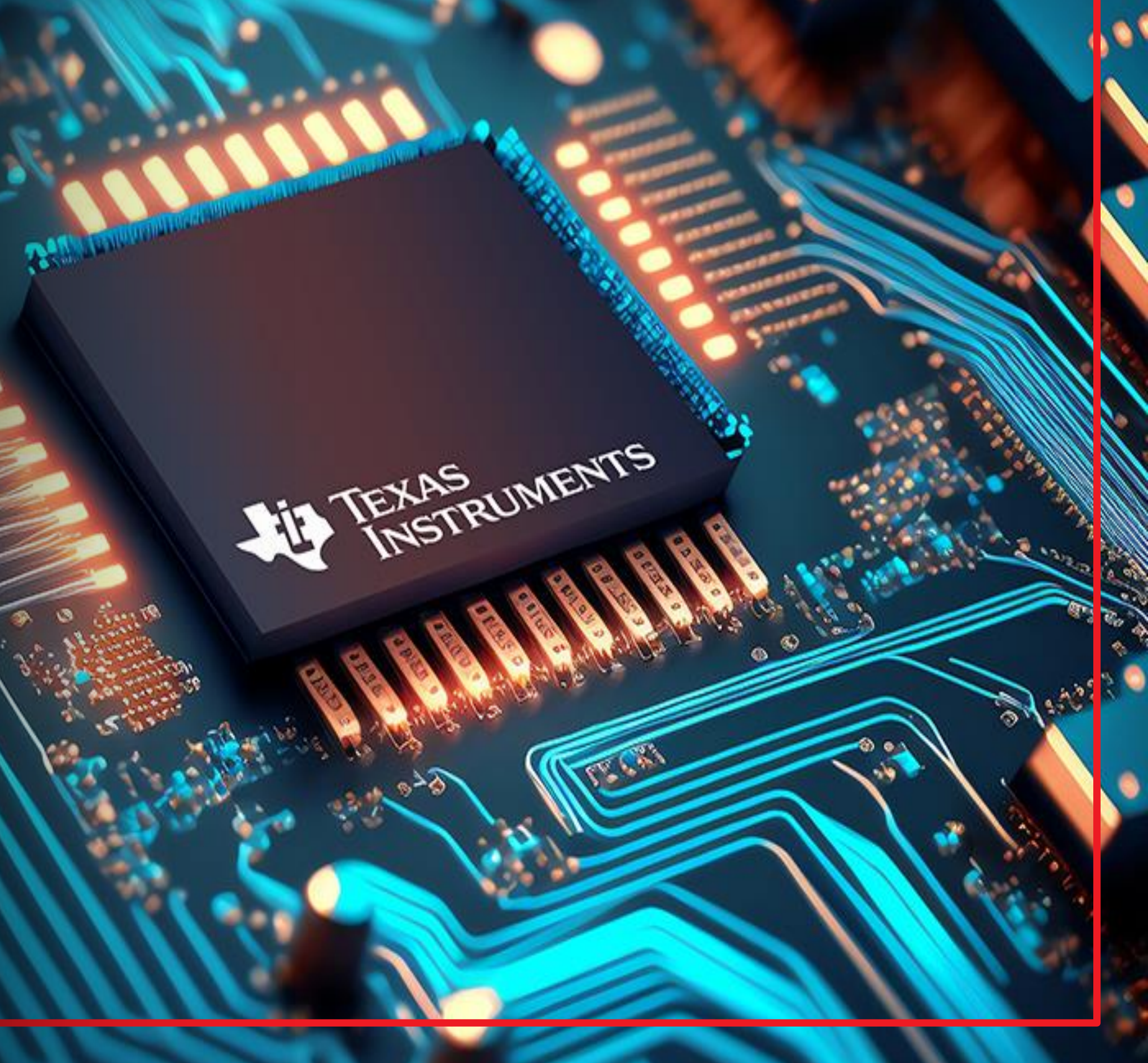
Product marketing engineer



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

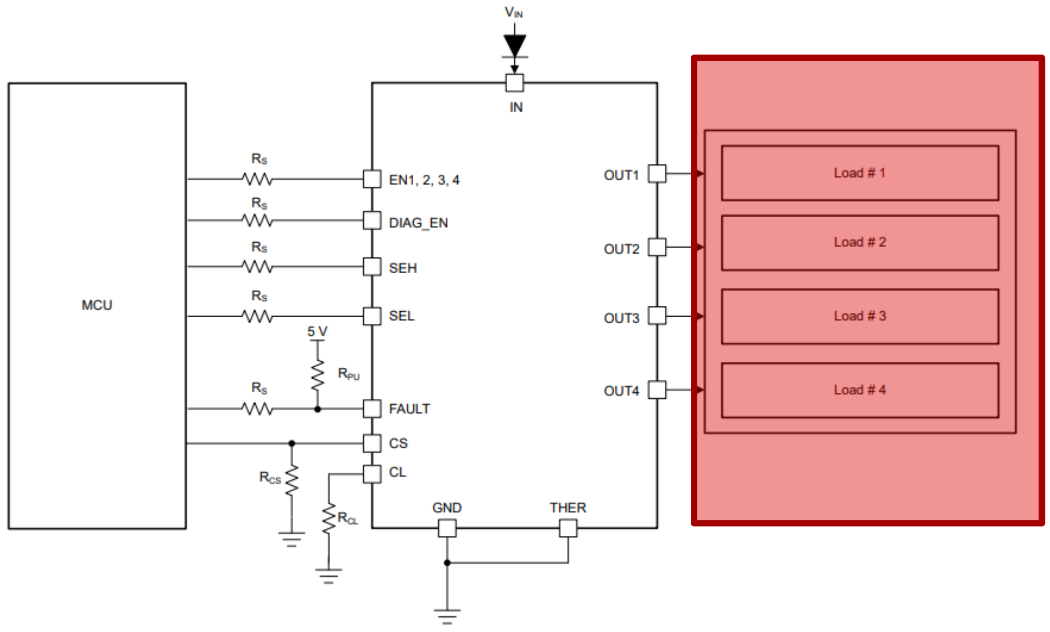
"Fault Management capability of a system or sub-system are consistently viewed **as essential for space mission success**, and is typically assessed at a high criticality level by satellite operators." NASA

Fault Management is accomplished in several dimensions:

