Feasibility of Powerline Communications (PLC) on Future Spacecraft:

EMI/EMC Test Results on COTS PLC Technology

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Jet Propulsion Laboratory
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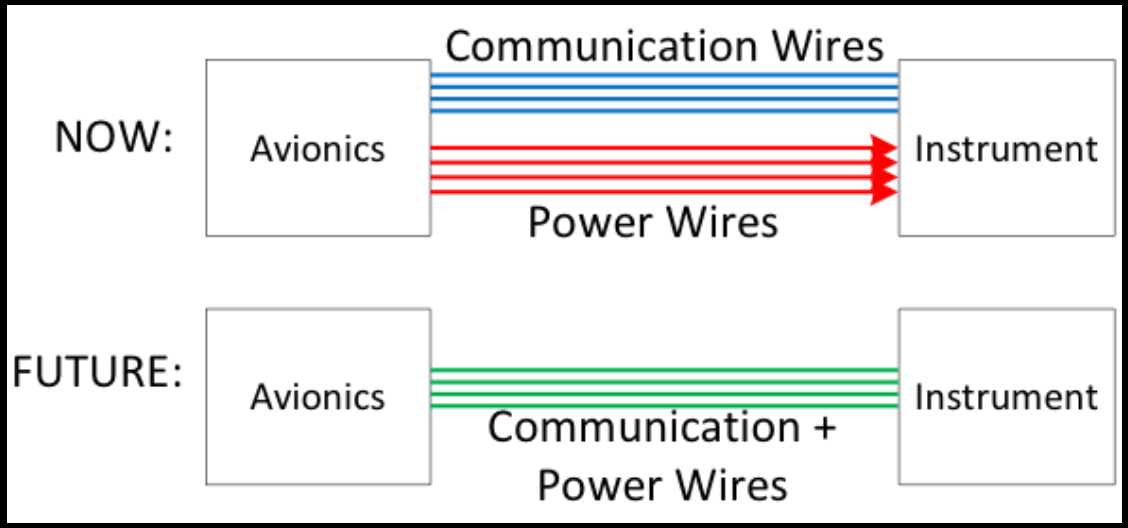
Agenda

- What is PLC?
- Motivation
- Our Implementation
- First Set of CE/CS Tests
- Second Set of CE Tests
- First Set of RE/RS Tests
- Lessons Learned & Future Work

What is Powerline Communication?

- Means of providing both power and data transmission on the same cable harness
- Robust, proven technology with multiple terrestrial applications



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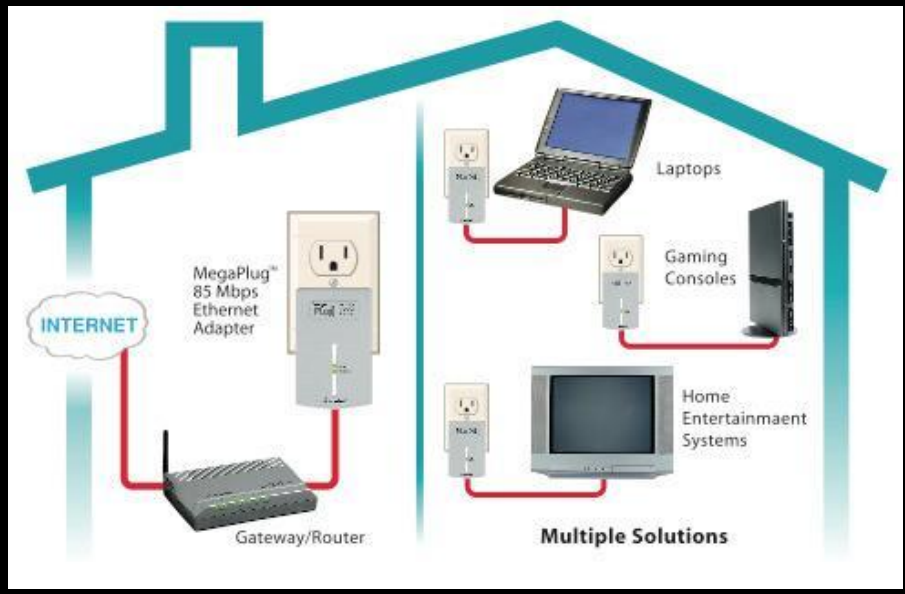

