

Sciencetech User Group Meeting



Electromagnetic Compatibility (EMC) Basics

General Overview and Introduction to EMC Concepts

August 11, 2015

PRESENTED BY
Chad Kiger
AMS Corporation
EMC Engineering Manager



EMC can be Simplified if you treat it like a Program

- EMC does not begin and end with qualification testing – Think of planting a seed in a garden
- It takes an EMC program
 - Understand EMC
 - Know the Requirements
 - System Design
 - Construction and Wiring
 - Qualification Planning and Testing
 - System Installation
 - Future Maintenance and Troubleshooting

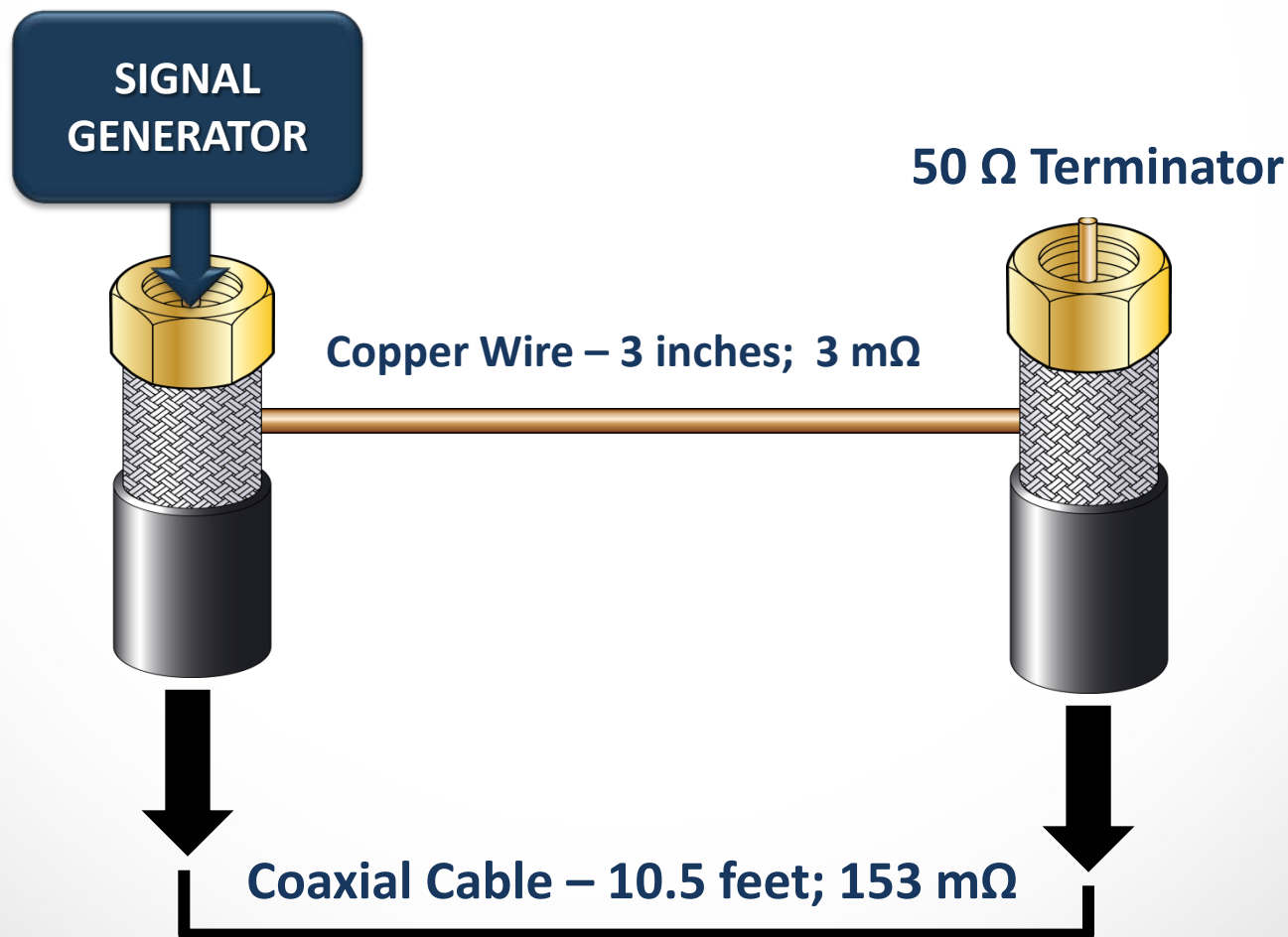


EMC is comprised of two parts

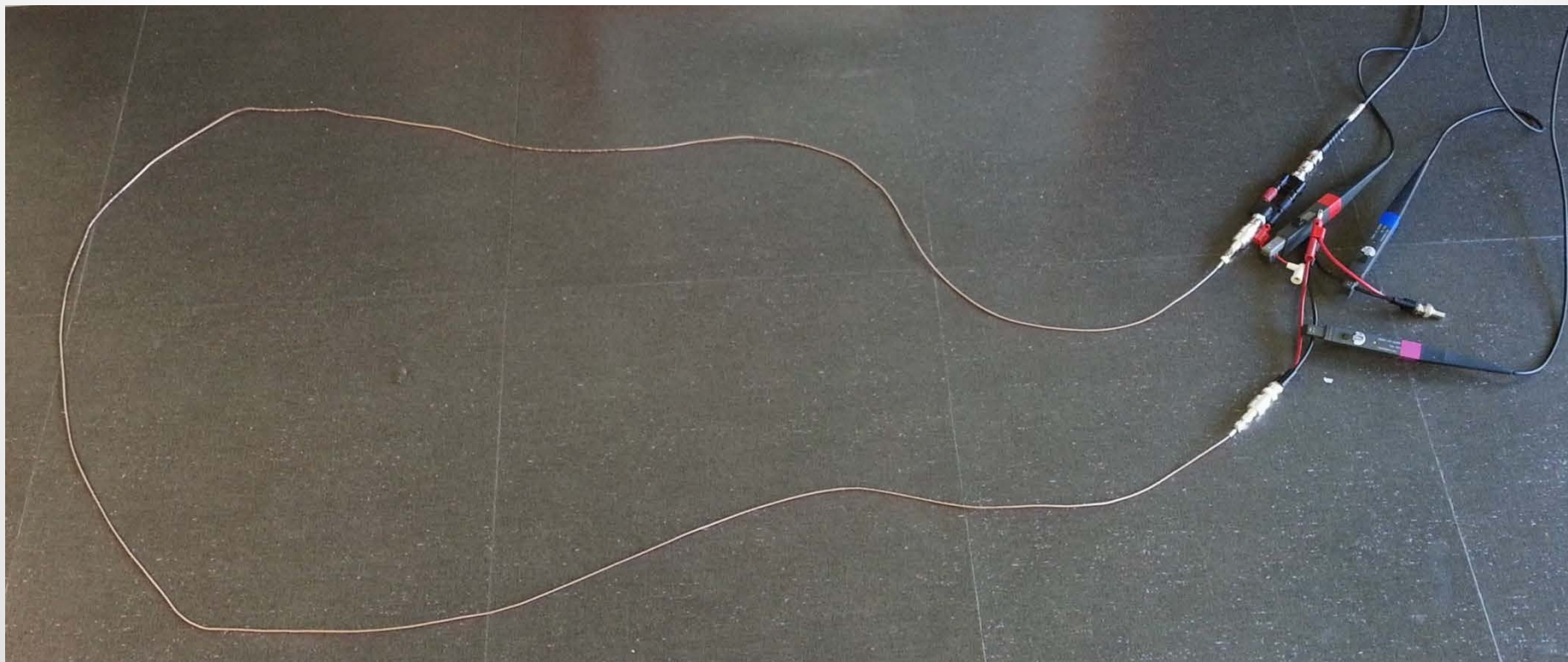
- Emissions – How much electromagnetic energy a device generates
- Immunity – How much electromagnetic energy a device can withstand



Myth 1: Noise Takes Path of Least Resistance



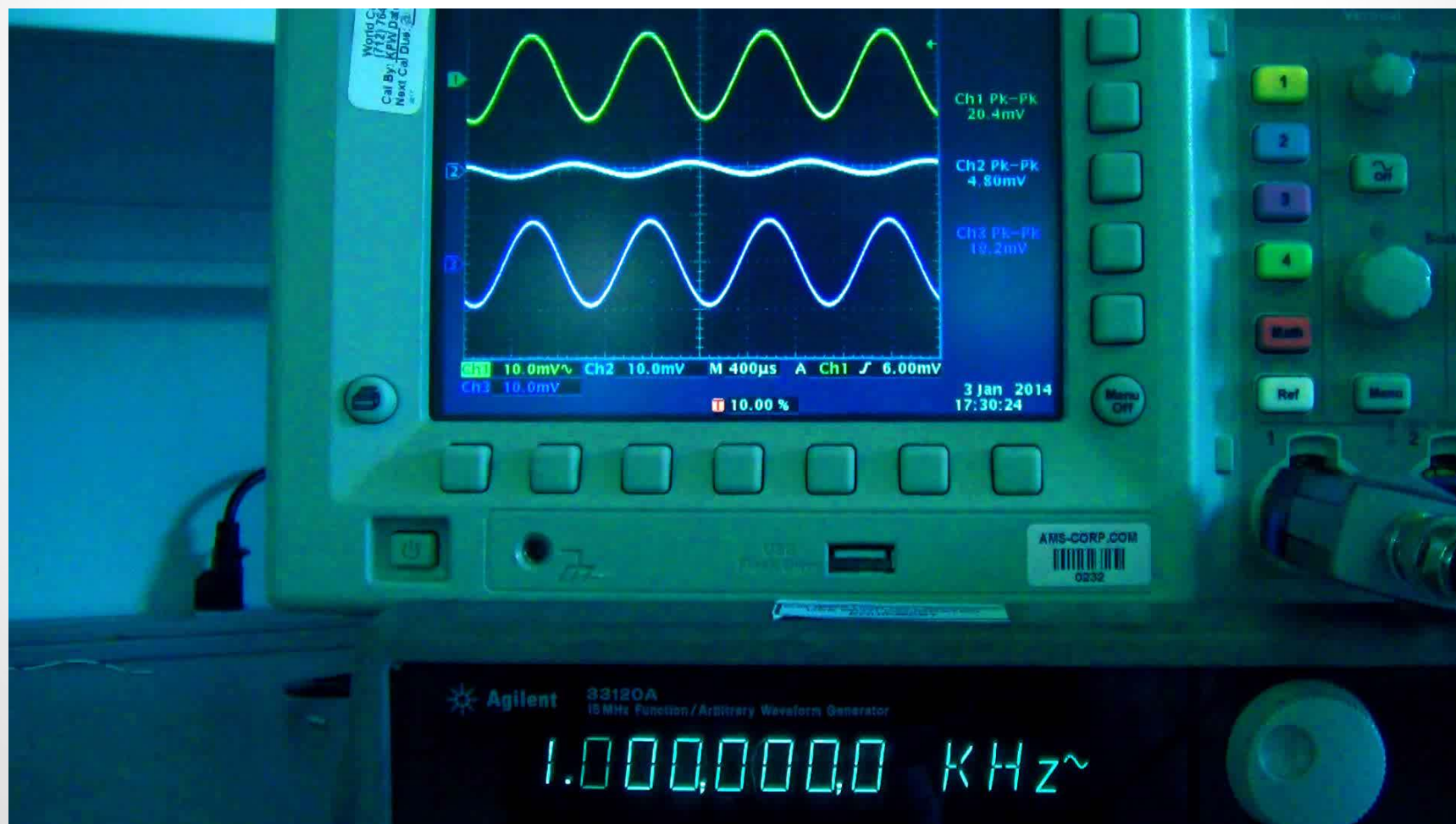
Where does Current Flow?



