MARS 2 IPB Short Circuit Protection MBARI Update

Update, Brenton Salmi, June 2024

Applied Physics Laboratory
UNIVERSITY of WASHINGTON

Overview of Project Goal

Add Short Circuit Protection to IPB

Problem

- IPB V1.0 circuitry not fast enough for short circuit protection
- Short circuit survivability is a desired operation after discussions with MBARI.

Short Circuit Uniqueness Vs. Overcurrent

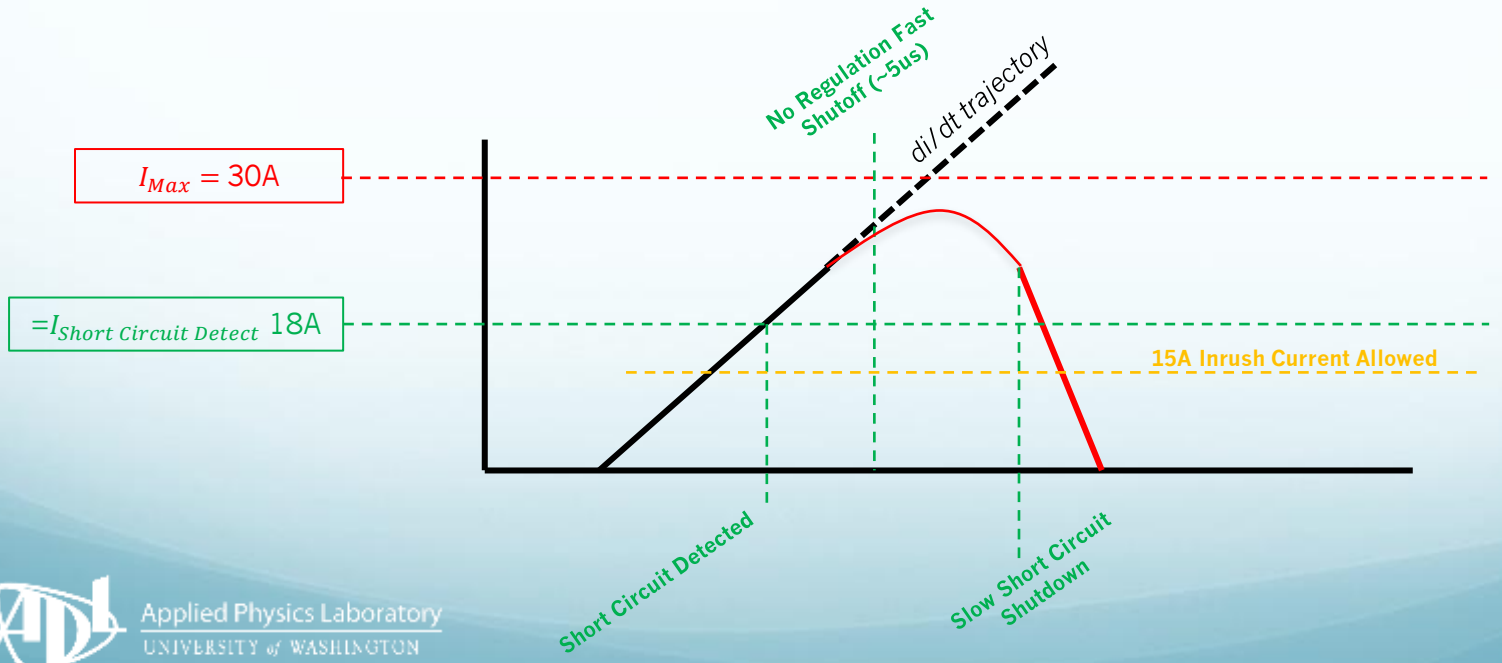
- Fault current rise times very fast (microseconds)
- High energy pulses from system capacitances (~90A at 375V observed!)
- Short circuit protection requires detecting, stopping current flow, and dealing with resulting inductive flyback
  - This needs to occur while not exceeding any component Safe-Operating-Area (SOA) – Typicallys <<10us

How To Achieve?

- Use high-speed analog sensing/comparators
  - Detect high currents above a threshold (e.g. 18A) that should never be present, even during in-rush current events.
- When detected, the system automatically removes all port current (disables the port) within ~10us
- Short circuit protection is integrated into existing channel fault logic
  - Latch and indicate as a normal channel fault (Short and overcurrent faults will look the same)
  - Building in overcurrent and short circuit identification would be difficult and require additional computer IO lines not currently present