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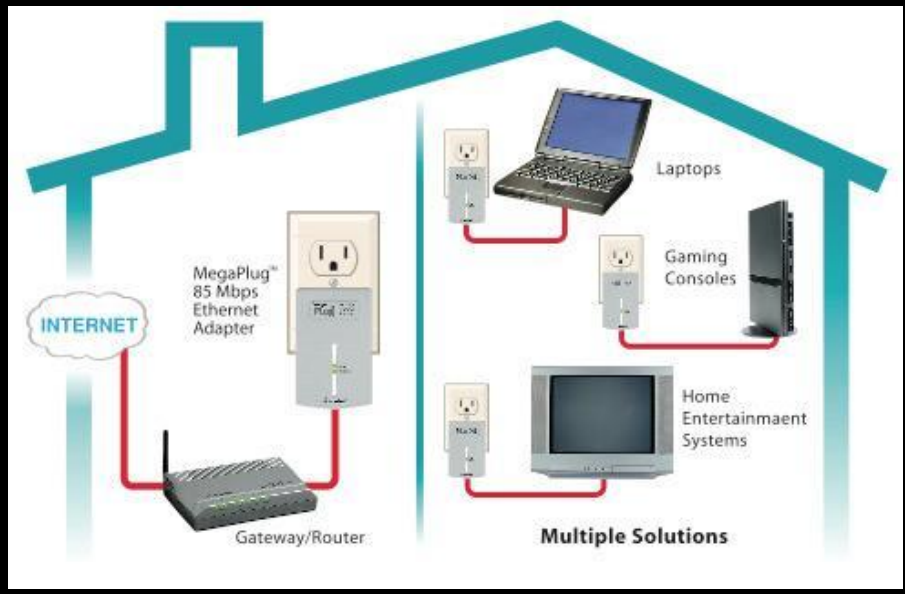
What if we applied PLC to spacecraft?!



Research Motivation

Less is More!

- Spacecraft mass drives mission cost
- PLC reduces mass and volume, increasing opportunities
  - Additional payloads or fuel
  - Saved costs
- Example: NuSTAR
  - PLC could have eliminated 1.36 kg off mast harness
- Goal: Prove feasibility of PLC on spacecraft and pave path to infusion

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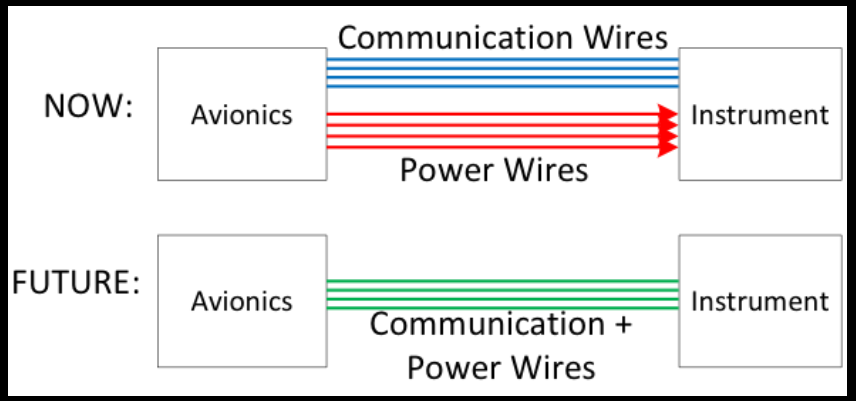

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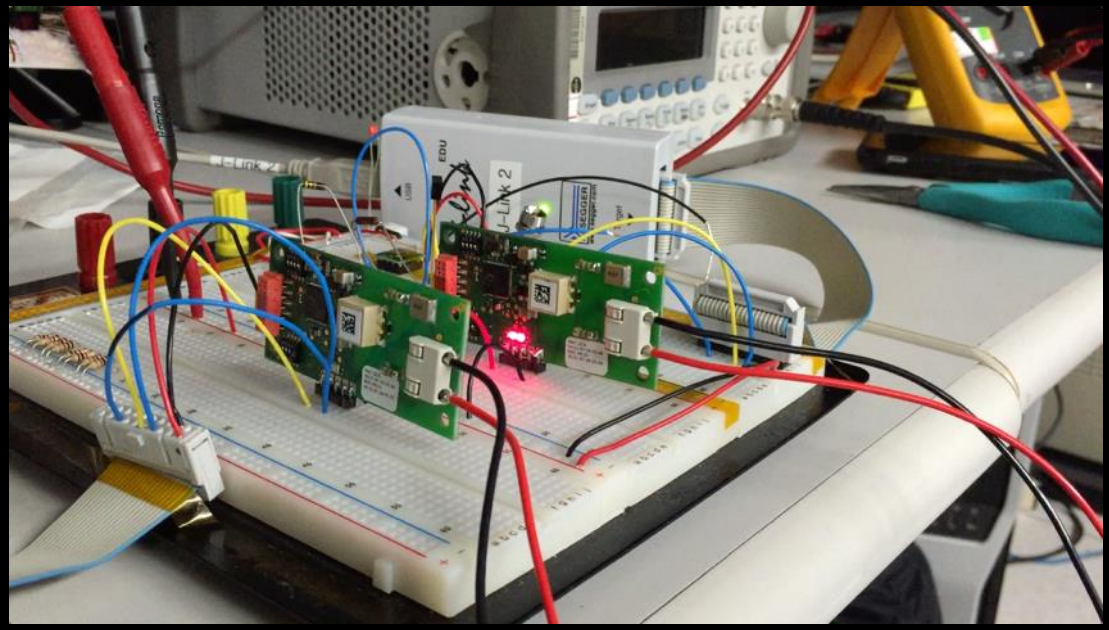
Our Implementation

COTS PLC as a Pathfinder

- I2SE Stamp 1 PLC modules with Qualcomm QCA 7000 processors
- Demonstration of PLC on JPL spacecraft-like 28 Vdc powerline