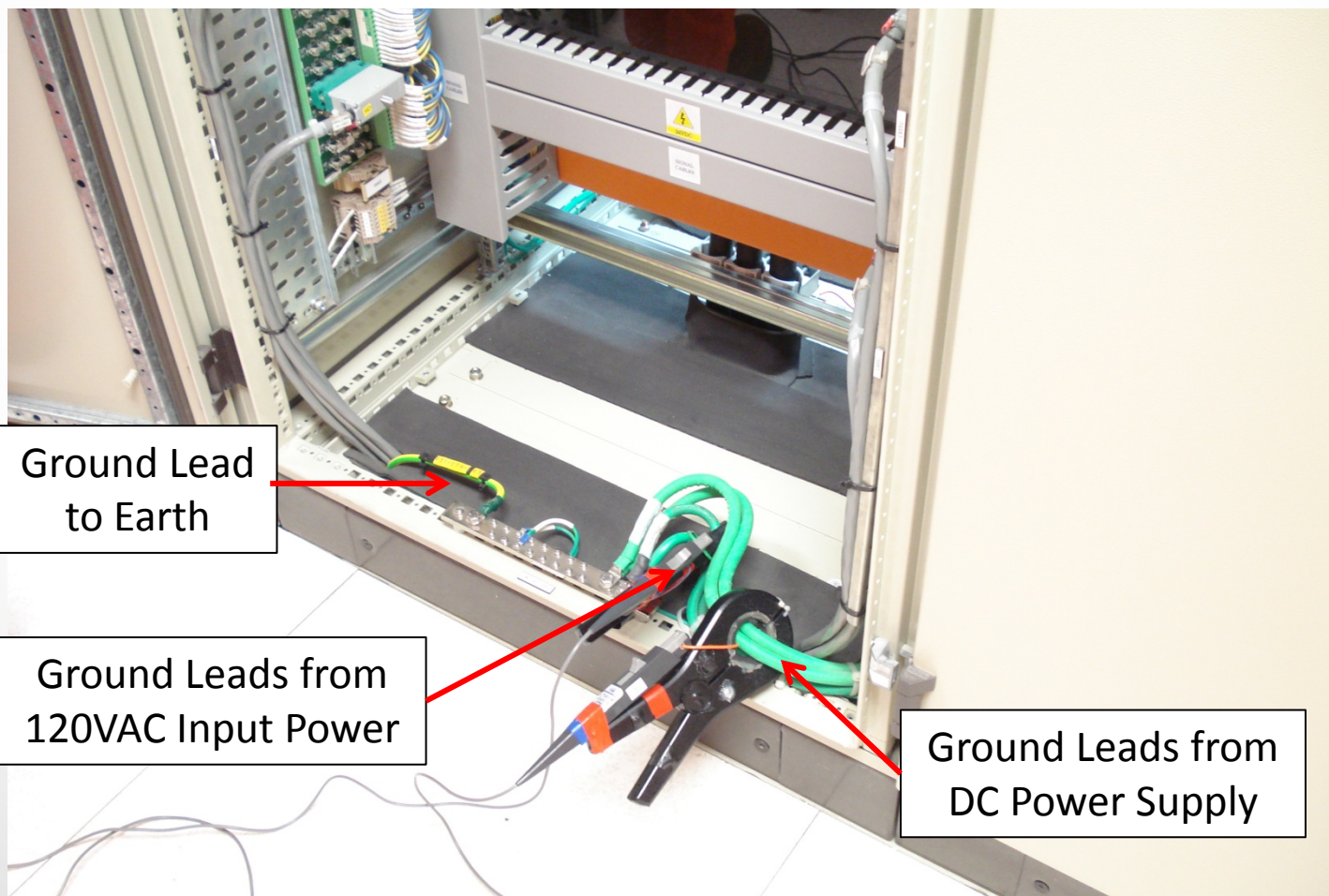
Cable Length – 10.5 feet; 153 m Ω

Short section – 3 inches; 3 m Ω

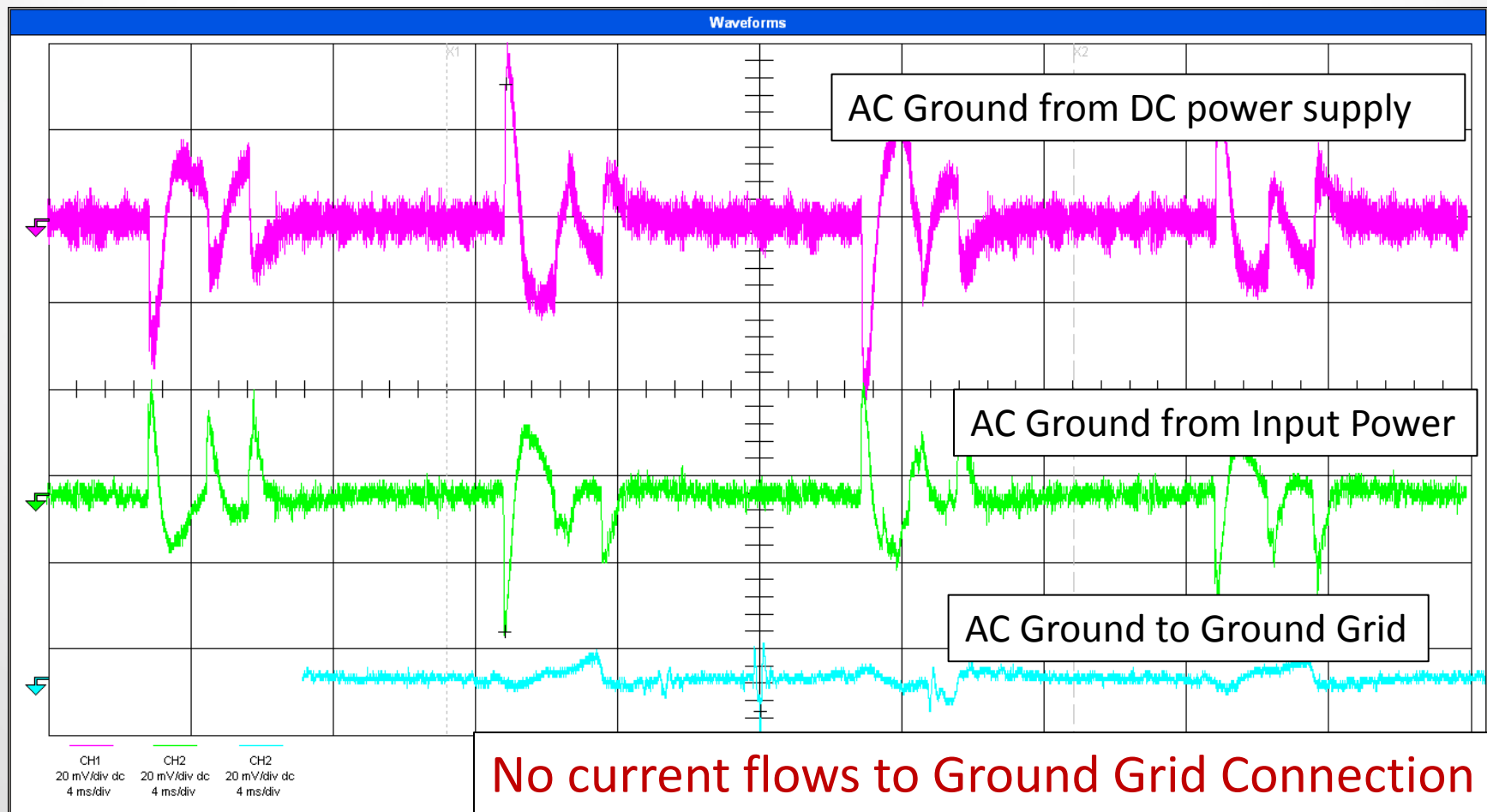
Video: Resistance vs. Impedance



Myth 2: Noise can be drained to earth/ground



Where does the Current Go?



Know the Requirements

- Nuclear Regulatory Commission (NRC)
 - Regulatory Guide 1.180 Revisions 0, 1 (2 under development)
- Electric Power Research Institute (EPRI)
 - Topical Report TR-102323 Revisions 0,1,2,3,4
- International Electrotechnical Committee (IEC)
 - IEC 62003 Revision 0, Revision 1 Under Development
- Military Standards
 - MIL-STD461 E,F
- International Standards
 - IEC 61000
 - CISPR
- Federal Communications Commission (FCC)
- Institute of Electrical and Electronic Engineers (IEEE)
- American National Standards Institute (ANSI)

