Evolution of Concept for Passivation of Spacecraft Power Subsystem

How the concept has evolved from early studies to recent proposals

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Electrical Power Passivation Unit, PAU
Overview

- Passivation implementation by short circuiting the Solar array sections.
- 12 SA sections, 5A, 150V
- No untimely passivation before end of mission, reliability > 0.9999
- Command IF, discrete HPC/SHPs (Standard High Power Command)
- The passivation function shall be reversible
  - As long as battery power available
- New Space COTS product, automotive AEC-Q, except the most critical parts
- Short circuit element, relay
  - Hi-Rel, 28VDC, 15A, 4PDT, ESCC 3602/004 (M402) selected to withstand 15 years mission + 25 years disposal phases

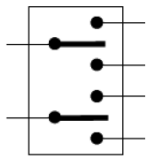


Figure G-1: Two open contacts (relay stuck in intermediate position)

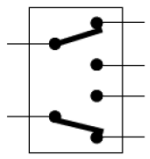


Figure G-2: Two contacts in opposite positions

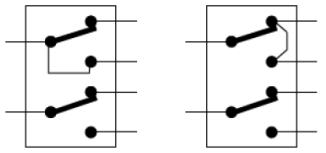
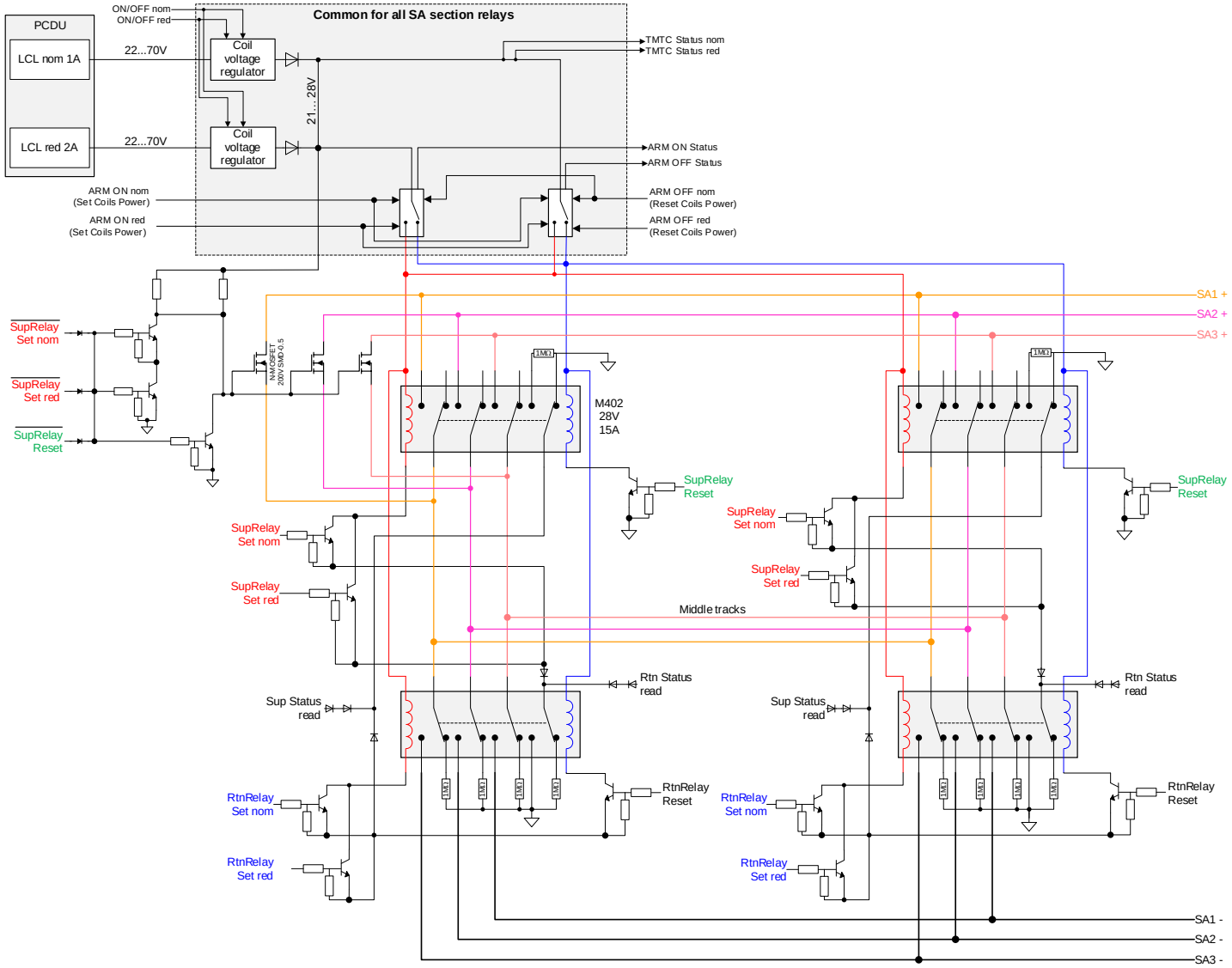