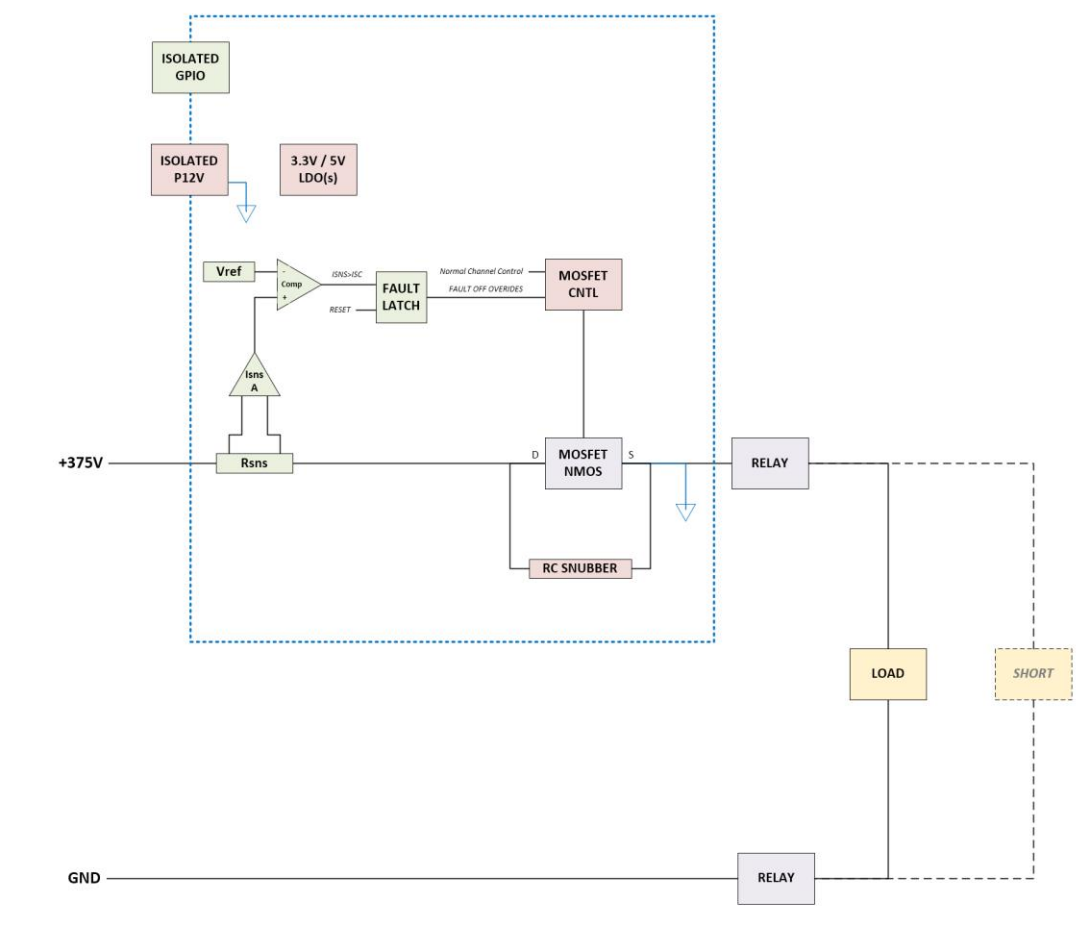
Short Circuit Timing Needs

- di/dt will be roughly 1.7MA/s per IGB inductors
  - (*may be faster due to L saturation*)
- MOSFET off must shutdown within ~10-15us regardless of current regulation to avoid relay damage
  - The MOSFET itself can handle MUCH more current <100us than 30A – it's safe!
- Setting SHORT threshold at 18A
  - Above 15A maximum inrush current
  - Gives ~7us of buffer before 30A relay welding
- Expected current profile below in a Short Cirucit FAULT condition
  - MOSFET transitions thorugh linear region limiting and ramping current down after FAULT is detected
  - MOSFET rated for 100's nano-second switching speeds



Short Circuit Protection

Minimum Viable (Test) Solution



Goals

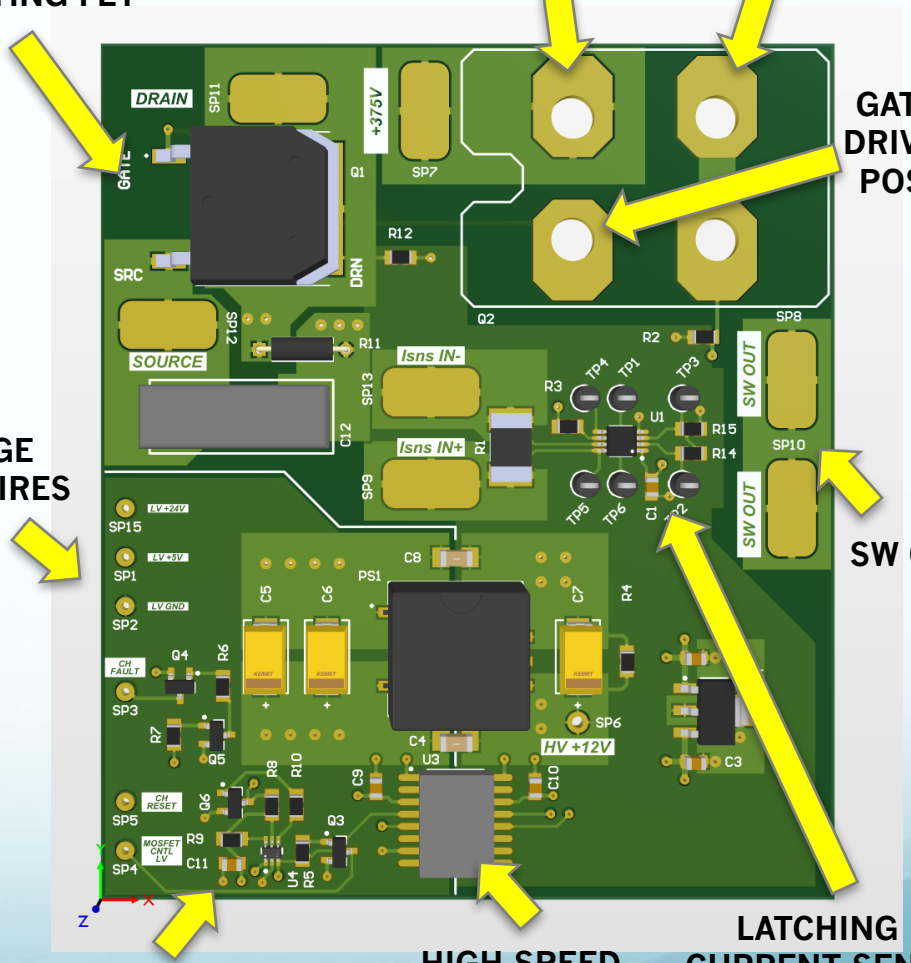
- **Develop short circuit detection**
  - *Accurate threshold*
  - *Fast enough action (us speeds)*
- **Modify Existing MOSFET driver**
  - *Requirement: Turn-off less than ~5us*
- **RC Snubber development**
  - *Tuning for size and Vds*
- **Short Simulation development**
  - *Safely create 375 V short circuit in the lab!*