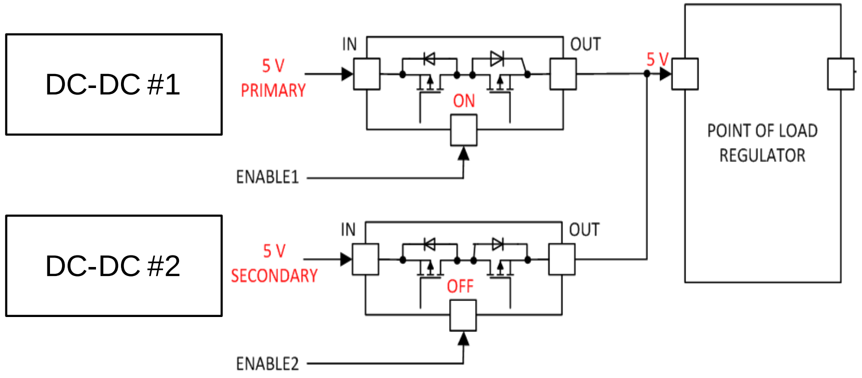
- Spacecraft Robustness, redundancy and margins
- Subsystem Hardware, Firmware and Software capabilities for Failure Detection Isolation and Recovery (FDIR)
- System-Level FDIR

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

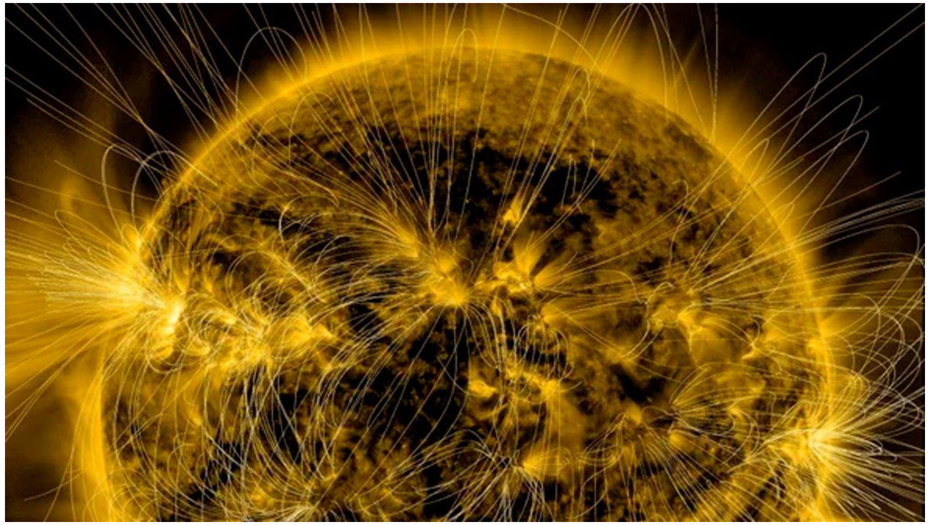
Solutions for detecting and isolating <u>issues in the downstream circuitry</u>