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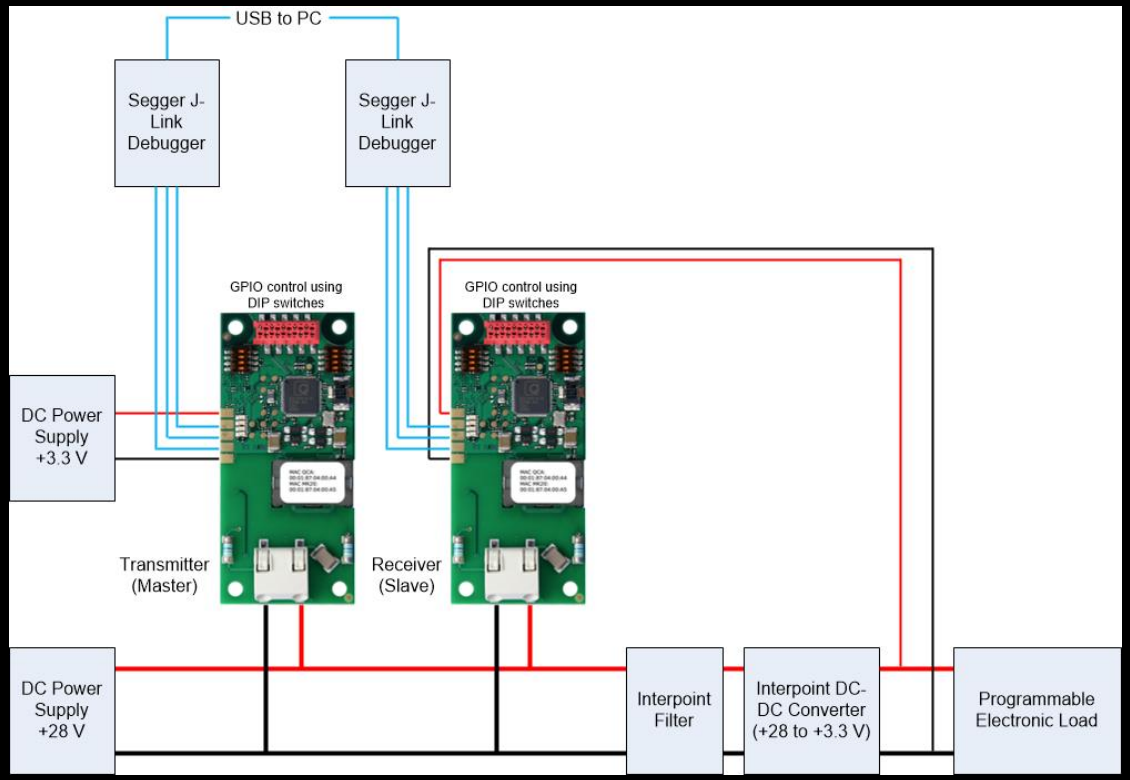

