EMCT Electromagnetic Compatibility Tutorial ®

IEEE

MODULE I: Propagation

Propagation from Devices, Circuit Boards, and Chassis (454 screens)

With the Propagation Module, we're introduced to the primary mechanisms that create EMI from active circuit boards. Using a layered teaching approach, we first learn about the fields that are created by a single device. Then, building on those concepts, we can understand the more complex fields that emanate from several devices, including how circuit boards couple EMI currents to attached wires or cables and form radiating antenna structures. Along the way, we learn the Fourier approach–that digital waveforms are comprised of many higher frequency sine waves. By a careful progression through important EMC design concepts, we're brought to the heart of the Propagation Module: Circuit Board Layout Considerations. In this all-important section, we learn how circuit boards create distributed transmission lines with respect to chassis structures and surface planes. We learn how to control EMI propagation using the reflection losses and null formations that form within the distributed transmission lines that are setup between the boards and the chassis. Then, we learn how to minimize losses by flux and inductive cancellation using transmission-line methods in the stack-up of circuit boards and individual traces. Finally, we study the techniques we'll need to reduce EMI coupling by partitioning the circuitry.

Introduction to EMC (43 Screens)

- Blocked and Lumped Equivalent Models
- Coupling Interrelationships to Chassis Structure
- Interface Connections as Antenna Equivalents
- Overview of Conductive-Case Shielding Containment
- Initial Susceptibility "Intrusions" Presented by ESD
- Interface Role as Antennas for "Exit and Entry Currents" in Susceptibility - Immunity Performance
- Overview of common-mode and Architectural Considerations

Section A - Logic Devices and Circuit Boards

- Logic Drivers and Cross-Conduction Currents
- Spectral EMI Characteristics of Various Signal Waveforms
- Spread Spectrum Approaches
- Common-mode Structures Within Circuit Boards
- Significance of Propagation Through an Imperfect Plane
- Peak Currents and Repetitive Impulse Surges
- Coupling of Common-mode Potentials to Heat Sinks and Heat Sink Arrays with resulting currents
- Storage Capacitors: Layout Locations, Methods, Rationale and Resonances
- "Array" Effect of Multiple Circuit Devices
- Interface Wires and Cables as Antenna Structures

Section B - Field Transfers To Structures from Circuit Boards

- Concept of Distributed Common-mode Transmission Lines
- Relationship and Modes of Field Transfers to Chassis Planes (adjacent conductive mechanical structures)
- Chassis Planes as Common-mode Image Returns: in Distributed Line and Surface Patch Modes
- Spectral Profile Alterations Derived from Imposition of Chassis Planes
- Multi-Mode Propagation Arrays
- Equivalent "Antenna Radial Propagation" of Common-mode Currents in Interface Wires and Cables
- Use of "Ground Nulls"
- Common-mode Field Displacements and Transfer Impedances to Chassis Structures
- Susceptibility Effects with "Ground Null" Implementations
- Concepts of Common-mode Regional Partitioning Through "Moats" and "Isolation Zones" to Increase Signal-noise Ratios

Section C - Circuit Board Layout Considerations

- Concept Review of Transmission Lines in Signal and Power
- Flux Linkage; Flux and Inductance Cancellation
- Dichotomous "Breaks" in Transmission Lines, and Occurrences of "Break-equivalents" in Circuit Boards
- Descriptions of Return Images in Relationship to Flux Linkage
- Reviews of Transmission Lines:
  - o Micro-Stripline, Stripline, Embedded Micro-Stripline; Asymmetrical Stripline, Edge-Coupled Differential Line; Broadside Coupled Differential Line
- Transmission Line Impedance Characteristics
- Power Plane Configurations and Impedances with Signal Imaging
- Circuit Board "Stack-up" Considerations for Power and Signal
- Power Planes and Edge Impedance Terminations
- Undercut Power Planes
- Multiple Dielectric Separations
- Skin Effect and Skin Depths
- Flux Linkage Patterns- "6-H" Rule
- "3-W" and "10-W" Trace Width Rules for Flux Boundaries of Traces – Derivations from "6-H" Rule
- Signal and Power Imaging for Various Board Layer Stack-ups
- Transmission Line Image Return Skew with Layer-Jumping Through Vias
- Skew Route Patch for Layer-jumping
- Factors for Consideration of Signal Imaging on Voltage Planes
- Design Discussion: 4 Layer Boards and Signal Imaging
- Design Discussion 2 Layer Circuit Boards – Inductance; Loop Area; and Architectural Topology
- Signal Impedance Matching
- Series and Parallel Signal Trace Terminations
- Circuit Board Functional (Common-mode and EMC Architectural) "Partitioning"
- Blind and Buried Via Applications
- Faraday "Fences" Used for Common-mode Partitioning
- "Picket Fences" for Board-Level Isolation Partitions
- 3-Dimensional Partitions
- Via patterns
- Analogue-Digital Partitioning
- Common-mode Inductor Techniques and Valuations
- Susceptibility / Immunity Partitioning in Circuit Boards
- Derivations of Circuit Board Topologies and EMC Architecture from Systems Electrical Architecture

Section D – Conducted Emissions

- Measurement Concepts of Conducted EMI Emission:
  - o References to LISNs;References to common-mode "ground plane"
- Detailed Circuit Descriptions of LISNs
- Differential-mode Propagation
- Examination of Differential-mode Equivalent in EMI Measurement Schematic
- Common-mode Propagation
- Small Devices, Common-mode Returns, and the Dipole Effect
- Common-mode EMI: Expanded Propagation and inter-relationships with Interconnected Devices

Elliott An NTS company

© Elliott Laboratories
684 West Maude Avenue
Sunnyvale, CA 94085-3518

www.elliottlabs.com
+1.408.245.7800
emctinfo@elliottlabs.com