Solutions for detecting and isolating <u>issues in the upstream circuitry</u>



Radiation-validated protection IC to maximize mission assurance



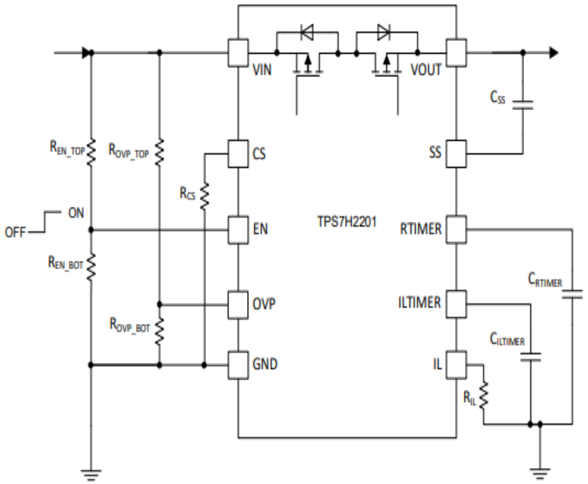
- There are many many challenges that need to be overcome to achieve a successful space mission.
- Focusing down on a subsystem's fault detection, isolation and recovery functions. This need to be designed to operate to the maximum expected radiation as this function can not fail due to radiation as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

Current monitoring of loads

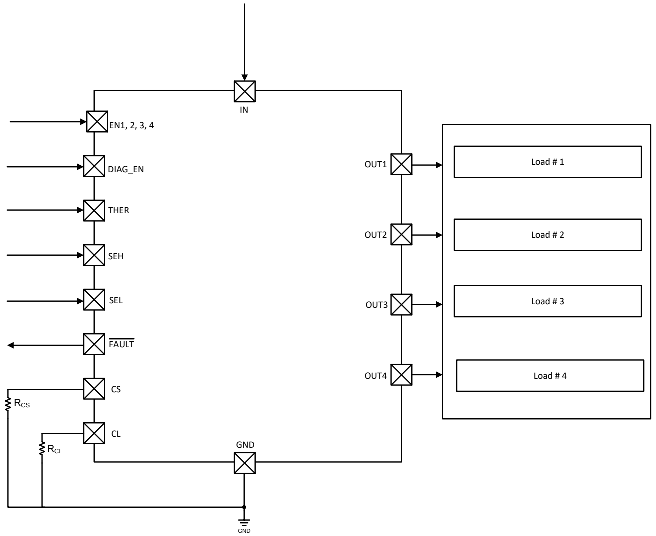
Current monitoring

- Particles in space (electrons, protons, neutrons, & heavy ions) cause devices to suffer threshold shifts, increased device leakage, create timing changes, decrease functionality and cause device failure.

- Monitoring for unexpected increases in current is a reasonable approach to detecting some of latch-up conditions on devices that might be more prone to radiation effects