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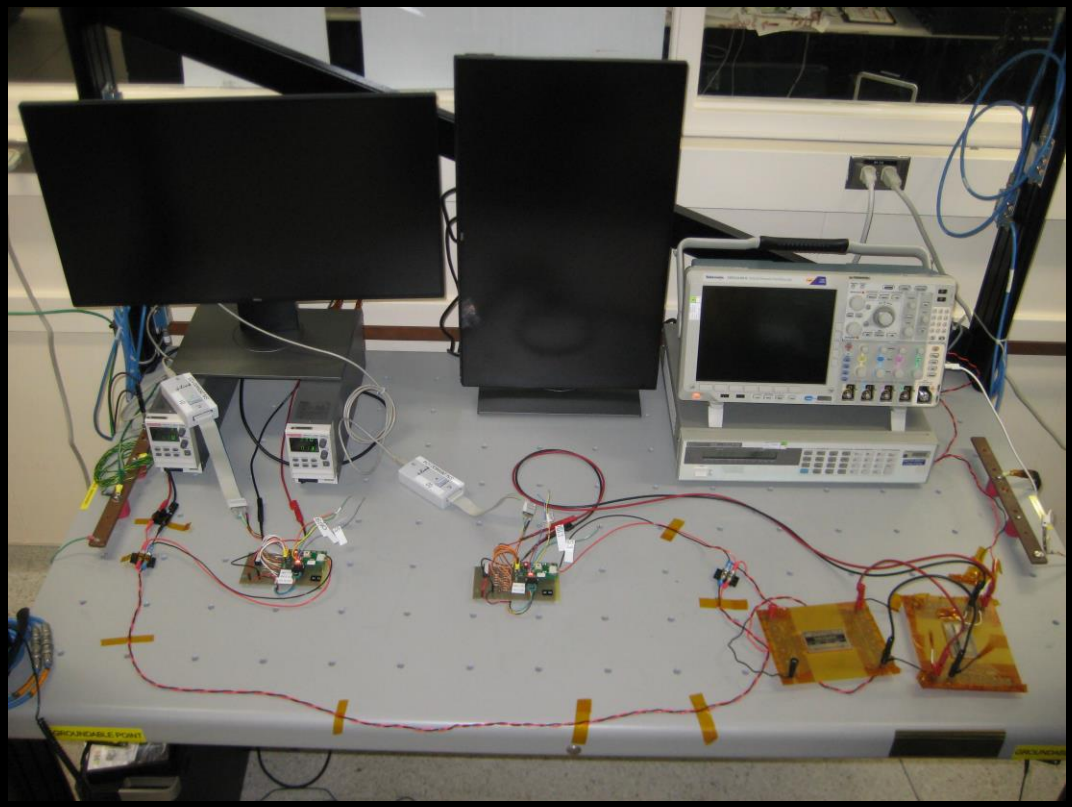
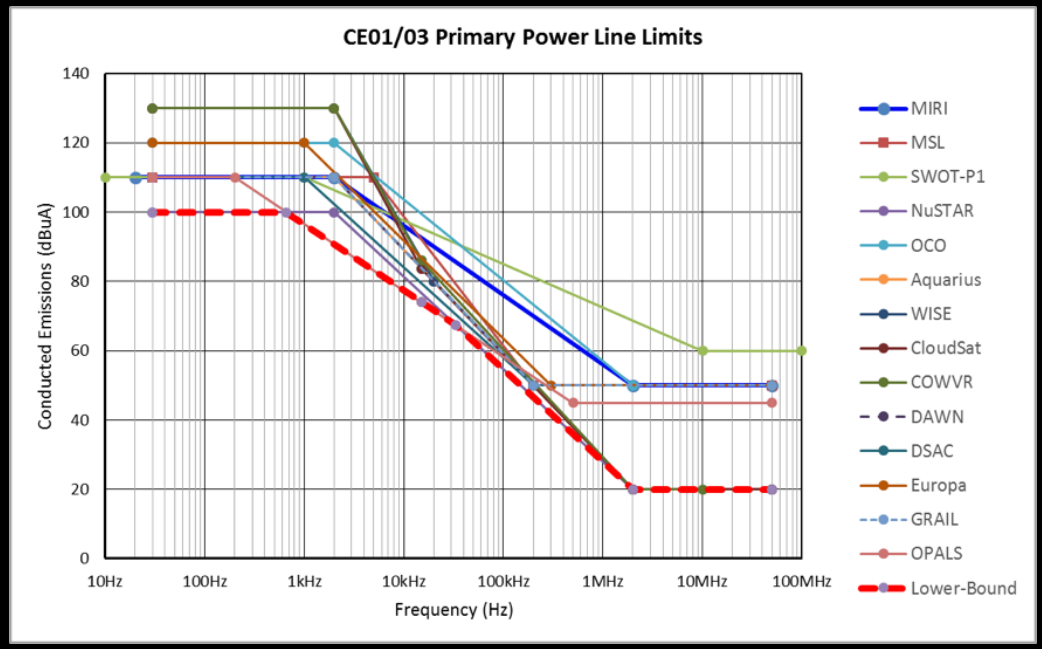


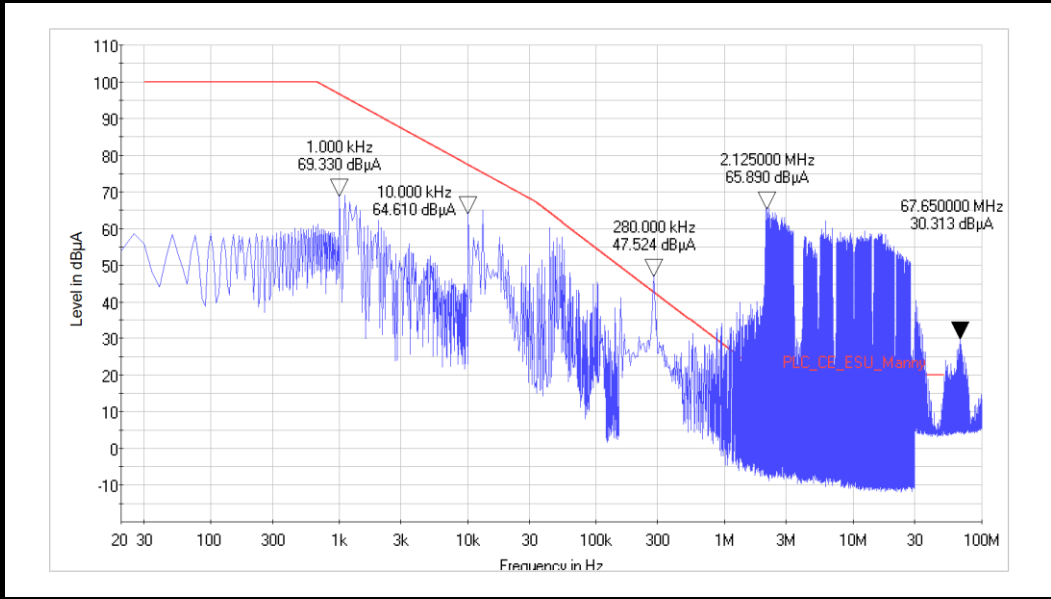
Initial CE/CS Testing

- CE requirements compiled from survey of multiple JPL missions
- Lower bound of survey used as CE01/03 limit line
- CS01/02 injection signal set to 1 Vrms, common JPL practice
- CS06 injection transient was ±56 Vpp calibrated to 5 Ω



