

Convergent Aeronautics Solutions Remote Current Differential Sensing

Paul Nowak

Brent Gardner

NASA GRC



Outline

- CAS Background
- Problem
- Solution
- AMPS Background
- Solution Description
- Results
- Conclusion



CAS Background

- Convergent Aeronautics Solutions (CAS) Project
 - Conducts short-duration research activities
 - Establishes early-stage concepts and technology feasibility
 - Looks to solve large-scale aeronautics problems with advancements driven by the non-aeronautics world



CAS Background

- “More-electric” aircraft can enable a multitude of options, including:

SHORTER RUNWAYS

FASTER FLIGHTS

BETTER FUEL EFFICIENCY

ADVANCED AIRFRAMES

LESS NOISE

MORE REDUNDANCY

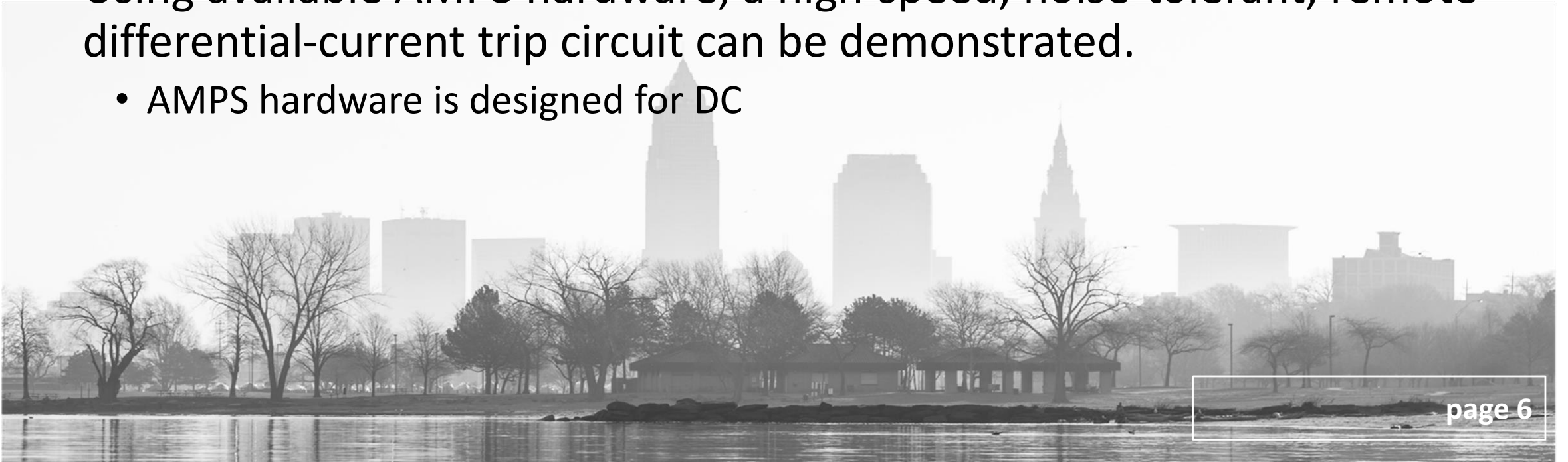


Problem

- More-electric aircraft require substantial and innovative power management, distribution, and fault protection schemes
- A method to discover and react to differences between currents provided by a source (generator) and delivered to the load (motor) is needed:
 - Sensors may have a significant physical distance separation (“remote”)
 - Fast enough for next-zero-crossing switching
 - Noise tolerant

Solution

- The NASA AMPS project recently developed a modular, digitally-controlled circuit breaker.
- Using available AMPS hardware, a high-speed, noise-tolerant, remote differential-current trip circuit can be demonstrated.
 - AMPS hardware is designed for DC



AMPS Background

Advanced Exploration Systems (AES) Program

- AES Modular Power Systems (AMPS) Project

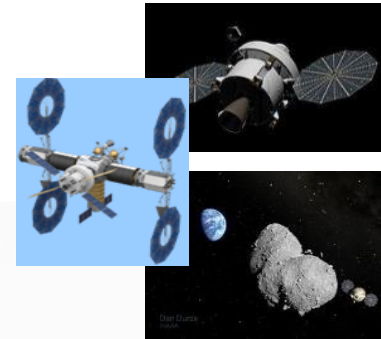
Directive

- Develop a vocabulary of modular power components along with associated standards to provide power system commonality across a variety of exploration vehicles.