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

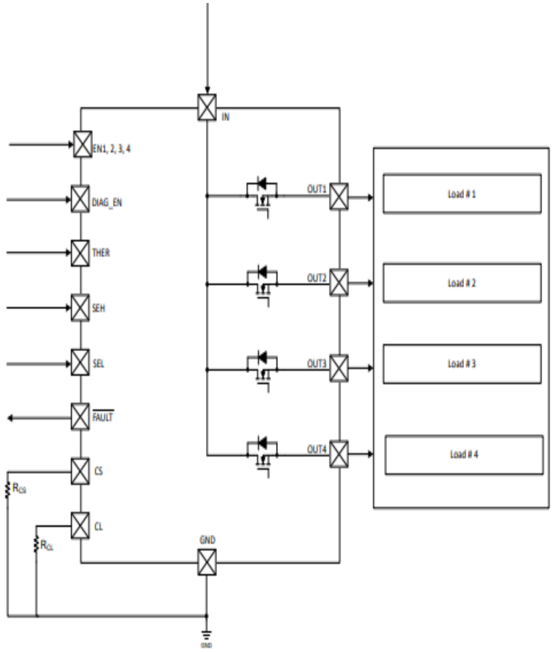


Wide VIN eFuse
4.5V to 32V, 4ch 1.35A
TPS7H2140-SEP

Fault response recovery

MCU controlled recovery

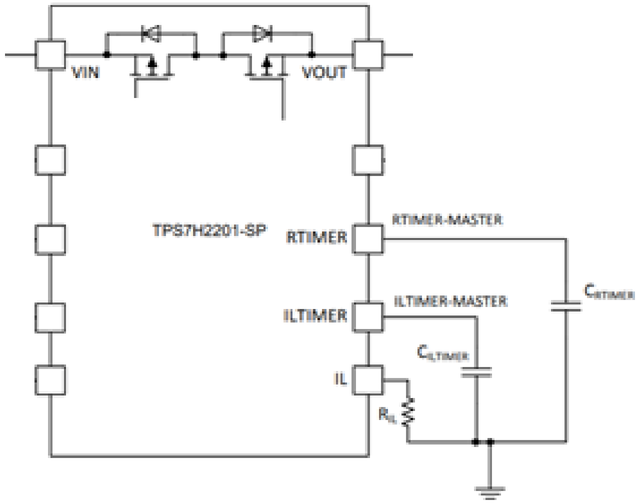
- Set programmable current limit
- When current limit threshold on any channel is exceeded a flag is set to record the channel and the FAULT pin is taken low to alert the MCU
- The MCU identifies the channel via internal flag and disables that channel
- Then the MCU can assert the ENx pin to re-activate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



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

Self recovery

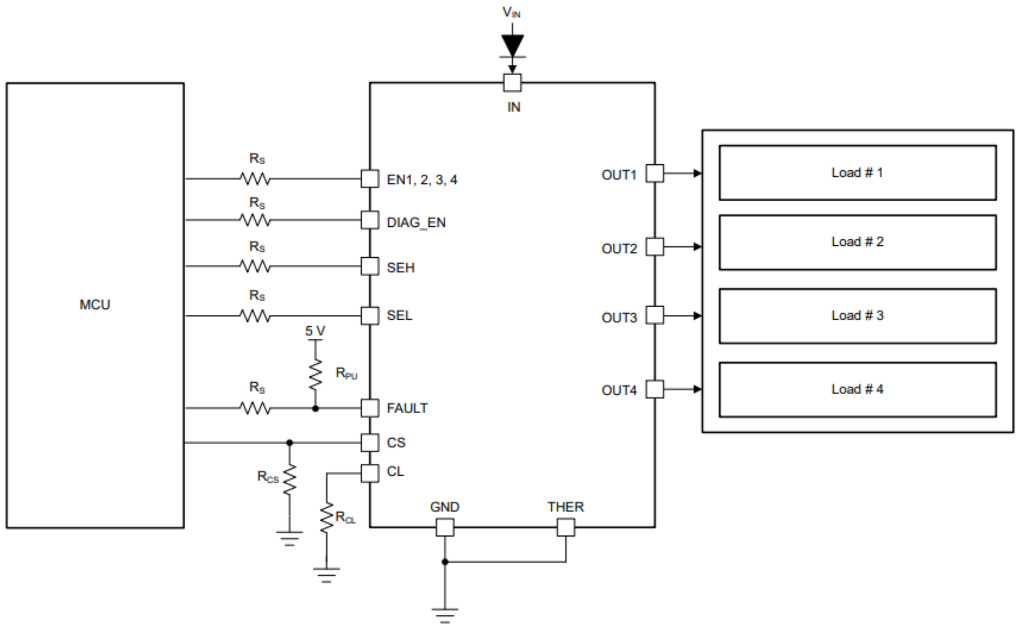
- Set the current limit threshold based on resistor value.
- The programmable current limit fault time is defined by the capacitor at the ILTIMER pin
- The capacitor connected to the RTIMER pin defines how long the device stays in retry mode
- Min off time of 20µsec before going into retry mode