Initial CE/CS Testing

- Substantial CE on both frequency and time domains
  - CE01/03: high current ripple at PLC modules' carrier frequencies (2 to 30 MHz)
  - 6.7 Vpp time domain amplitude
- Immune to CS01/02 injection and CS06 transients (zero BER)



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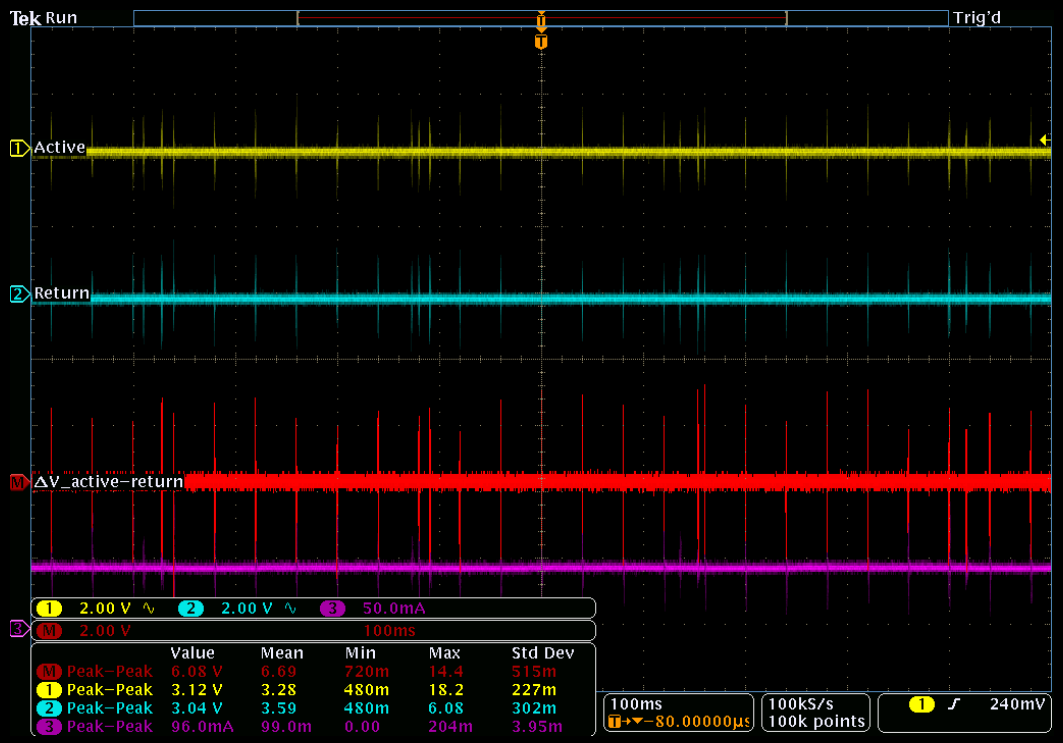
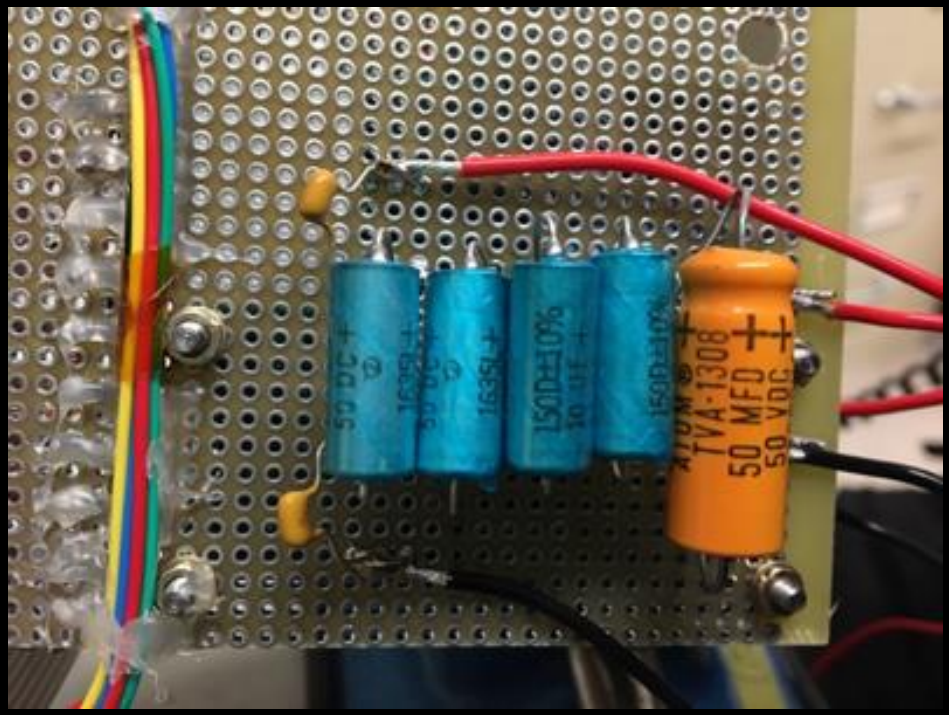


