

## Evaluation Techniques to Diagnose EMC Performance Issues (206 screens)

The Troubleshooting Module is intended to familiarize viewers with the concepts involved in the techniques of discovering and resolving the causes of non-compliance that may be encountered during Electromagnetic Compatibility compliance testing. The Troubleshooting Module contains a total of 3 sections covering an array of EMC troubleshooting techniques. This module starts off with a discussion of some of the common tools used in the EMC troubleshooting process, such as current probes, capacitive voltage probes, magnetic loop antenna and field probes. This is followed by discussion and experiments related to “ambient noise” in the EMC testing environment and further description of EMI spectra as it relates to formal compliance testing vs engineering evaluation testing. The bulk of the module lies in the remaining two sections, which focus in-depth on troubleshooting techniques for EMI conducted emissions and radiated emissions, respectively.

### Section A – Overview: Essential Concepts Common to Most EMC Troubleshooting Evaluations

- Introduction to Localized Explorations:
  - Current Probes – Exploratory Measurements on Primary Power Wires
  - Current Probes – Evaluation of Common-mode Currents related to Excessive Radiated EMI Emission
  - Capacitive Voltage Probes
  - Loop Antennas or Magnetic Field Probes
  - Immunity (Susceptibility) Effects
- Discussion and Experiments Related to Ambient EMI Conditions
- Descriptions and Importance of Congruence of EMI Spectra Between Compliance and Exploration Tests:
  - Narrowband Spectra
  - Frequency Modulation Patterns
  - Amplitude Modulation Patterns
  - Wideband Spectra
  - Modulation Time-Domain Displays
- EMI Immunity / Susceptibility R.F. Continuous Wave Influences
  - References to Demodulation and Detection Mechanisms (Linked to the Design Module)

### Section B – Conducted EMI Emission

- Review of Conducted EMI Emission (Measurement) Concepts:
  - References to Line Impedance Stabilization (Artificial Mains) Networks
  - References to Test Setup Ground Plane
- Discussion of Current Probe Relevance to Voltages at LISN
- Conducted Ambient EMI Experimental Setup (in non-shielded labs)
- Experimental Procedures to Identify the Modes of Propagation:
  - Differential-mode
  - Common-mode
- Discussion and Experiments Related to Ambient EMI Conditions
- Current Probe Transfer Impedance, Microamperes, and dB References
- Differential-mode Suppression Concepts
- Exploration of the Common-mode Return Path
  - Safety-earth ground wire
  - Interface Cables to Interconnected Devices
  - Distributed Transfer Impedances
  - Imbalances of Return Path in Power Mains

- Discussion and Experiments Related to Ambient EMI Conditions
- Common-mode Suppression Concepts
- Descriptions and Troubleshooting Expanded Common-mode EMI Distribution

### Section C – Radiated EMI Emission

- Introduction to Radiated EMI
  - Propagation from Cables
  - Differential-mode to Common-mode Conversion
  - Slotted-line aperture approximations
  - Dipole-like effects – “Hot” Case Symptoms
  - Cable Propagation From Flux-Induction
  - Leakage From Electromagnetic Fields From
    - § Inadequate Case Connections;
    - § Gaps;
    - § Apertures;
    - § Aperture Arrays
    - § Penetration Through Thin-Film Coating
    - § Propagation From Circuit Devices in Unshielded Cases
- Troubleshooting Radiated EMI Susceptibility / Immunity
- Conceptual Approach: “A View of Wavelength”
- Probing at Microwave Frequencies
  - Use of “Feed Horns” as Probes
- Aperture Arrays at Microwave Frequencies
- Evaluations with Current Probes
- Slotted-line and Loop Apertures (In Cable Arrangements)
- Aperture-based Cable Flux Induction
- Aperture Arrays and Cables
- Common-mode Currents and EMI Propagation From Cables
- Current Probes, Transfer Impedance Functions, Microamperes, Compliance and dB Ratios
- Probing Cable Shield Connections
- Probing Individual Wires in an Interface Cable
- Common-mode Suppression with Coils and Ferrite Sleeves
  - Valuation of Coils or Ferrite Sleeve Impedance
  - Relevance to Common-mode Impedance of Cables
  - Application of dB Ratios to Impedance
- Delta-T Evaluations: Common-mode Conversions
- Evaluations With Loop Probes
  - Construction of Loop Probe
- Use of Loop Probes
  - Field Direction & Orientation
  - Relationship of Fields to Flat Plane
  - Exploration of Thin-Film Shields
  - Exploration and Troubleshooting the “Hot Case” Syndrome
  - Troubleshooting Unshielded or Minimally Shielded Products
    - Probing Inside a Product
    - Exploring Modular Shields on Circuit Boards
    - Field Structures of Apertures in Shields
    - Relevance of Field Structure to Compliance Issues
    - Discussion of Gaps and Wavelength Examples
- Troubleshooting Inter-product / System Interactive Dependencies
  - Appearance of “Hot Case” Syndrome
  - Excitations – Stimuli as Common-mode Currents
  - Excitations – Stimuli as Field Transfers
  - Intersystem Spatial Dependencies
    - Cable Positioning Influences
    - Grouped Cables – Phasing Relationships
    - Induced Currents From Apertures
    - Positioning Relationships to Loop Formations and Slotted Line Approximations
  - Alterations of Radiated EMI Spectra