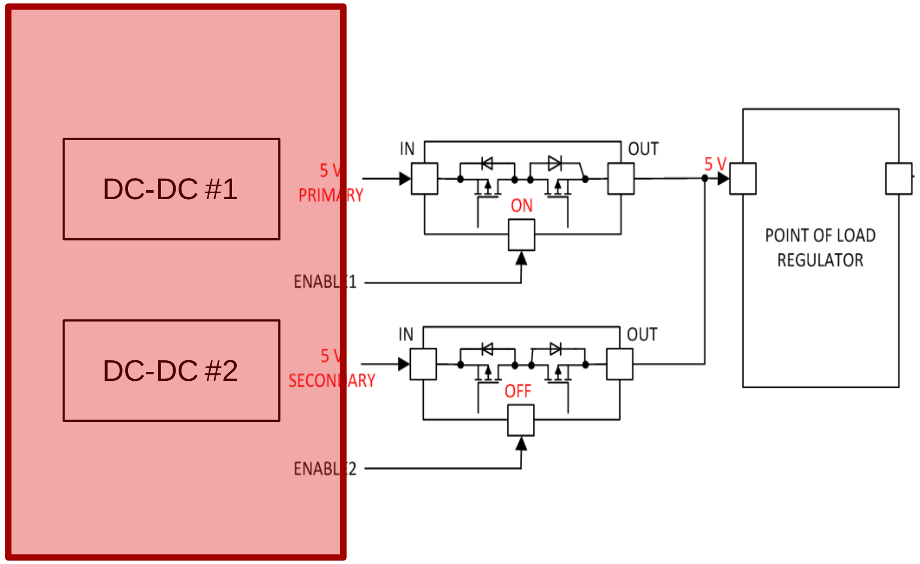
High current eFuse
1.5V to 7V, 6A
TPS7H2201-SP &
TPS7H2201-SEP