Signal Amplitude Mitigation & CE Retest

- Signal amplitude attenuation methods explored
- Current approach: 90 µF parallel capacitor with 1 µF inner/outer DC block
- Successful frequency and time domain CE reduction



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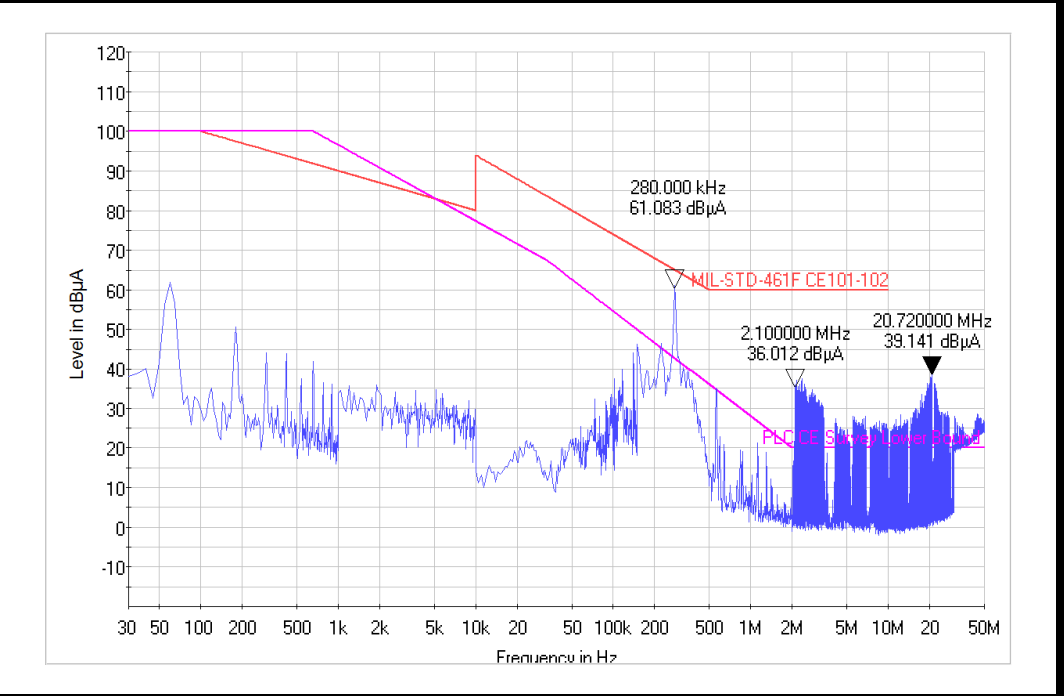

