INNOVATING NUCLEAR TECHNOLOGY

ANALYSIS AND MEASUREMENT SERVICES CORPORATION

EMI/RFI Troubleshooting

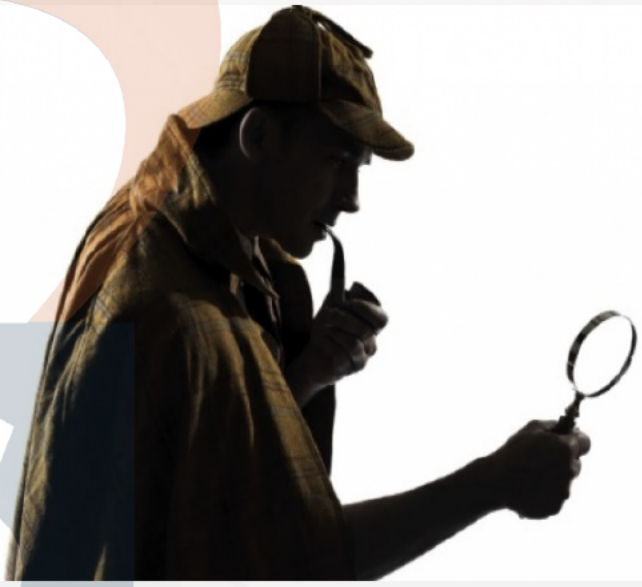
Instrumentation and Control Testing and Troubleshooting Course for TVA

EMI Problem Determination

- **You probably have an EMI problem if:**
  - The circuit checks out functionally before and after the incident
  - Independent circuits actuated simultaneously (a plus if in the same area)
  - Incident is over in milliseconds
  - Circuit has history of sensitivity to position of cables, grounds or people
  - Incident coincides with power off/on action
  - High level EMI can be observed

Systematic Approach to Solving EMI Problem

- Define the problem
- Gather information
- Focus on the weak link
- Develop an interference model (Source, Victim, Path)
- Prepare a test plan and use it to measure EMI levels
- Obtain accurate & reliable test data
- Evaluate test data
- Design and implement fixes