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

Solutions for detecting and isolating <u>issues in the downstream circuitry</u>

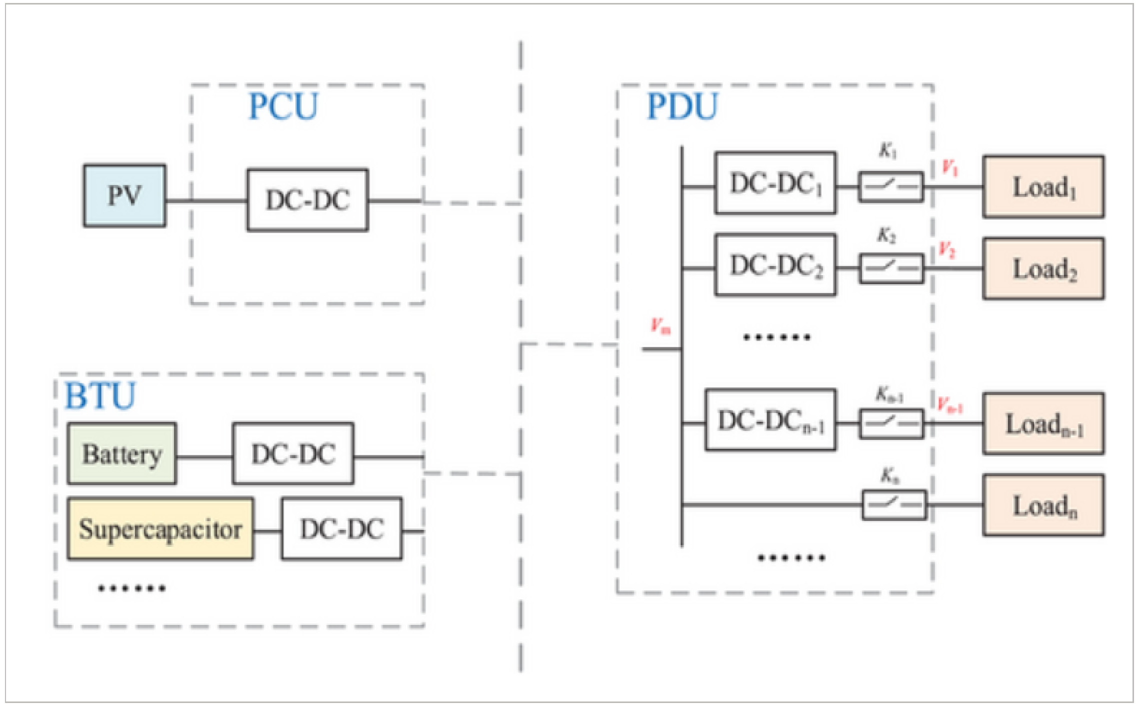


Solutions for detecting and isolating <u>issues in the upstream circuitry</u>

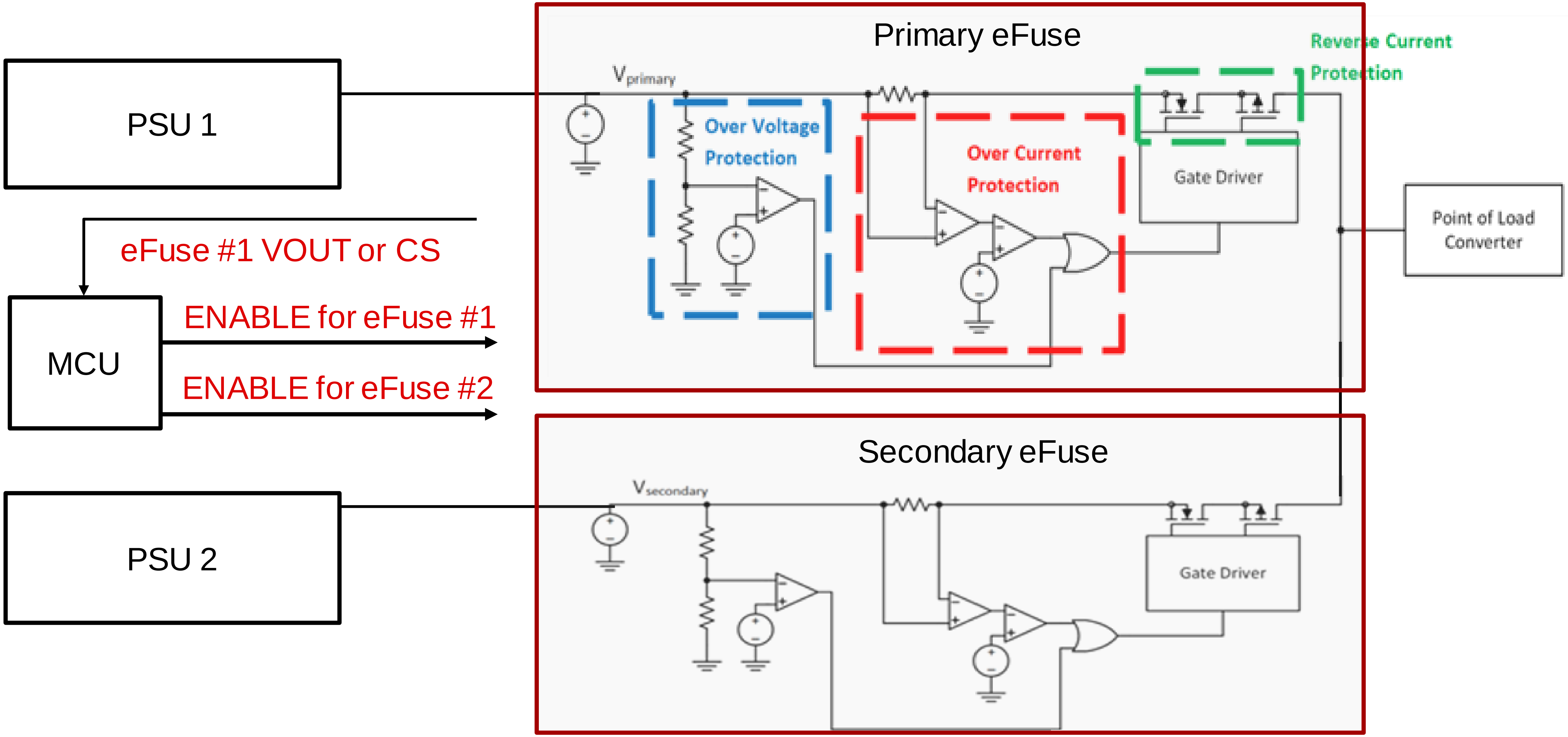


Redundancy. . . minimize single point of failure

- 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

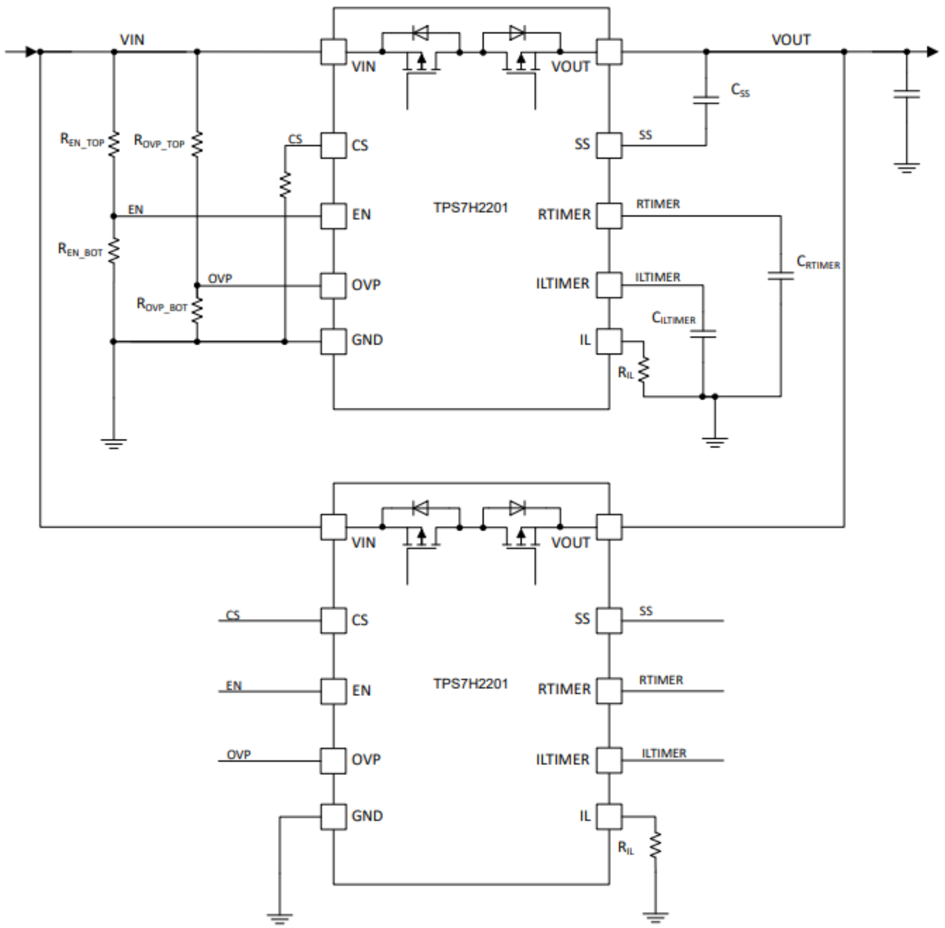
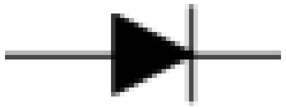


Figure 9-6. Parallel Configuration to Reduce Resistance or Increase Current Capability

Reverse current protection approaches

Diode



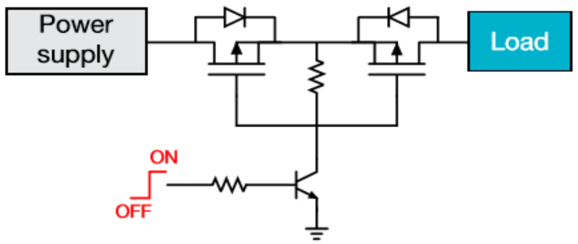
Advantages

- Simple
- Low cost and BOM count

Disadvantages

- Highly inefficient due to large voltage drop across the diode

Back-to-back MOSFETs



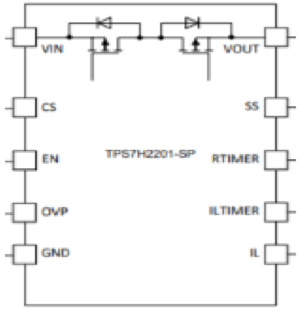
Advantages

- Current blocking in both directions
- Higher power efficiency

Disadvantages

- Larger solutions size and BOM count
- Only provides reverse current protection
- Increased Rdson value due to dual FETs