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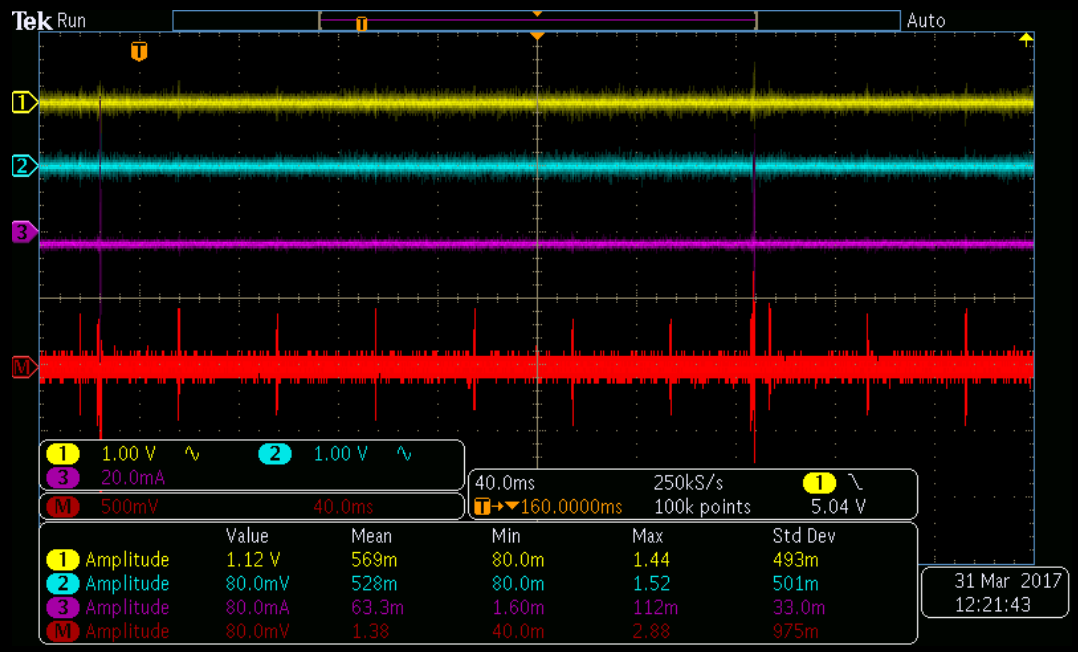
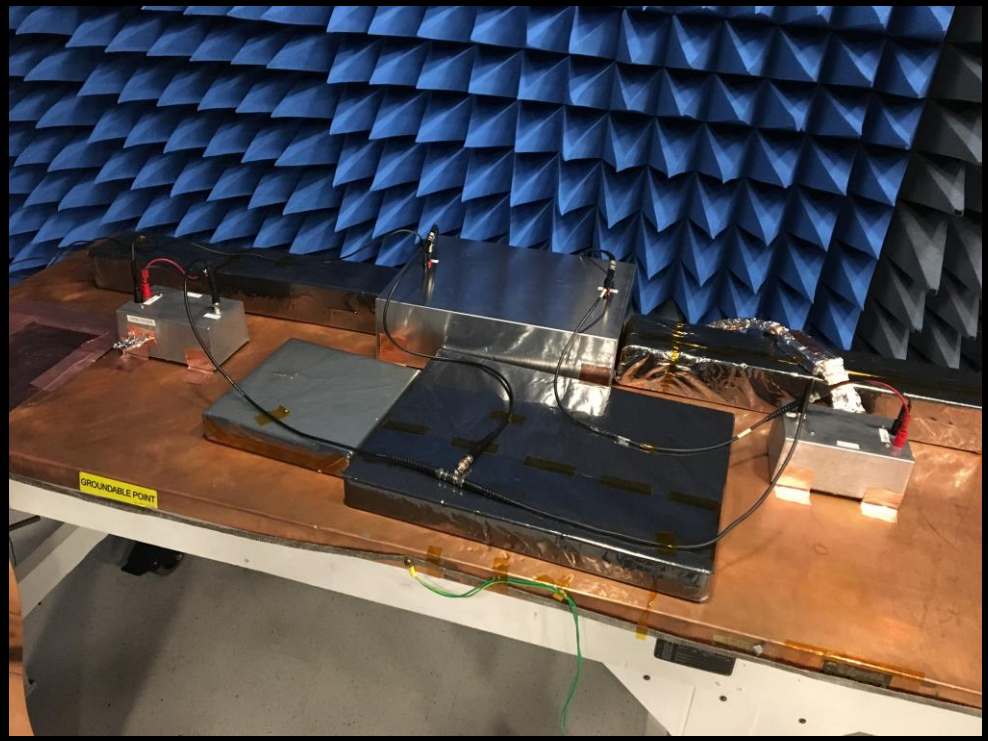


Initial Round of RE/RS Testing

- RE102 and RS103 tested in accordance to MIL-STD-461F
- Aluminum chassis built to house PLC modules and EMI filter/DC-DC converter
- BNC cables used as powerline harness due to schedule constraints



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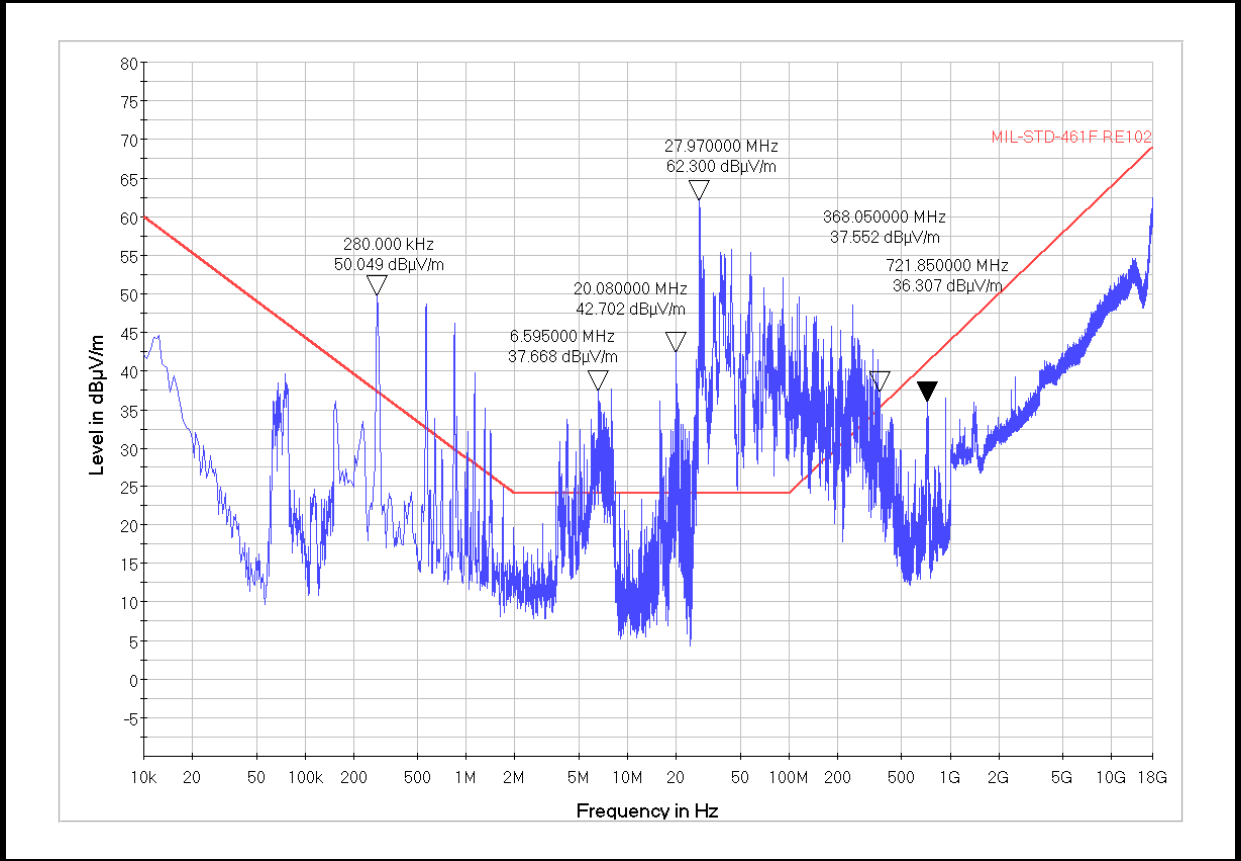
- RE102 showed tremendous exceedances throughout measurement spectrum
- Immune to RS103 20 V/m E-field exposure (zero BER)