Methodology

- Minimize the number of unique units needed to realize a power system
- Infuse new technology into future power systems and components, and prove their capabilities in exploration-based ground demonstrations.

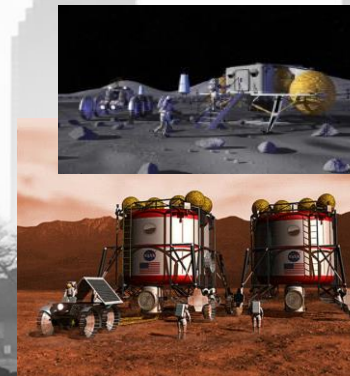
Applications



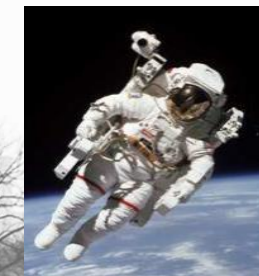
Exploration Missions



Mars / Lunar Rovers



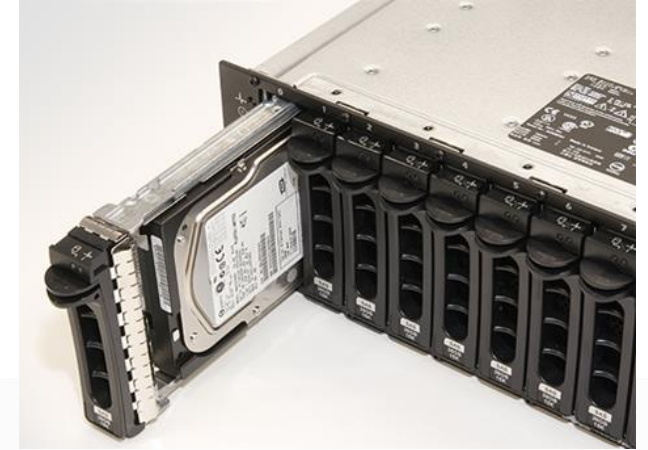
Planetary Outposts



EVA Suits

AMPS Background

- Rationale for Modular Components
 - Reusability
 - Interchangeability between multiple platforms/missions
 - Reduced space components needed
 - Flexibility
 - Scalable for a wide range of architecture sizes/power levels
 - Spectrum of architectures from centralized to distributed
 - Reliability
 - Failures cause reduced capability, not complete loss of use
 - Hot-swap replacements minimizes down-time and system effects



AMPS Background



Modular Electronic Units



Used
in this
demo

Load Switchgear

Housekeeping

Intelligent Controller

High Power (Bus) Switchgear

Bidirectional Converter

Shunt Regulator

Can be
arranged
to build:

Power System Functional Units



Secondary Power
Switchgear

Primary Power
Switchgear

Bus
Isolator/Converter

Battery Charge
Discharge
Converter

Solar Array
Regulator

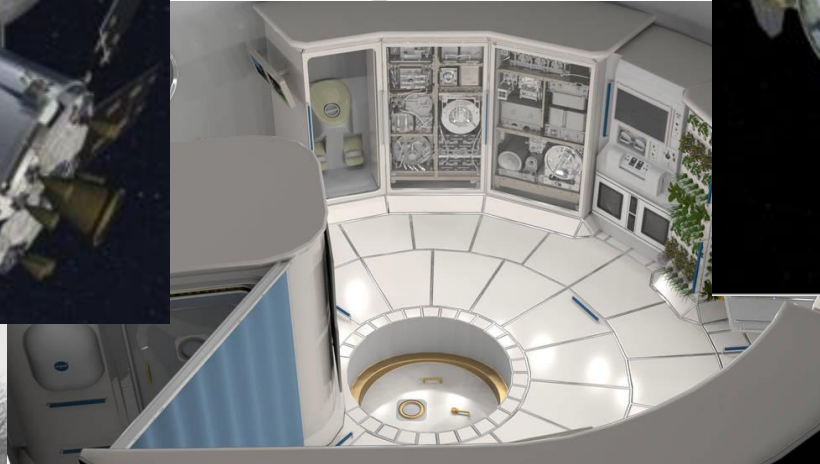
AMPS Background

- Targeted Applications

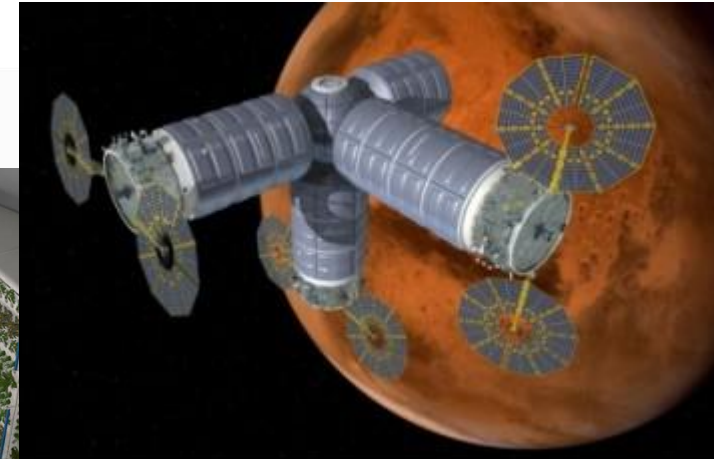
Beyond Low-Earth Orbit



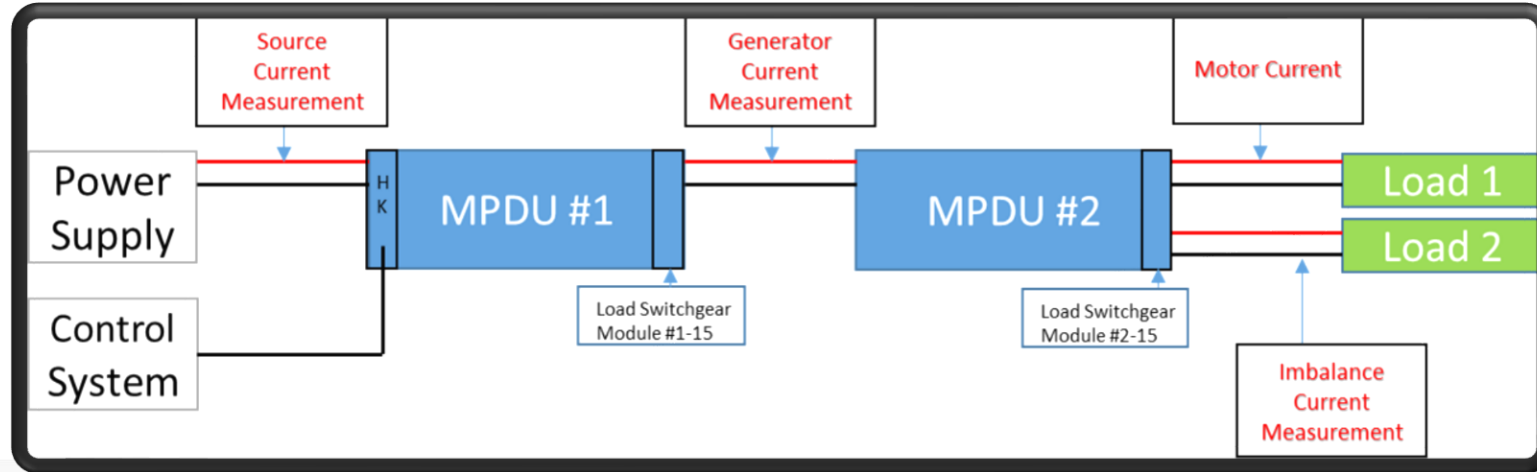
Cis-Lunar Habitat



Deep-Space Transit

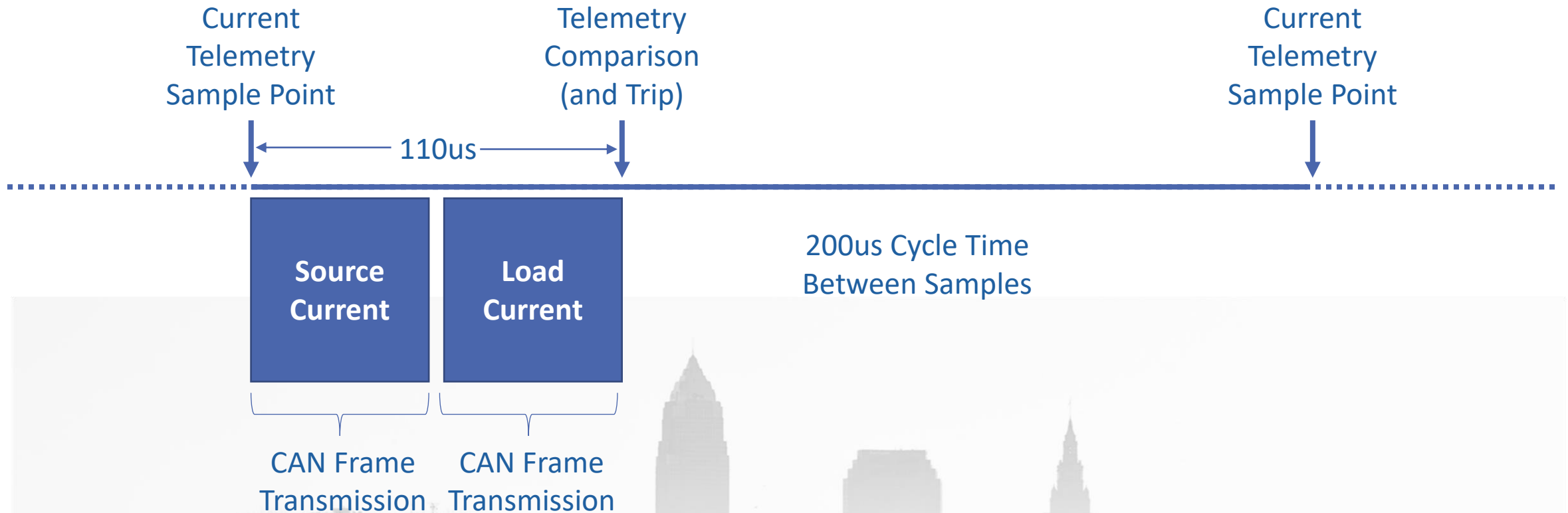


Solution Description

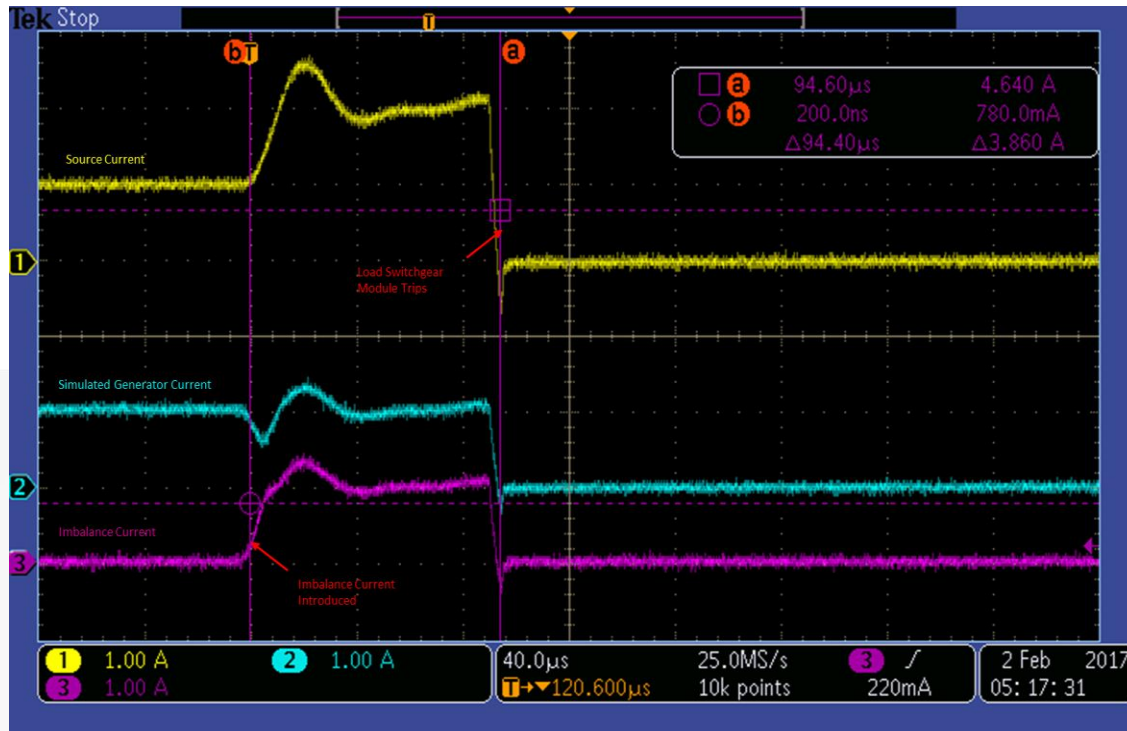


