Testing for EMC Compliance - Approaches and Techniques
(One or Two Day Seminar)

Introduction
This course presents fundamental aspects related to testing products for EMC compliance with a focus on commercial and light-industrial environments. Both emissions and immunity are examined in a manner that permits one to understand what is required and how to perform basic tests. A fundamental understanding on conformity assessment is presented for those who have no need to visit a test facility but is responsible for regulatory compliance – in other words, how to repeat a test back in-house (after failing at a test site) to verify the failure and to isolate the problem area.

Basic theory on the need to comply is presented along with instrumentation required to perform testing, either compliance or non-compliance. Troubleshooting techniques are included. Instrumentation and support equipment along with specialized diagnostic probes and tools is discussed. Use of the material presented should result in reduced design time, manufacturing costs and improved time-to-market.

Course Objective
This course presents both simplified theory on how RF energy is generated within a system and means of propagation. Once an RF signal breaks through protection levels related to both EMI and immunity, one must spend time to locate the source of the problem and then apply mitigation using a variety of components or redesign at considerable expense. Troubleshooting requires knowledge and skill in using the proper instrumentation and transducer (probe or antenna), along with understanding the type of field being measured (electric and/or magnetic). Mathematical and simulation analysis will *not* be presented. Real-world troubleshooting techniques with a proven track record will be presented; both conventional and non-conventional techniques.

Upon completion, one should be able to test products for EMC compliance and identify problems quickly. In addition, one will have the knowledge to help design and/or develop an in-house EMC test laboratory.

Who Should Attend
The course targets engineers and technicians that are unfamiliar with testing and troubleshooting. Experienced test engineers may find benefit as a refresher course. In addition, this course is especially useful for practicing design engineers of all disciplines, regulatory compliance and EMC consultants.

No formal training in electronic theory is required or experience in EMC testing, as the course is presented at the “fundamental level.” The participant, upon completion should be able to perform in-house testing and analysis at minimal cost, or be able to locate a problem area that caused failure at a commercial test facility. Solving EMC problems in-house becomes less expensive than spending time and money at a commercial test-house.

Benefits of Attending
- Increased job knowledge
- Allows first-time compliance to international EMC requirements
- Reduce design time and manufacturing costs
- State-of-the-art design and layout techniques presented
- Allows one to perform testing and troubleshooting in an efficient manner

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).

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Testing for EMC Compliance - Approaches and Techniques
(One Day Version)

How RF Energy Exists
- Types of Electromagnetic Fields
- How Transmission Lines Create EMI
- Right Hand Rule
- Maxwell's Equations
- Electric and Magnetic Field Components
- Magnetic and Electric Field Representation
- Closed Loop Circuit
- Time and Frequency Representation
- Radiated Emissions From a Closed Loop Circuit
- Loop Area Between Components
- Common-Mode and Differential-Mode Currents
- Differential-Mode/ Common-Mode Currents in a Chassis

Instrumentation
- Time Domain Analyzer (Oscilloscope)
- Characteristics to Consider in Choosing an Oscilloscope
- Oscilloscope Probes
- Frequency Domain Analyzers
- Spectrum Analyzers
- Receivers
- Pre-Compliance Versus Compliance Analyzers

Test Facilities
- Open Area Test Site (OATS)
- Chambers
- Screen/Shield Rooms
- Reverberation Chamber
- TEM and Other Specialized Test Cells

Probes, Antennas and Support Equipment
- Need for Transducers (Probes and Antennas)
- Concerns When Using Transducers
- Voltage Probes
- Current Probes
- LISN/AMN (AC Mains)
- Coupling/Decoupling Networks (CDNs)
- Bulk Current Injection (BCI) - Probe and Insertion Clamp
- Near-Field and Closed-Field Probes
- Sniffer Probes
- Far Field Antennas

Radiated Testing
- Overivew on Radiated Testing
- Radiated Immunity
- Electrostatic Discharge (ESD)
- Power Frequency Magnetic Field Disturbance

Emission Testing
- Radiated Testing - Beyond Standard Procedures
- Compliance Measurement Procedure
- Typical System Configuration
- Operating Conditions
- Conducted Emissions Setup
- Conducted Emissions Testing (AC Power Mains)
- Radiated Emissions
- Test Report Requirements

Conducted Immunity Testing
- Common Tests Performed for Conducted Immunity
- Electrical Fast Transients / Bursts Testing (EFT/B)
- Surge or High Energetic Line Transients
- RF Current Conducted Immunity
- AC Mains Supply Dips, Dropouts and Interruptions

Radiated Immunity Testing
- Concerns Regarding Radiated Immunity Testing
- Commercial Radiated Immunity Testing Techniques

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Testing for EMC Compliance - Approaches and Techniques

(Two Day Version)

Fundamentals of EMC Testing
- Definition of EMC Terms
- Basic Aspects of EMC

How RF Energy Exists
- Types of Electromagnetic Fields
- How Transmission Lines Create EMI
- Right Hand Rule and Maxwell's Equations
- Electric and Magnetic Field Components
- Magnetic and Electric Field Representation
- Closed Loop Circuit
- Time and Frequency Representation
- Radiated Emissions From a Closed Loop Circuit
- Loop Area Between Components
- Common-Mode and Differential-Mode Currents
- Differential-Mode/ Common-Mode Currents in a Chassis

Instrumentation
- Time Domain Analyzer (Oscilloscope)
- Characteristics to Consider in Choosing an Oscilloscope
- Oscilloscope Probes
- Frequency Domain Analyzers: Spectrum and Receivers
- Pre-Compliance Versus Compliance Analyzers

Test Facilities
- Open Area Test Site (OATS)
- Chambers: Screen/Shield/Reverberation
- TEM and Other Specialized Test Cells

Probes, Antennas and Support Equipment
- Need for Transducers (Probes and Antennas)
- Concerns When Using Transducers
- Voltage Probes
- Current Probes
- LISN/AMN (AC Mains)
- Coupling/Decoupling Networks (CDNs)
- Bulk Current Injection (BCI) - Probe and Insertion Clamp
- Near-Field and Closed-Field Probes
- Sniffer Probes
- Far Field Antennas

Emission Testing and Troubleshooting
- Systematic Approach for Emissions Testing
- Systematic Approach for Immunity Testing
- Minimum Requirements for Performing EMC Tests
- Potential Problems During Emission Testing Conducted Testing
- Overview on Performing Conducted Testing
- Common-Mode and Differential-Mode on Wires and Cables
- Determining Coupling Modes
- Coupling Paths for Conducted Emissions

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- Electrical Fast Transients / Bursts Testing (EFT/B)
- Surge or High Energetic Line Transients
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Radiated Immunity Testing
- Concerns Regarding Radiated Immunity Testing
- Commercial Radiated Immunity Testing Techniques

Simplified Testing and Troubleshooting Techniques
- Quick Fixes and Solutions – Conducted Currents
- Quick Fixes and Solutions – Radiated Fields
- Simplified Troubleshooting Techniques
- Simplified Testing and Troubleshooting Concepts Using Probes
- Switching Power Supply Effects on CM Conducted Noise
- Enclosure Resonances and Shielding Effectiveness
- Determining if Emission Noise is Differential or Common-Mode
- Potential Problems When Using Ferrite Clamps
- Measuring Shielding Effectiveness of Materials and Enclosures
- Measuring Noise Voltage Across Seams in Enclosures
- Printed Circuit Board Level Diagnostic Scanners