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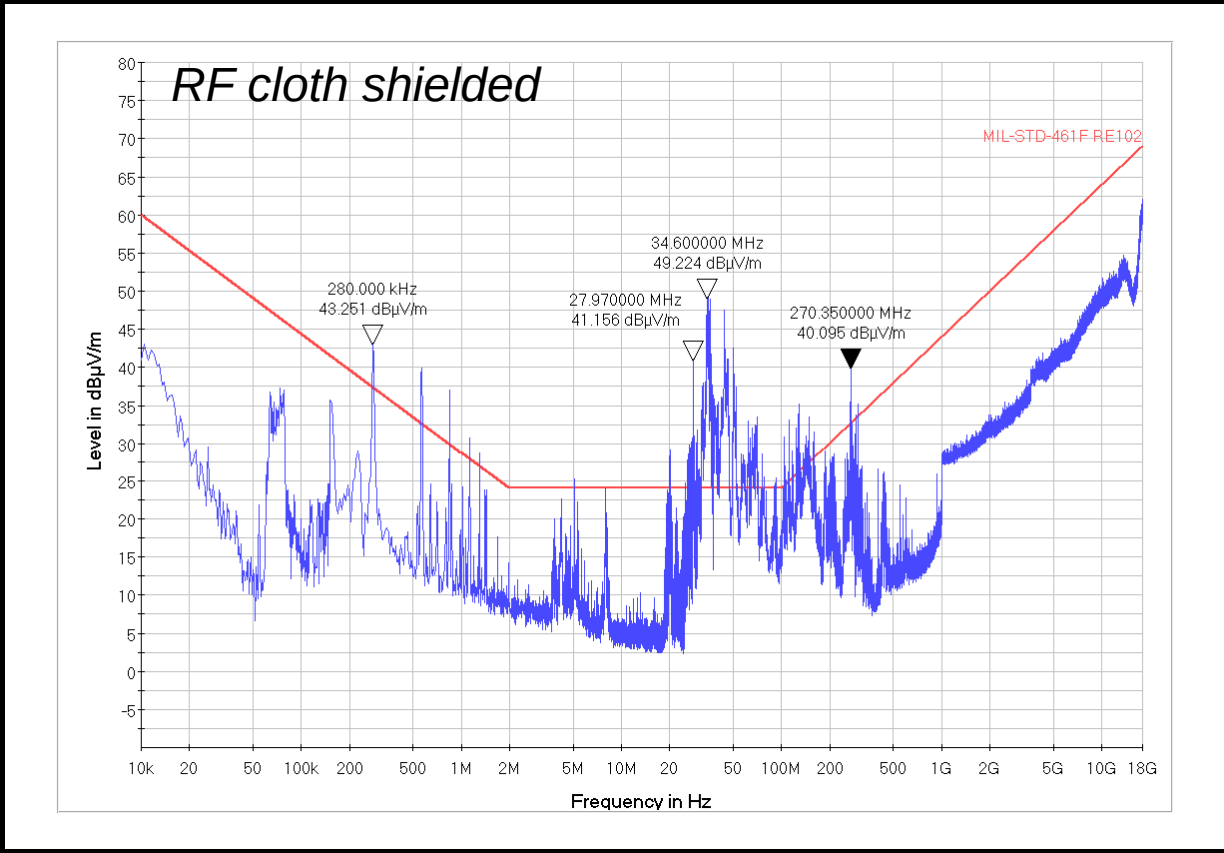

Conclusion

Lessons Learned

- Maintain a flight-like configuration/design throughout the R&D process
- Create room for margin while prototyping; test outside normal practices

Future Work

- Continue upgrading testbed
  - Shielded twist wire pairs
  - Flight-like connectors and chassis
- Margin testing
- Design PLC devices tailored for spacecraft DC buses

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