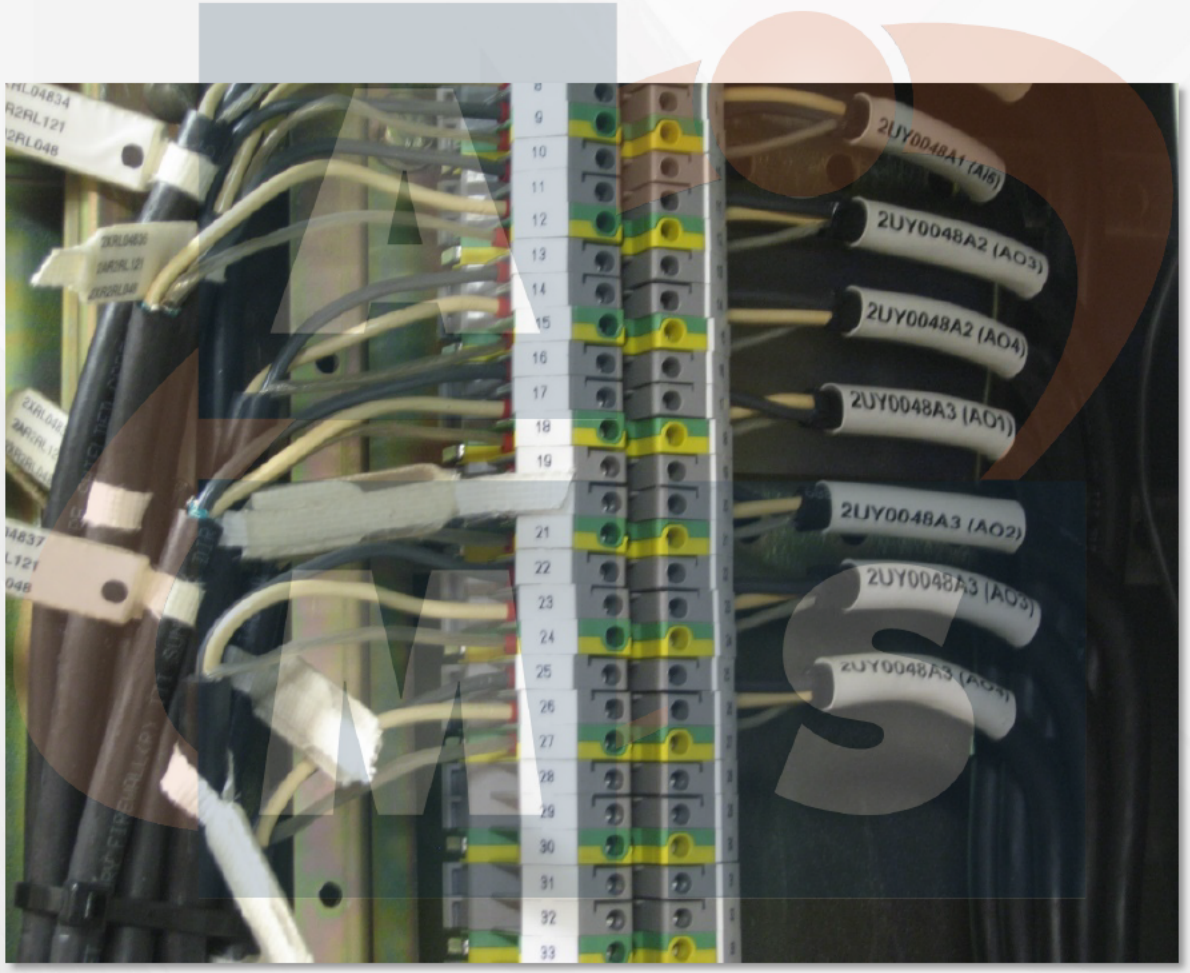
Develop EMI Model

- **For the victim system, determine relationship between possible aggressors and victim. Develop imaginary boundary around each potential victim and consider:**
  - Relationship between power leads and I/O leads
  - Location of nearby or internal inductive loads
  - Ungrounded or missing shields
  - Ground loops on low frequency circuits
  - Missing or wrong location grounds on high frequency circuits
  - Connections from sensitive points to possible antennas
  - Improper cabling or wiring
  - Improper selection or location of filters

Develop EMI Model

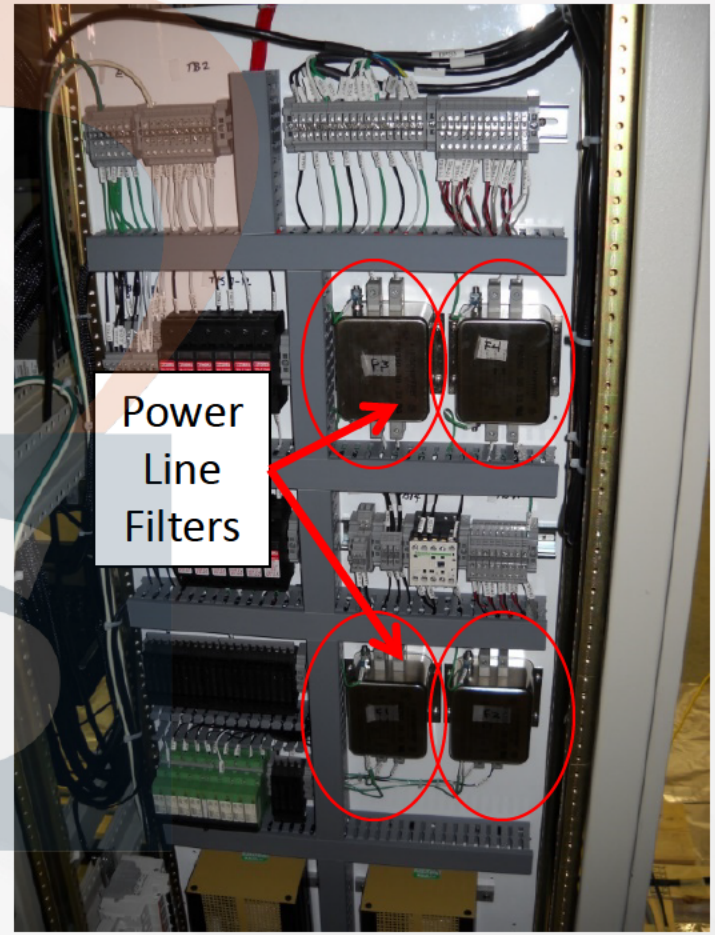
- Ground loops on low frequency circuits
- Missing or wrong location grounds on high frequency circuits
- Connections from sensitive points to possible antennas
- Improper cabling or wiring
- Improper selection or location of filters
- Relationship between interfering systems and victim(s)

