Montrose Compliance Services, Inc.

Grounding and Shielding for System Level Noise Reduction

(Two Day Seminar)

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 that the system is installed within. The field of EMC is complex, dealing with several major areas of concern, two of which includes grounding and shielding.

Grounding is one of the more 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 primarily 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 a mechanical solution whereas grounding is electrical. Adequate levels of shielding are necessary for enhanced performance, yet improper implementation or choice of shielding 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 identify 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 through free space or interconnects.

For many applications, it is impossible to incorporate suppression techniques within a printed circuit board to a level that provides for optimal operation. Shielding is a secondary 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

About the Instructor

Mark Montrose is principle consultant of Montrose Compliance Services, Inc., a full service regulatory compliance firm specializing in Electromagnetic Compatibility with 30 years of applied EMC experience. Prior to becoming a consultant, Mark was responsible for regulatory compliance for several high-technology companies in Silicon Valley, California. His work experience includes design, test and certification of both Information Technology (ITE) as well as Industrial, Scientific and Medical products (ISM). He is assessed by a European Competent Body to perform CE compliance approval and in situ testing and certification of industrial products.

Mark is a Senior Member of the IEEE and a past member of the *Board of Directors* of the IEEE as Division VI Director (2009-2010). He is also a long-term past Board member of the IEEE EMC Society plus Champion and First President of the IEEE Product Safety Engineering Society. He was a popular distinguished lecturer for the IEEE EMC Society and is considered an expert in printed circuit board design and system level applications for EMC compliance. He has presented numerous papers based on sophisticated research related to printed circuit boards and the field of EMC at International EMC Symposiums and Colloquiums worldwide. Mark also provides personalized in-house seminars and consulting services to corporate clients worldwide in addition to the University of California, Santa Cruz extension program.

Mark has authored the following best-selling text/reference books published by Wiley/IEEE Press.

- *Printed Circuit Board Design Techniques for EMC Compliance*, 1996-1st ed / 2000-2nd ed.
- *EMC and the Printed Circuit Board - Design, Theory and Layout Made Simple*, 1999.
- *Testing for EMC Compliance – Approaches and Techniques*. 2004.
- Contributing author to the *Electronics Packaging Handbook*, Chapter 6, 2000 (CRC/IEEE Press).

Montrose Compliance Services, Inc.
Electromagnetic Compatibility and Product Safety

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INTRODUCTION TO EMC
- Definition of EMC Terms
- The Decibel, Variations and Pitfalls
- Signal Spectra (Fourier Analysis)
- How Printed Circuit Boards Create EMI
- Right Hand Rule and Maxwell's Equations
- Electric and Magnetic Fields
- Loop Area Circuits 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 and Path of Least Impedance
- Common-Mode and Differential-Mode Currents
- Power and/or Return Bounce

BASIC GROUNDING CONCEPTS
- Grounding Concepts and Definitions
- Different Types of Grounds Possible in a System
- Multiple Return Path Possibilities
- Grounding Misconception
- Product Safety Requirements and Signal Referencing
- Dealing With Ground Currents
- Important Grounding Principles

GROUNDING METHODOLOGIES
- Floating/Single/Multiple/Hybrid Grounding Systems
- 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
- Common-Mode Rejection
- Avoiding Ground Loops
- Isolation Techniques

PRINTED CIRCUIT BOARD GROUNDING CONCEPTS
- Grounding and Layout Considerations
- Functional Partitioning
- Identifying a Grounding Plan
- Grounding Analog & Digital Circuits
- Variations on Split Plane Configurations
- Routing Traces and Return Currents
- Concerns With Layer Jumping Transmission Lines
- Routing Over Split Planes
- 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 and Signal Reference to Chassis
- Handling Fault Currents
- Using A/D Converters and Dealing with AC Ground Voltages
- Grounding Between Different Circuits and Interconnects

SHIELDING THEORY
- Definition and the Need to Shielding
- Transmission Line Theory of Shielding Effectiveness
- Skin Depth and Absorption Loss
- Reflections and Loss in Copper and Thin Shields
- Apertures and Waveguides
- Printed Circuit Board Shielding Components
- Shielded Cables-Different Types, Use and Implementation

SHIELDING APPLICATIONS AND IMPLEMENTATION
- Effects of Shield Discontinuity and Slot Antenna Effects
- Common Gasket Material
- Properties - Common Types of RF Gaskets and Fingers
- Characteristics of Common Gasket Materials
- Mechanical Problems When Using Gaskets
- Electrochemical Grouping
- Gasket Implementation
- Conductive Coatings and Metallization Techniques
- Concerns When Using Conductive Coatings
- Shielding Integrity Violations
- Shield Discontinuities. Slot Antenna and Joint Unevenness
- Proper and Improper Shield Penetrations
- Cable Shield Grounding Requirements and Implementation
- Implementation a Cable Shield into an Assembly
- Terminating a Cable Shield
- Aspects to Consider When Specifying a Shielded Cable
- Shielded Compartments
- Measuring Shielding Effectiveness