Figure G-3: Short circuit between fix contacts

Relay Failure Cases, ECSS-Q-ST-30-02C

- Three different PAU evolution concepts will be presented

1. Most Reliable and Complex Concept



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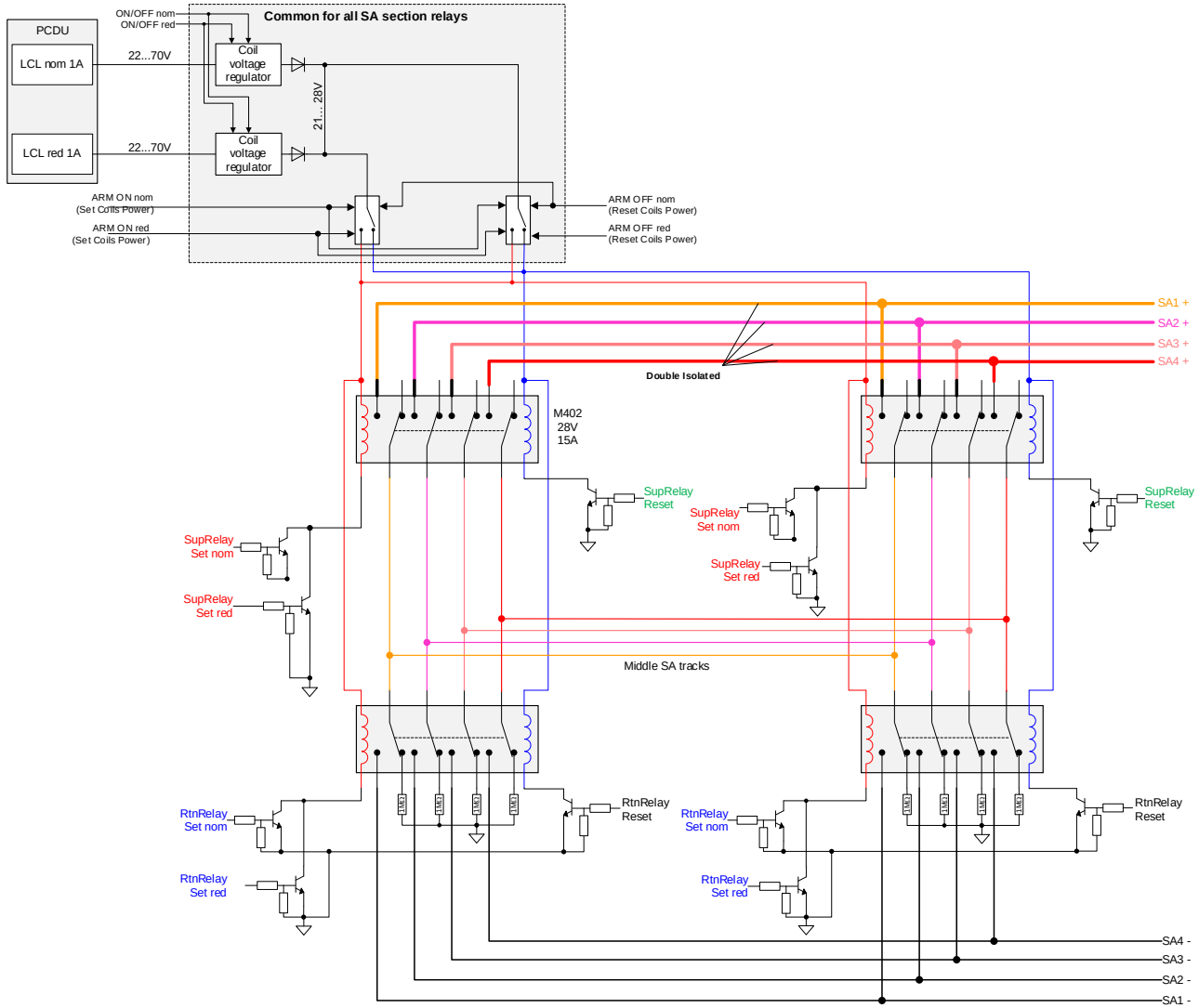
1. Most Reliable and Complex Concept