Shield Grounded through DIN Rail



Example of Poor EMI Filtering

- EMI/RFI Filters Located in Middle of Panel
- Routes “dirty” power throughout cabinet
- Ground Wire is used to bond filter to cabinet creates a high impedance
- Intermixes filtered and un-filtered cables

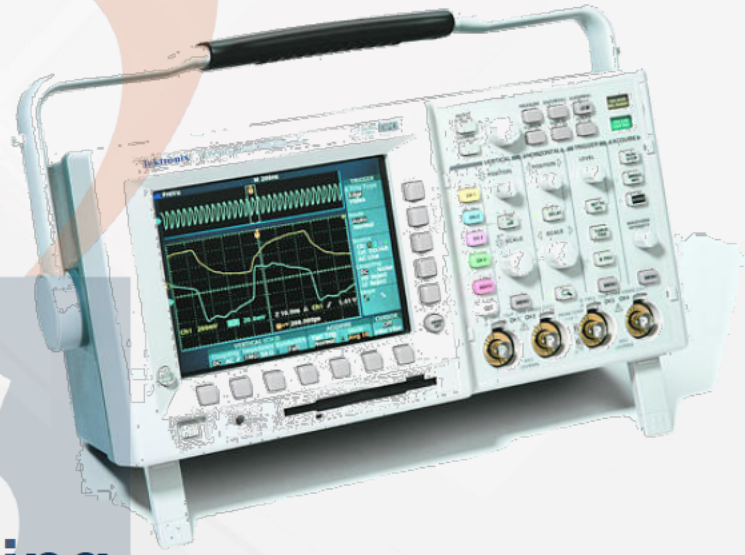


Prepare a Test Plan

- **Description of equipment to be tested**
- **What to test for:**
  - As found EMI levels
  - Integrity of cabling and shielding
  - Improvement in immunity
- **Prediction of measurement data**
  - Time domain.
    - Level, duration, and shape

Prepare a Test Plan

- **Selection of test equipment**
  - Know how to operate
  - Cautions on testing
- **Impact on plant operation**
- **Interference with other systems**
- **Why problems can disappear while testing**



Measure EMI Levels at Equipment Interface

- **Select non-intrusive techniques**
  - Current probe, Differential Voltage probe, E-Field and H-Field probes, etc.
- **Identify probable test points**
  - Maintain flexibility to find highest sources.
  - Common mode vs. differential mode.
- **Identify potential aggressors that need to be operated to create EMI**
  - On an ac system, odds are 1 out of 3 that you will get a high level EMI of the “correct polarity” on a single activation.
  - DC switching should generate repeatable transients

Obtain Reliable and Accurate Test Data

- **Keep accurate records of testing**
  - Location of test probe(s).
  - Equipment & plant condition.
  - Follow test plan and document any deviations.
- **Prevent data aliasing**
- **Confirm test probe only measuring EMI at test point**
- **Confirm test probe is not introducing EMI into the system**
- **Remember voltage levels – can it affect the system or is it zoomed in on the signal**