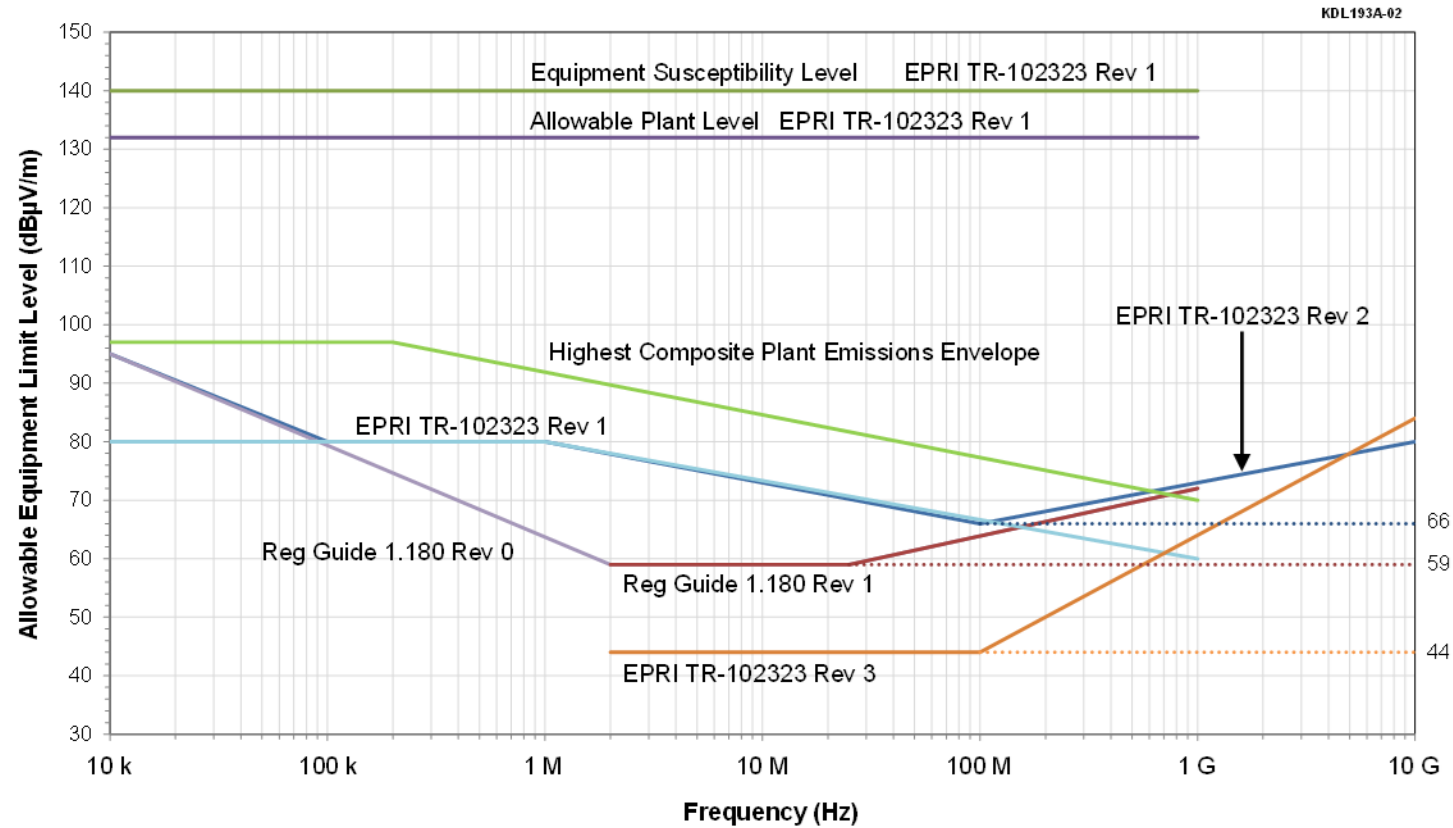


Applicable EMC Tests from EPRI

Susceptibility Tests		
	MIL-STD-461E	Commercial Standard
Low-Frequency Conducted	CS101	IEC EN 61000 Part 4 Section 13 And 16
High-Frequency Conducted	CS114	IEC EN 61000 Part 4 Section 6
Low-Frequency Radiated	RS101	IEC EN 61000 Part 4 Sections 8, 9 and 10
High-Frequency Radiated	RS103	IEC EN 61000 Part 4 Section 3
Surge	CS116	IEC EN 61000 Part 4 Section 5 and 12 or IEEE C62.41-1991
Electrically-Fast Transient	CS115	IEC EN 61000 Part 4 Section 4 or IEEE C62.41-1991
Electrostatic Discharge	N/A	IEC EN 61000 Part 4 Section 2
Emissions Tests		
	MIL-STD-461E	Commercial Standard
Low-Frequency Conducted	CE101	None
High-Frequency Conducted	CE102	IEC EN 61000-6-4 or FCC 47 CFR Part 15
Low-Frequency Radiated	RE101	None
High-Frequency Radiated	RE102	IEC EN 61000-6-4 or FCC 47 CFR Part 15

Differences Among Testing Guidance

High Frequency Radiated Emissions – MIL-STD-461E RE102



What tests are critical?



- **Emissions**

- CE102 High Frequency Conducted
- RE102 High Frequency Radiated

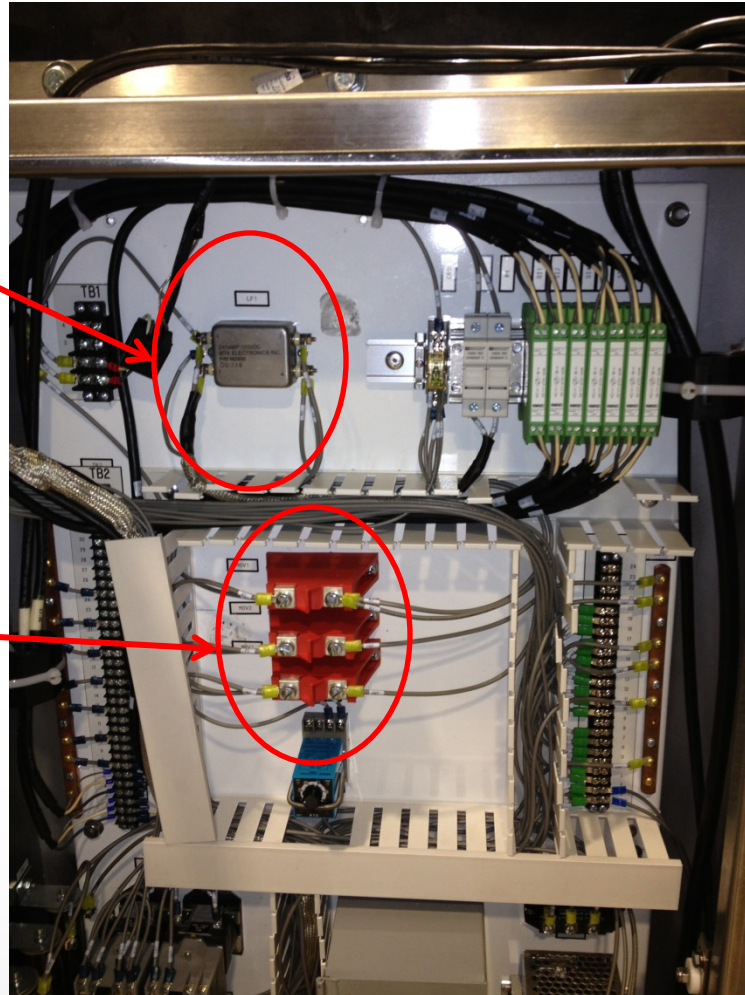
- **Susceptibility**

- Electrically Fast Transients (EFT)
- CS114 High Frequency Conducted
- RS103 High Frequency Radiated