- Parallel and Serial SA short circuit redundancy
  - In total 16+2 Relays
- 200 V MOSFETs, parallel with upper relays, provide possibility to short circuit 150V SA voltage, protection against arcing, contact welding, relay max voltage 28V
  - Hi-Rel MOSFET selected, In total 12 MOSFETs
- Minimized HPC/SHP IF number
  - One HPC/SHP command controlling all upper/lower relays -> high current needed to drive several relay coils
  - PCDU LCLs and PAU coil voltage regulators provides the coil current capability
- Two stage redundant commanding, coil power ARMing + coil powering
- Discrete Relay status provided -> 3 SA sections /relay
  - A lot of electronics parts
- 50 krad TID requirement
  - Thick Aluminum shielding needed to protect Automotive electronics
- Mass ~3.9 kg, Envelope 250 mm x 180 mm x 45 mm (w x d x h).

2. Reduced Complexity



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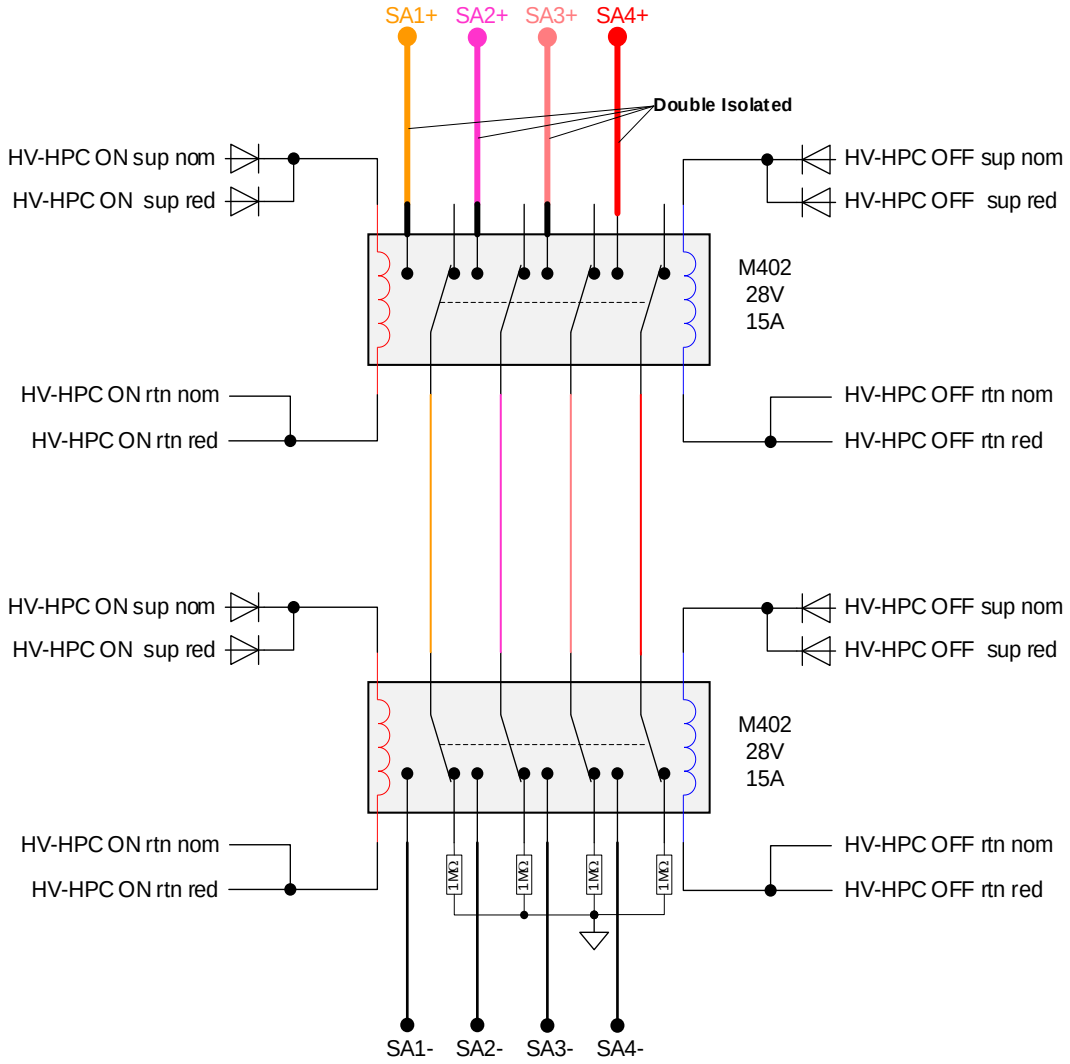
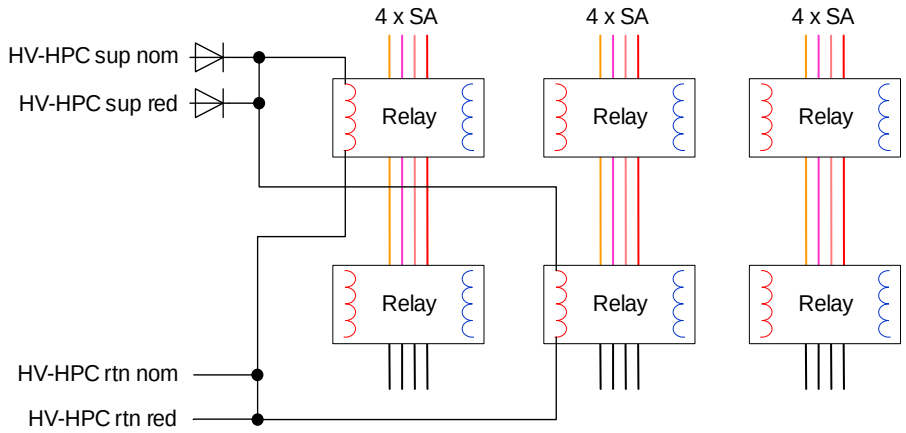
2. Reduced Complexity

- MOSFETs removed
  - SA short circuit only when voltage is below 28V
- Relay status removed-> 4 SA sections / Relay
- Totally 12+2 Relays
- Reduced costs
- Requirement 50 krad -> 30 krad TID
  - Thinner aluminum shielding needed to protect automotive electronics
- Mass ~3.0 kg, Envelope 200 mm x 180 mm x 45 mm.

3. Most Simple and Cost Efficient





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3. Most Simple and Cost Efficient

- Parallel SA SC relays removed
  - In total 6 Relays
  - After one failure, 4 SA sections not able to SC
  - ARMing function removed, HPC/SHP command itself provides the ARM functionality
- Direct HV-HPC relay control
  - (more) 12 HPC/SHP needed, max two Relay/ HPC/SHP command
  - Simpler electronics (command oring diodes only)
  - Coil commands cross coupled to different relays to avoid activation by single command.
- Electronic components minimized
- Radiation shielding optimized
- Mass ~1.5kg, Envelope 180 mm x 120 mm x 45 mm.

Electrical Power Passivation Unit, PAU
Conclusion

- Implementation of passivation unit was optimized in co-engineering phase with the customer to minimize the cost and complexity still maintaining adequate reliability
- Complexity of the PAU is finally a system level decision of the reliability

Thank You