Fundamentals of Grounding and Shielding For System Level Noise Reduction

Introduction

This course stresses applied Electromagnetic Compatibility (EMC) related to the design of circuits and systems. Designers need to concern themselves with development, propagation and reception of unwanted RF fields both to and from the environment of use. The field of EMC is complex, dealing with a wide range of component and system level analysis, two of which includes grounding and shielding.

Grounding is one of the most important aspects of a product design to prevent development and propagation of unwanted RF currents. The concept and implementation of grounding is vague and confusing, yet it forms an inseparable part of a product's architecture. Grounding is used for EMC and ESD protection, to protect against electrical safety hazard, along with lightening and surge protection.

Shielding is required for applications where suppression techniques for undesired RF fields cannot be implemented to a satisfactory degree, or when a system is exposed to external RF noise that can cause functional disruption. Shielding is mechanical in nature whereas grounding is electrical. Adequate levels of shielding are necessary for enhanced performance, yet improper implementation or choice of material may cause increased harm to the compatibility of a product operating within a specific environment.

Course Objective

This fundamental course presents both simplified theory and applied engineering applications for implementing grounding methodologies for printed circuit boards and enclosures as well as shielding techniques. One must recognized RF current flow in a system and the need to keep undesired energy from traveling to areas that can be disrupted. Disruption can be operational failure or development of undesired RF fields that can propagate via free space or through interconnects.

For many applications, it is impossible to incorporate suppression within a printed circuit board to a level that provides for optimal operation. Shielding is a secondary protection application that provides significant value to ensure emission and immunity requirements are met. Failure to incorporate shielding using sound engineering knowledge can develop more problems for the designer to deal with beyond that of functionality.

Who Should Attend

This course is intended for *practicing* engineers of all disciplines; system designers, regulatory compliance, EMC consultants, students, mechanical and PCB designers. No formal training in electronic theory is required. Engineers in other disciplines, technicians, supervisors and managers can also gain valuable insights into aspects of PCB and system design for today's high technology products, along with obstacles that exist for designers when incorporating a printed circuit board within an enclosure.

Benefits of Attending

- Increased Job Knowledge
- Enhanced Signal Integrity
- Teaches EMC Suppression versus Containment
- Allows First-Time Compliance to EMC Requirements
- Reduce Design Time and Manufacturing Costs
- State-of-the-Art Design and Layout Techniques Presented

Fundamentals of Grounding and Shielding For System Level Noise Reduction

(Two Day Seminar)

INTRODUCTION TO EMC

- Definition of EMC Terms
- The Decibel, Variations and Pitfalls
- Signal Spectra (Fourier Analysis)
- How RF Energy is Created
- Right Hand Rule and Maxwell's Equations
- Electric and Magnetic Fields
- Loop Area Between Circuit and Components
- Component Characteristics at RF Frequencies

ELECTRICAL NOISE CONCEPTS

- Basic Concepts Related to Reducing Electrical Noise
- Digital Components as a Source of EMI
- Basic Aspects of EMC and the Environment
- How Does Current Travel–What Path Does It Take?
- Path of Least Impedance / Typical Wire Configuration
- Concept of Self Inductance
- Common-Mode and Differential-Mode Currents
- Power and/or Ground Bounce

BASIC GROUNDING CONCEPTS

- Grounding Concepts
- Different Types of Grounds Possible in a System
- Multiple Return Path Possibilities
- Grounding Misconception
- Product Safety Requirements
- Dealing With Ground Currents
- Important Grounding Principles

GROUNDING METHODOLOGIES

- Floating/Single/Multiple/Hybrid Ground Systems
- Cable Shield Grounding
- Ground Trees

GROUND LOOPS & COMMON IMPEDANCE COUPLING

- Inductance of Wire
- Minimizing Ground Inductance
- Mutual Inductance/Capacitance Between Transmission Lines
- Common Impedance Coupling
- Difference in Loop Area–Square vs. Circle
- Ground Loop Control – System and Adapter Cards
- Avoiding Ground Loops
- Isolation Techniques

PRINTED CIRCUIT BOARD GROUNDING CONCEPTS

- Grounding and Layout Considerations
- Functional Partitioning
- Identifying a Grounding Plan
- Grounding Analog & Digital Circuits in a PCB
- Variations on Split Plane Configurations
- Routing Traces and Return Currents Using Multiple Planes
- Concerns With Layer Jumping Transmission Lines
- Interplane Capacitance
- Pinout Configurations–Interconnects
- Digital-to-Analog Partitioning (Mixed Signal Grounding)
- RF Current Density Distribution
- Screws as a Radiating Antenna

GROUNDING IMPLEMENTATION EXAMPLES

- Avoiding Common-Impedance Coupling
- Cause of Ground Voltage Potential Between Two References
- Connecting AC Signal Reference to Chassis
- Ground Versus Floating Related to Hazardous Fault Currents
- Grounding Between Different Circuits Using Interconnects
- Ground Concept Summary–Signal Reference and Chassis

SHIELDING THEORY

- Shielding Effectiveness
- Transmission Line Theory of Shielding Effectiveness
- Skin Depth and Absorption Loss
- Multiple Reflections and Loss in Copper and Thin Shields
- Apertures in Shielding Walls
- Waveguide

SHIELDING APPLICATIONS AND IMPLEMENTATION

- Effects of Shield Discontinuity
- Gasketing and Conductive Coatings
- Joint Unevenness
- Common Gasket Material
- Properties - Common Types of RF Gaskets and Fingers
- Characteristics of Common Gasket Materials
- Potential Mechanical Problems When Using Gaskets
- Electrochemical Grouping
- Conductive Gasket Implementation
- Conductive Coatings
- Characteristics of Common Surface Coatings
- Comparison of Metallizing Techniques
- Concerns When Using Coatings
- Shielding Integrity Violations
- Proper and Improper Shield Penetrations
- Common Cable Shielding Configurations
- Cable Shield Termination Concepts
- Implementation a Cable Shield into an Assembly
- Terminating a Cable Shield
- Aspects to Consider When Specifying a Shielded Cable
- Shielded Compartments