Design for EMC

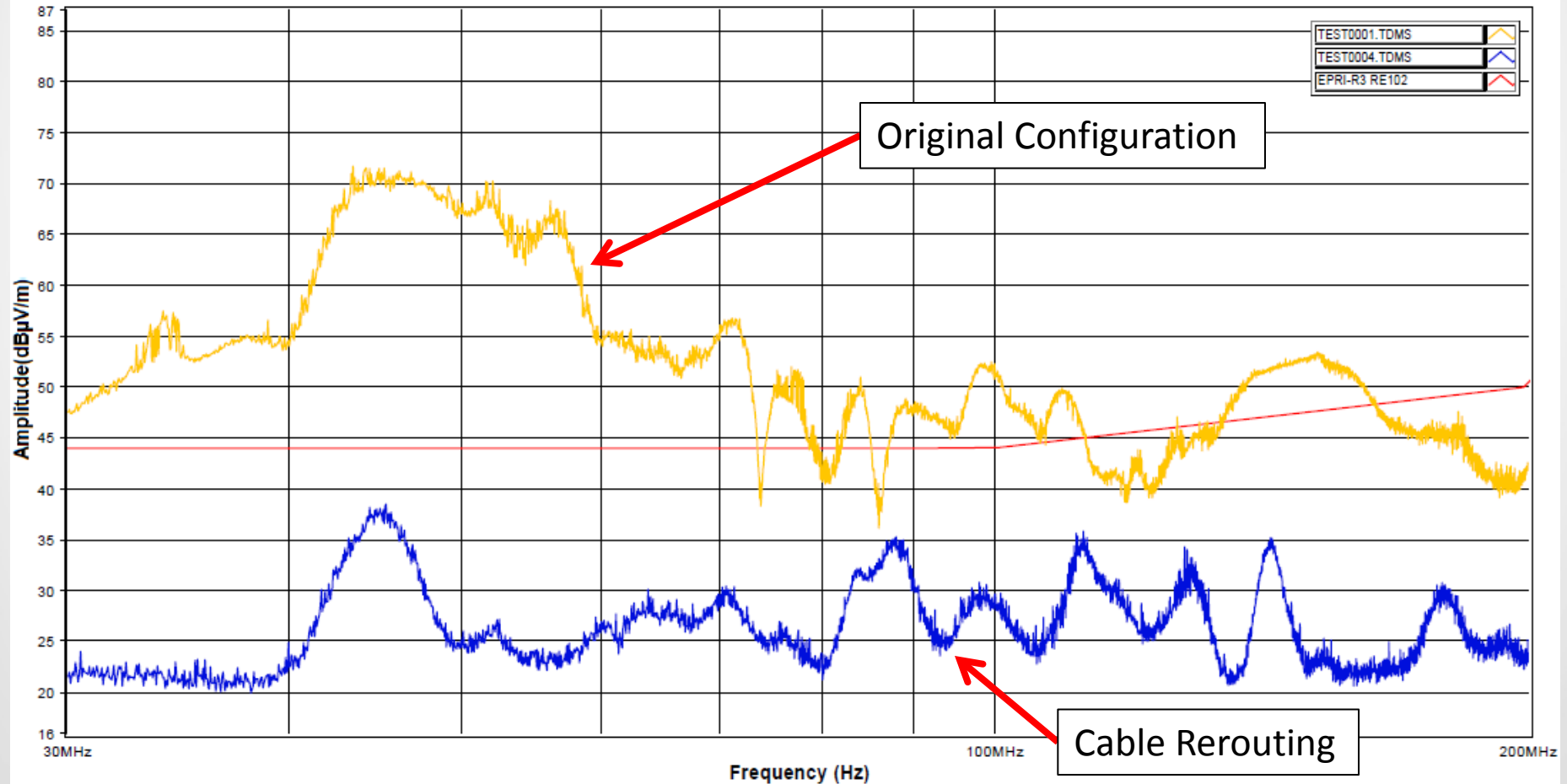
Power Line Filter

Surge Suppressors
(MOVs)



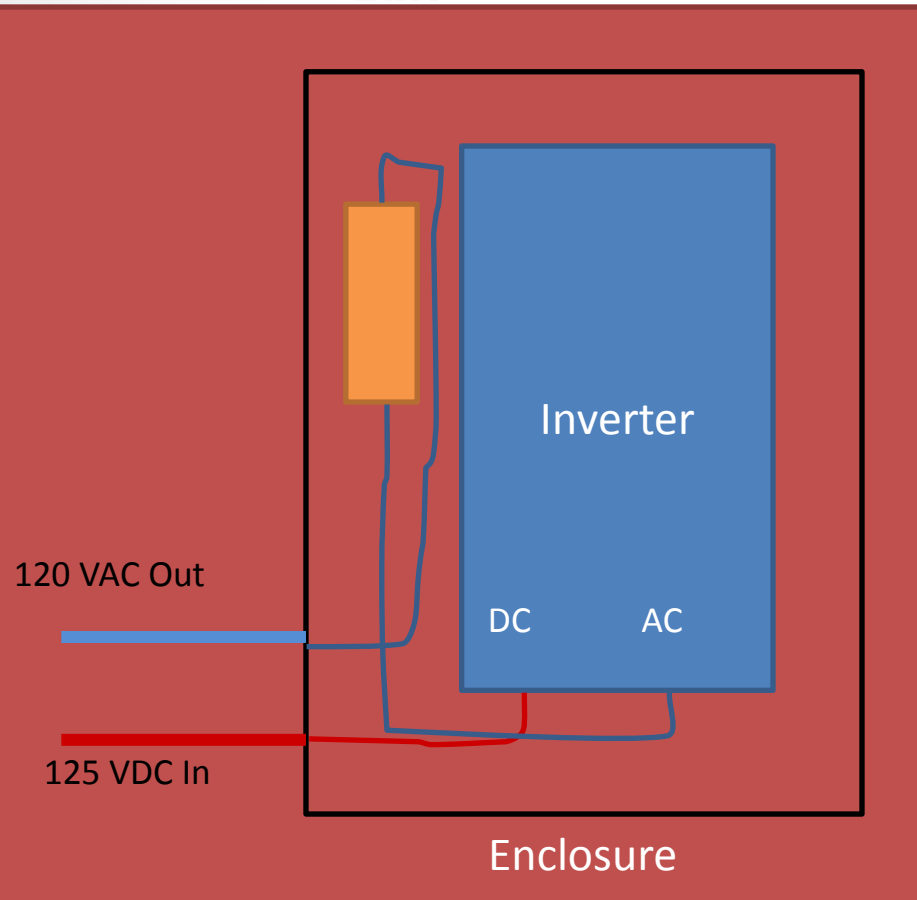
- MOVs are downstream of power line filter
- MOVs are in the middle of the cabinet
- Input and output of MOVs and filters are routed together
- MOVs and Filter have long leads to Ground
- There is no separation of power and signal cabling

