Fundamentals of Applied EMC Engineering
(Two Day Seminar)

Introduction
The field of Electromagnetic Compatibility (EMC) is considered to be *Black Magic* by those who not working within this specialized niche of engineering. In reality, one can solve complex problems by understanding fundamental or basic aspects of Maxwell's equations (made simple in this course). A brief overview on concerns related to printed circuit board design and layout along with secondary methods to achieve EMC such as filtering, shielding and gasketing is examined.

An overview on the international compliance arena is also presented along with the process one must take toward testing, troubleshooting and certification of a system.

Course Objective
This course includes the following introductory topics, which covers most of the field of applied EMC engineering. Regardless how many years experience as an engineer, a fundamental seminar provides significant value since many have a tendency to over-think solutions and not identify the actual source or problem area. A senior engineer also tends to tackle simple problems using complex simulation analysis. A refresher in EMC basics will allow one to visualize problem differently and which will also provide guidance on new approaches toward achieving compliance quickly and at lowest cost.

1. Definition on what the field of EMC covers
2. What it takes to be EMC compliant
3. Fundamentals of Signal Integrity (time domain analysis)
4. Fundamentals of EMC (frequency domain analysis)
5. Fundamentals of PCB design and layout
6. Grounding
7. Filtering, shielding and gasketing
8. Approach toward testing, troubleshooting and certification

Who Should Attend
This course is an introduction to the field of applied EMC engineering. The target audience is anyone interested in learning new concepts and techniques that will help one achieve EMC quickly and at low cost. Mathematical concepts and analysis are kept to a bare minimum (simple algebra). Practicing design engineers of all disciplines, regulatory compliance, EMC consultants, academic professors and students, corporate management, and PCB designers will significantly benefit from the material presented. No formal training in electronic or electromagnetic theory is required. Concepts, theory and applications are presented in an easy to understand format using practical and real world examples.

Benefits of Attending
- Increased job knowledge
- Enhanced signal integrity and EMC compliance
- 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

2353 Mission Glen Drive
Santa Clara, CA 95051-1214
☎ and FAX + 1(408) 247-5715
mark@montrosecompliance.com

Fundamentals of Applied EMC Engineering
(Two Day Seminar)

INTRODUCTION TO EMC REQUIREMENTS
- Definitions and Basic Aspects of EMC
- Elements of the EMC Environment
- Regulatory Requirements
- International Immunity Requirements
- Performance Criteria for Immunity Tests

WHAT IT TAKES TO BE EMC COMPLIANT
- Areas of Concerns to Achieve EMC
- System Requirements
- North American and International Limits
- Documentation Requirements

FUNDAMENTALS OF SIGNAL INTEGRITY (TIME DOMAIN ANALYSIS)
- Signal Integrity Concerns
- Lossy and Lossless Transmission Lines
- Relative Permittivity (Dielectric Constant)
- Reflections – Poor Signal Integrity
- Transmission Line System
- Signal Distortion Characteristics
- Crosstalk
- Termination Methodologies and Examples

FUNDAMENTALS OF EMC (FREQUENCY DOMAIN ANALYSIS)
- Signal Spectra (Fourier Analysis)
- Maxwell Equations Made Simple
- Electric and Magnetic Field Impedance
- Magnetic and Electric Field Representation
- Closed Loop Circuit
- Loop Area Between Components and Radiation
- Noise Coupling Mechanisms
- Common-Mode and Differential-Mode Currents
- Comparison of Radiation Mechanisms
- Need for Flux Cancellation

FUNDAMENTALS OF PCB DESIGN AND LAYOUT
- Fundamental Requirements
- Component Characteristics at RF Frequencies
- Image Planes
- RF Current Density Distribution
- Ground Loop Control
- Functional Partitioning
- Component Selection Related to EMC
- Defining Capacitor Usage
- Using Capacitors in Parallel
- Effects of Capacitors in Parallel
- Power and Ground Plane Capacitance
- Microstrip and Stripline Topologies
- Impedance Control
- Capacitive Loading
- Calculating Maximum Trace Lengths
- Trace Separation and the 3-W Rule
- Routing Traces and Layer Jumping
- Partitioning
- Isolation (Moating) and Bridging
- Image Plane or Moat Violation
- Digital and Analog Partitioning
- Grounding I/O Interconnects

GROUNDING SYSTEMS
- What is Ground?
- Grounding Hierarchy
- Different Types of Grounds
- Grounding Misconceptions
- Reasons for the Need to Ground
- Floating, Single-Point, Multi-Point, Hybrid
- Cable Shield Grounding and Ground Trees

FILTERING, SHIELDING AND GASKETING
- Signal and Power Line Filter Configurations
- Basic Filter Component Characteristics
- Capacitive and Inductive Filtering
- Filtering Guideline
- Defining Shielding Effectiveness
- Transmission Line Theory of Shielding
- Losses Achieved with Shielding Material
- Skin Depth and Absorption Loss
- Reflection Loss - Plane Waves/Thin Shields
- Apertures
- Waveguide Below Cutoff
- Common Gaskets and Mechanical Problems

APPROACH TOWARD TESTING, TROUBLESHOOTING AND CERTIFICATION
- International Requirements and Differences
- Testing Methodology and Approach
- Knowing the Test Environment
- Self-Compatibility
- Validation of Measured Data
- Pitfalls and Problems
- Process for Designing Systems to Achieve EMC
- Formal EMC Qualification Tests Requirements
- Strategy for EMI Debugging/Troubleshooting
- Testing and Troubleshooting Concerns
- Emission, Immunity and In Situ Testing
- Systematic Approach for Testing
- Compliance Measurement Procedure
- Performing Testing-Beyond Standard Procedures
- Systematic Approach to Solving