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



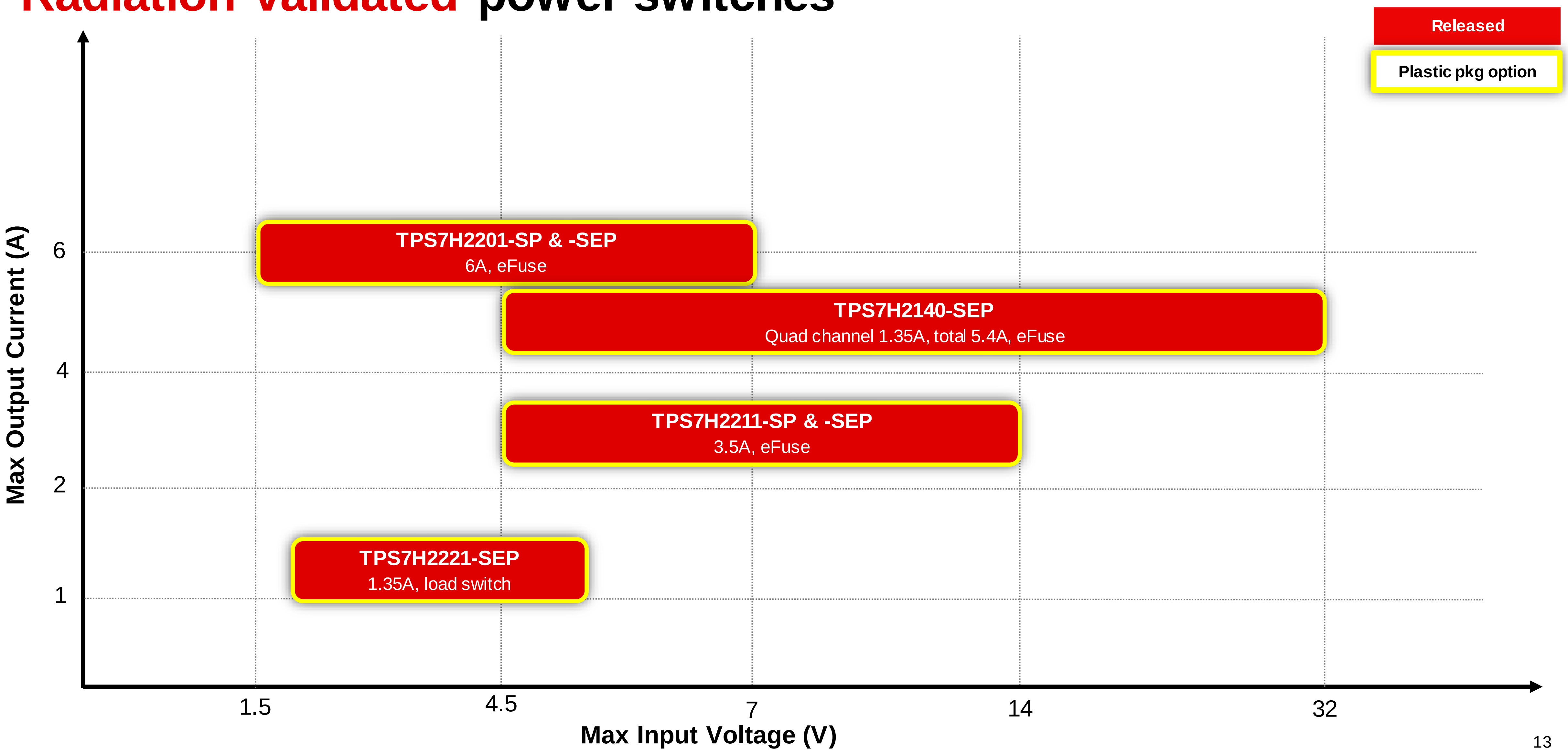
Advantages

- 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 Rdson value due to dual FETs
- Increased cost

Radiation validated power switches



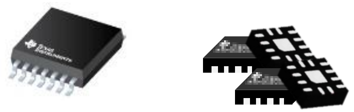
TI Space product grades

Same radiation levels, same qualification, different package

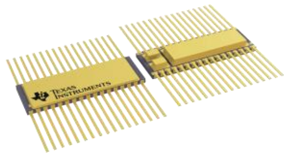
LEO Missions

Rad Tolerant Plastic
TI -SEP

GEO Missions



Rad Hard Plastic
QML Class P



Rad Hard Hermetic
QML Class V

Pin-to-pin compatible, different radiation levels

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 - - - - - - - - - - - - - - - - - >**	

TEXAS INSTRUMENTS

Overview of space-rated power switches

Device	V_{in}	I_{out}	Size	Feature capability
TPS7H2201-SP TPS7H2201-SEP	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
TPS7H2211-SP TPS7H2211-SEP	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
TPS7H2140-SEP	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
TPS7H2221-SEP	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

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