Excessive Inverter Emissions

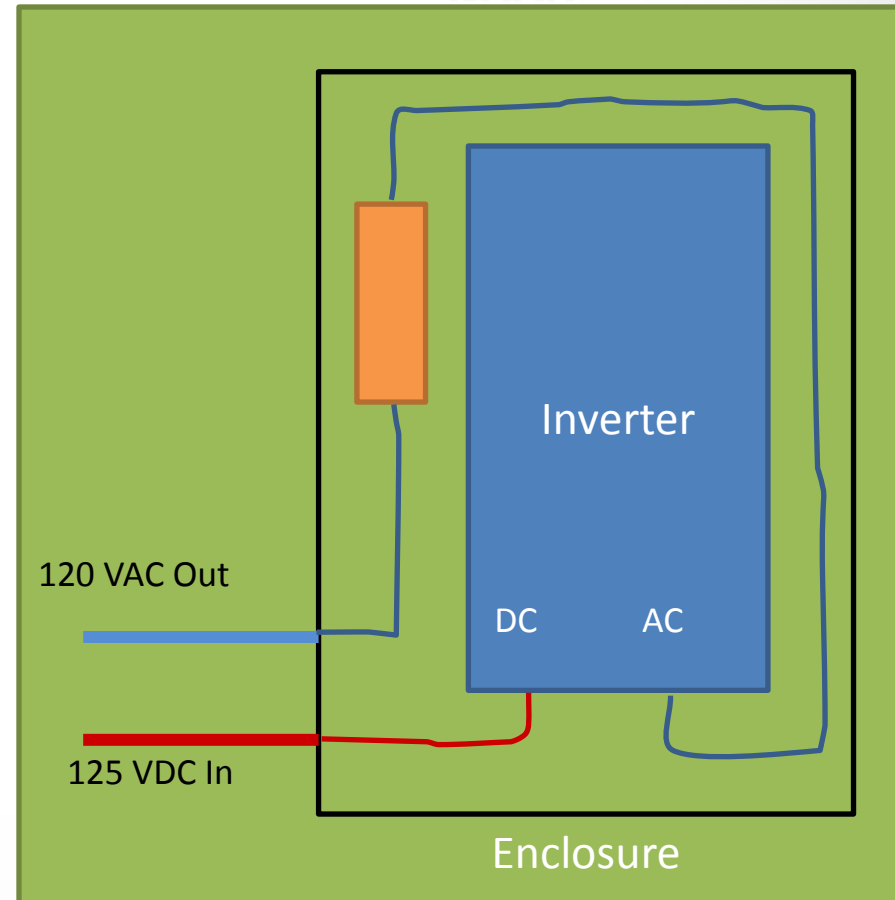


Impact of Cable Rerouting

BAD

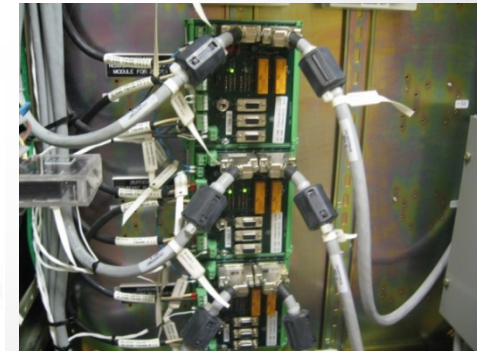


GOOD



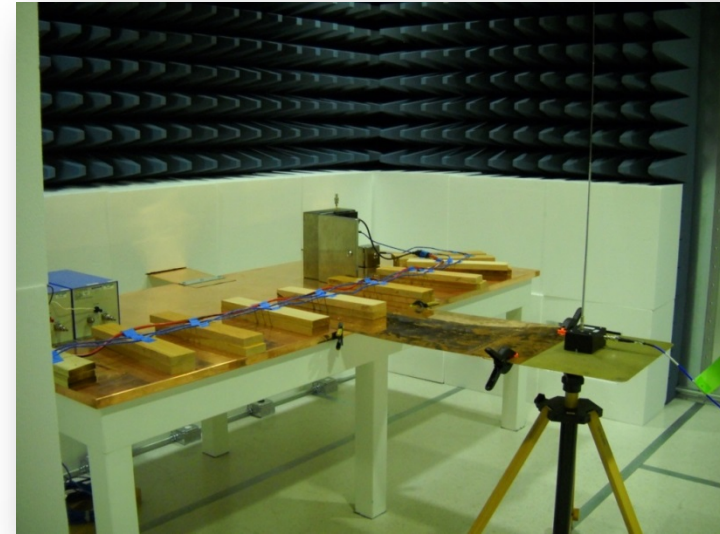
Follow EMC Best Practices

- **Power Line Filters**
 - At the cabinet boundary
- **Maintain Twisted**
 - With GND Wire for Power
- **Power and Signal Cable Separation**
 - Cross at 90°
 - Separate Cabinet Entry
- **Shield Bonding**
 - Short Leads
 - EMI Reference
- **Ground**
 - Follow Safety Codes
 - Follow EMI Practices
- **Do not tie-wrap cables**



Have a Plan for Qualification Testing

- **Cable Type**
 - Impacts emissions and immunity
 - Shielding can significantly change results
- **Cable Length**
 - Standards have specific requirements
 - Affects effective antenna length
- **Equipment Grounding**
 - Impacts noise return path
 - Dictates shielding performance
- **Mode(s) of Operation of the EUT**
 - Steady-state mode of operation
 - Response time of system



DO NOT FORGET ACCEPTANCE CRITERIA – Its not contained in the EMC guidance documents

- **How much can the Analog I/O deviate?**
 - 4-20mA signal – 0.02%, 2%, 20%
- **Can the Digital I/O change state?**
- **How much deviation or ripple on output of a power supply?**
- **Different acceptance criteria for different EMC tests?**
 - Surge/EFT vs. other tests



EMC Qualification Testing

- **Verify the testing is performed according to the test plan**
- **System configuration is critical**
- **Support equipment should not impact the test results**



Options for Addressing EMC failures

- **Live with it**
- **Modify the system**
- **Buy something else**
- **Pencil-whip it**
- **Perform EMI/RFI site survey**
 - Existing System/Location
 - During Installation
 - Post Installation