Notes

- **IPB Overcurrent Protection**
  - *This remains in the system but is NOT shown on this slide*
  - *Protects against minor overcurrent issues*
    - *Many load faults may never produce high currents like a short upstream*
    - *E.g. Power limited shorts/faults in load*

Adapter PCB

- Mounts using standoffs to the SOT-227 IPB PCB pads
  - Brings out
    - +375V
    - MOSFET Gate Control
    - MOSFET Driver GND
- Solder pad configurability
  - Supports 2 configurations desired
    - Single +12V supply
      - Adapter PCB +12V DC/DC DNP'd
    - Dual +12V supply
- Will be integrated onto IPB 2.0



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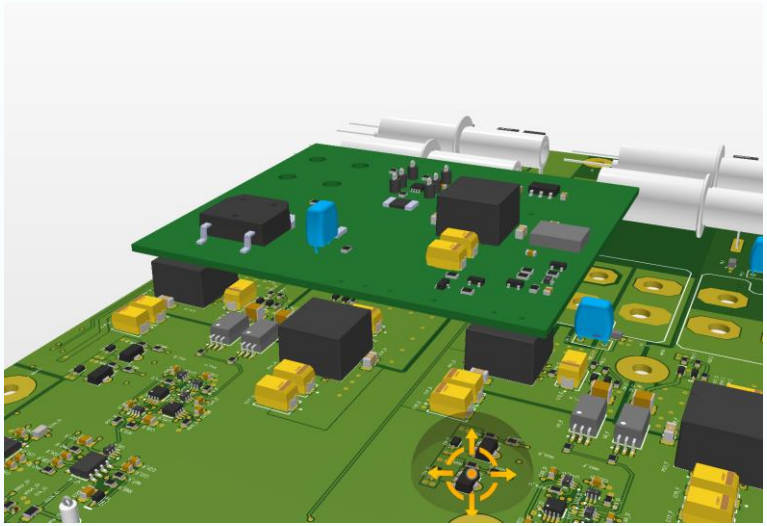
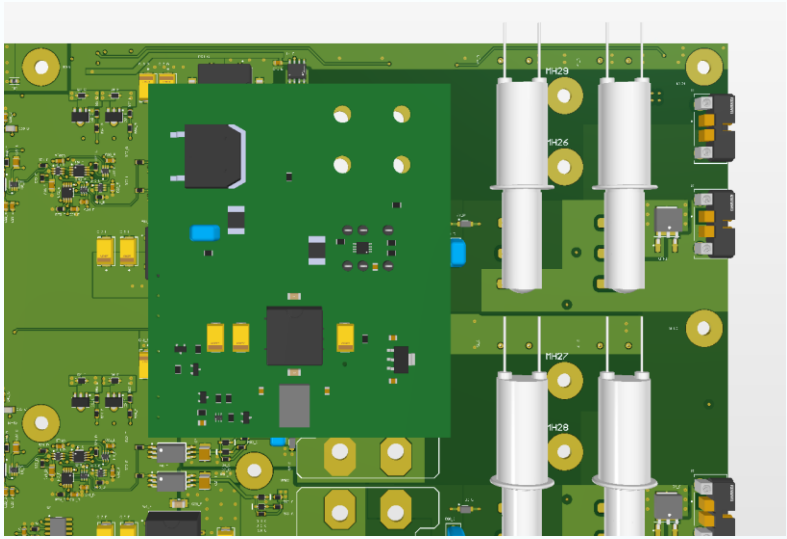
Adapater PCB FIT 3D





- Fits over a single channel
- Uses 0.5 to 0.75 inch standoffs
- A handful of solder flywires to the IPB PCB