- The switchgear modules publish their sensed current to a CAN bus.
- The switchgear modules compare local and remote sensor values.
- If difference is beyond a tolerance threshold, circuit is broken (tripped)
- Current imbalance is simulated by a secondary load (Load 2)

Timing Diagram

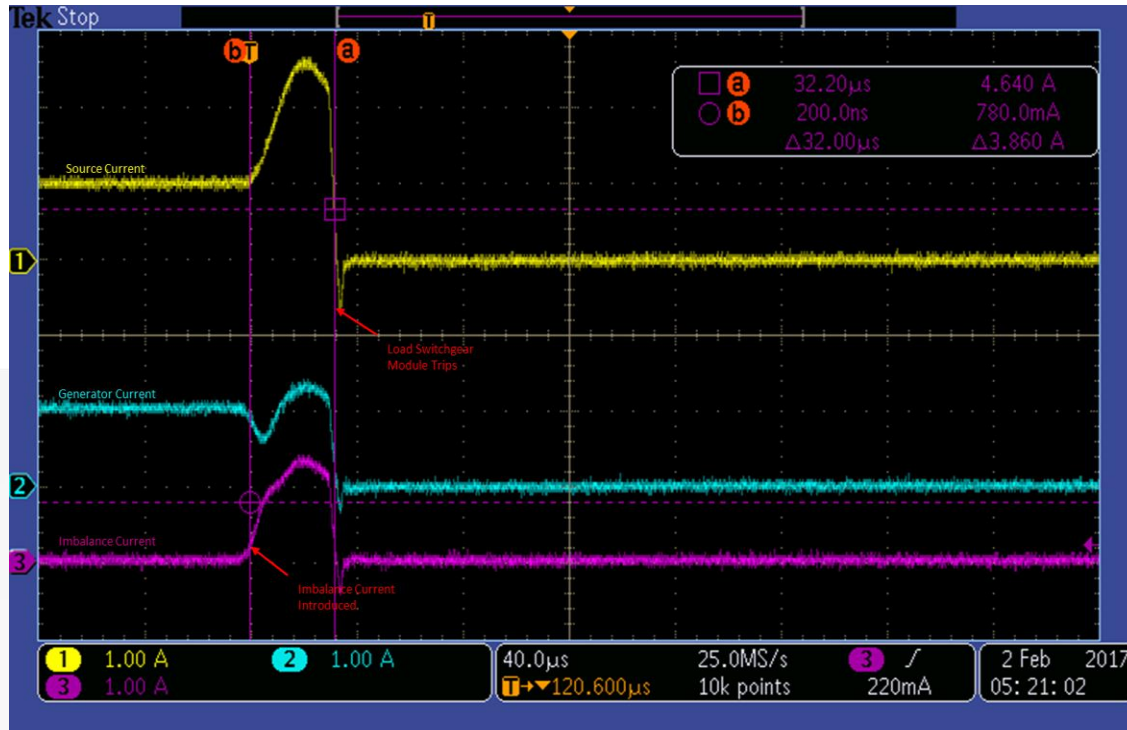


Results



- Circuit is broken within 100 microseconds of imbalance load being introduced
- CAN bus communications can effect the delay of the trip

Results



- Circuit is broken within 32 microseconds of imbalance load being introduced
- The CAN bus polls the switchgear cards every 300 microseconds, so that is the longest delay that could occur.

Conclusion

- This data shows that the current between a generator and motor could be monitored digitally and shut off if an imbalance occurs
- The CAN bus can be optimized to decrease the amount of delay
- Future work of this technology can be expanded to include an AC version of this test.