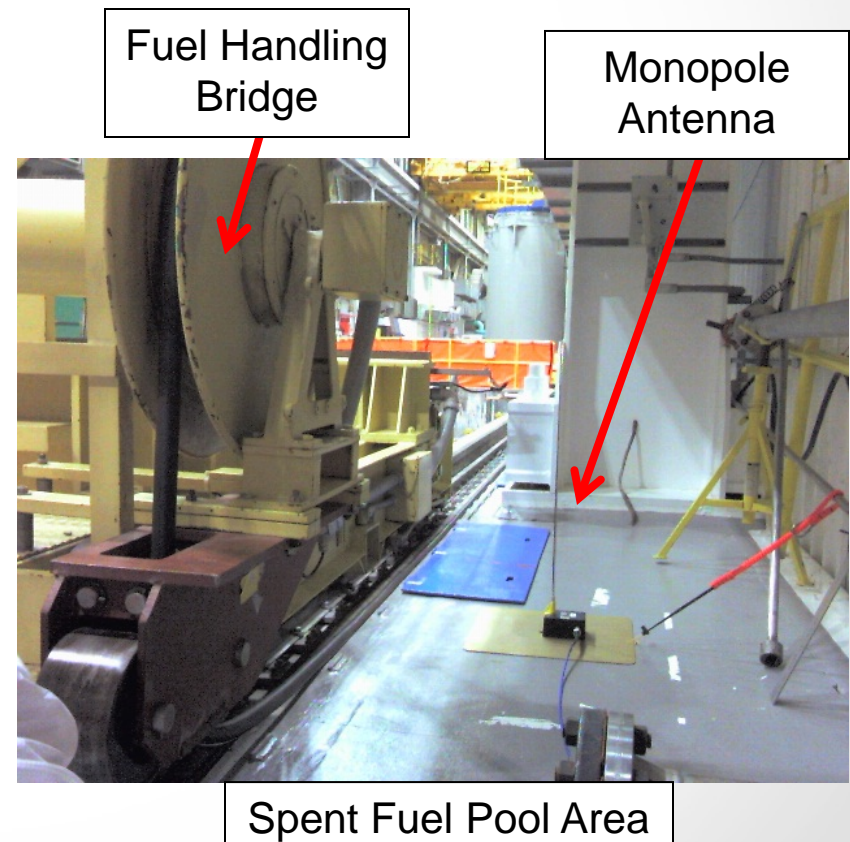
EMC Testing is usually put off until the very end

- EMC Testing performed during FAT testing
- System failed CE102 and RE102 emissions testing
- No time to implement and test EMC recommendations



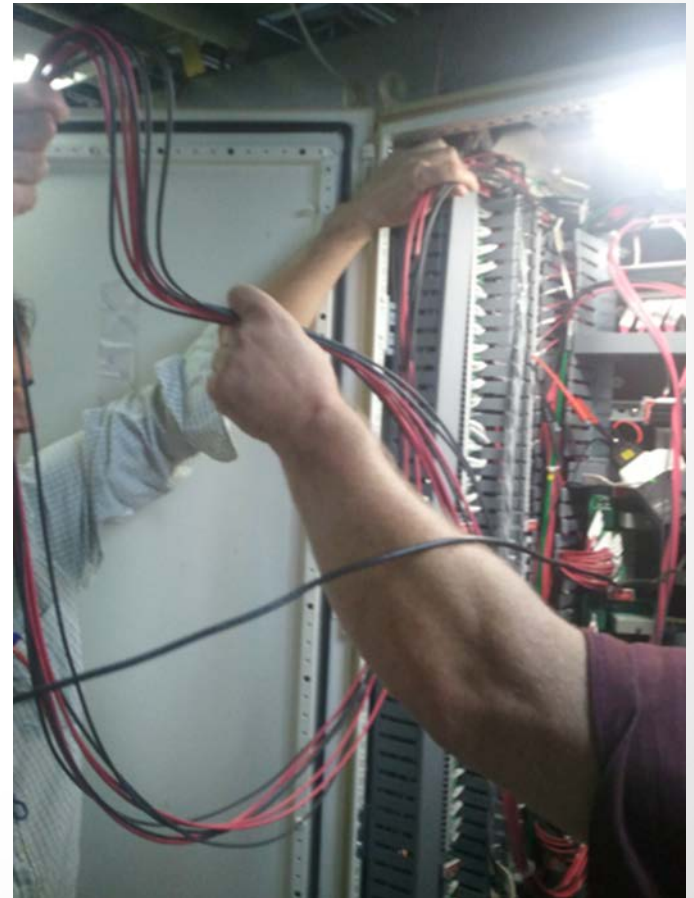
On-site testing showed impact of EMC recommendations and plant installation

- Testing was performed with the system de-energized, energized, and operating
 - Spent Fuel Pool
 - Reactor Building
- “As left” CE102 and RE102 test results would not significantly increase the level of emissions at the point of installation



Plant installation is critical for EMC

- Evaluate configuration differences
- Incorporate qualification testing modifications
- Apply EMC best practices
- Assess impact of existing plant wiring on system performance

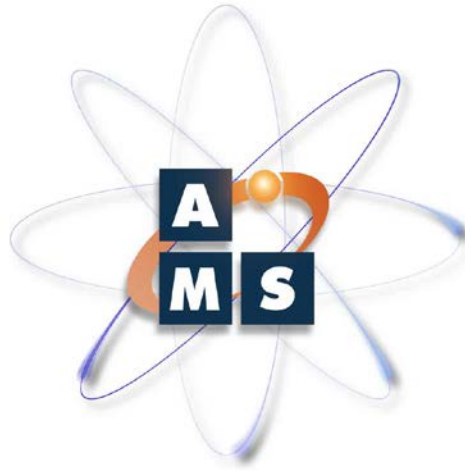


EMC Concerns can be Managed Without Significantly Impacting Schedules, Costs, and Sanity

- Attention to detail during the design phase
- Select the appropriate tests and levels for EMC Qualification testing
- Equipment failures can be managed through mitigation and/or justification
- Understand what to look for during installation and troubleshooting
- EMC is not Rocket Science



Thank You



INNOVATING NUCLEAR TECHNOLOGY

ANALYSIS AND MEASUREMENT SERVICES CORPORATION

ANALYSIS AND MEASUREMENT SERVICES CORPORATION

AMS Technology Center, 9119 Cross Park Drive

Knoxville, TN 37923 USA

Phone: 865-691-1756

email: info@ams-corp.com

website: www.ams-corp.com

Chad Kiger

EMC Engineering Manager

chad@ams-corp.com

865-691-1756 Ext 130



INNOVATING NUCLEAR TECHNOLOGY
ANALYSIS AND MEASUREMENT SERVICES CORPORATION