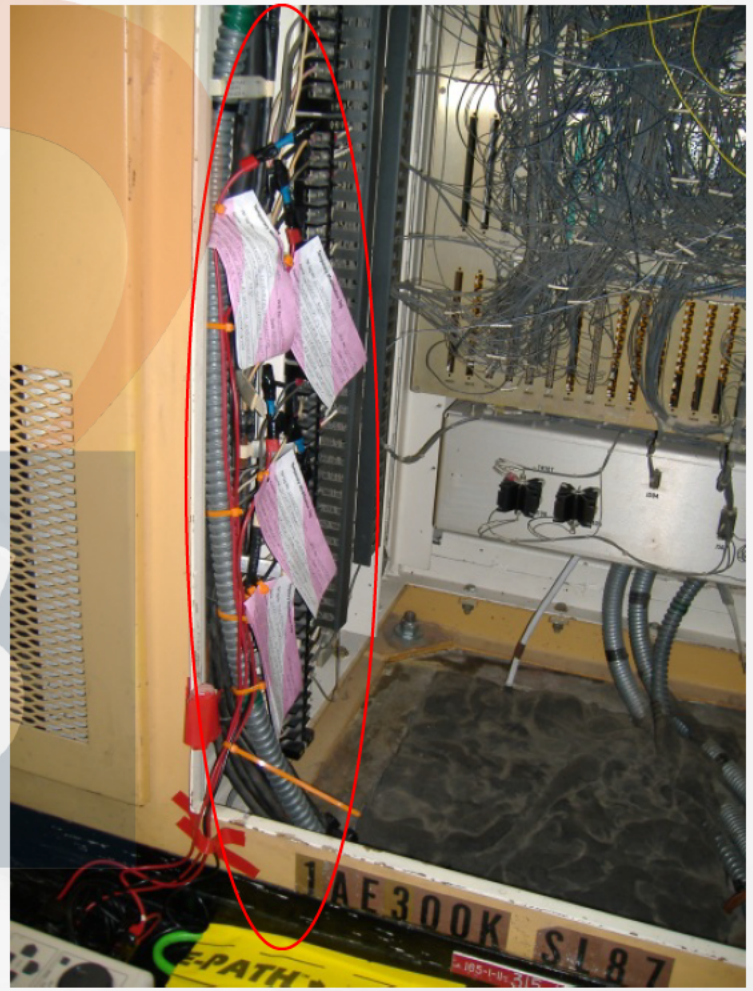
Cable Length and Routing for EMI Troubleshooting

Avoid long runs of cabling and keep individual conductors as close to each other as possible

Better Installation of Test Leads

- **Good Practice**
  - Short leads to Recorder
  - Lead pair bundled together

- **Bad Practice**
  - Individual leads
  - Tie-wrapped to plant cabling



Evaluate the Test Data

- **Compare levels at various penetrations to boundary**
  - Is EMI common mode or differential mode?
  - Is EMI high frequency or low frequency?
  - Is EMI predominantly current, voltage, or wave?
  - Are levels greater than what would normally be expected?
  - Can EMI be identified as coming from a unique source?

- **Compare signatures from different cables**
  - Correlation.
  - Time delayed if simultaneous (correlate to coupling distance).

Design EMI Fixes for Model

- **Use standard techniques that have been proven**
  - Power filters, ferrite beads, capacitors, grounding straps, surge arrestors, RC snubber (filter), time delays, cable routing, shielding, etc.
- **Use techniques that are practical at the point of application**
- **Recognize that coupling paths are complex and it may be necessary to use more than one fix at different locations**

Test EMI Fixes

- Develop a plan for temporary installation and test of fixes
- Install all fixes before testing
- Fixes must use correct installation techniques to prevent EMI
  - Impedance control
  - Proper shielding
  - Proper grounding
  - Minimum loop area
  - Place at the boundary of protection
  - Use proper cable routing techniques

Troubleshooting Goals

- Do not interfere with system being tested
- Be certain that the data you generate is useful and understood
- Be certain instruments and techniques are appropriate

EMI Troubleshooting Summary

- Confirm That Problem Is EMI
- Determine Probable Coupling Path
- Determine Probable Aggressor
- Locate Coupling Path “Failure”
- Design and Test EMI Fixes

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Thank You

Questions?