

Electronic Product Design and Retrofit for EMC

A unique blend of applications, hardware demonstrations, and supporting theory for both beginning and advanced students



Gain a solid understanding of the problems encountered in designing and troubleshooting for EMC

Course Overview

Circuit design and EMC engineers will learn how to recognize and solve common electromagnetic compatibility (EMC) problems in PC boards, connectors, and cables. Understand and apply conductive, capacitive, inductive, and far-field coupling models to real hardware designs.

What You Will Learn

- Identify noise sources and apply solutions to EMC problems
- Minimize radiated EMI by designing low inductance signal interconnects
- Distinguish between useful and invalid EMI “rules of thumb” and design hints from books and application notes
- Understand ground loops, in what circuits and frequency ranges they may cause problems, and how to eliminate them
- Clearly identify and manage the three different types of “ground” in schematics and physical circuits
- Identify and debug the different modes of conducted emissions using LISN, current probes, and phasing networks
- Apply diagnostic techniques in a systematic way to investigate and improve circuit designs
- Recognize and reduce the efficiency of the most common EMI antenna structures that cause emissions and immunity problems
- Improve the quality of sensor and instrumentation signals in the presence of noise

Course Specifications

Intended Audience

Digital, Analog and RF circuit design and EMC engineers who want a solid understanding of applied EMC theory and applications for practical hardware design and troubleshooting.

Prerequisites

A good understanding of fundamental circuit theory

Course Length

2 or 3 days, depending on course options selected

Course Format

Instruction consists of 80% lecture and 20% hardware demonstrations conducted by an EMC expert with graduate education from the University of Missouri-Rolla EMC Laboratory, and 15 years of relevant and recent EMC design and debug experience.

Delivery Methods

Scheduled on-site at a client’s location, or open enrollment through UC-Berkeley, General Motors University, and SILENT’s annual Fall Engineering Workshop.



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EMC & RF Design Consulting & Training

Silent Solutions LLC

Detailed Course Syllabus

Measuring and Inducing Noise

- Near-field, far-field, & conducted noise coupling
- Prediction and uncertainty of radiated emissions
- Schematics and math behind emissions tests
- Schematics of and signal types in immunity tests

This section begins with a demonstration of interference between two physical electronic products. The four noise coupling paths are defined using simplified electromagnetics and applied to the demonstration. You will learn about the basic physics of noise coupling, the inherent problems associated with emissions testing, and the equivalence of most immunity tests in this section.

Lumped & Parasitic Capacitance, Inductance and Current Paths

- Capacitance in ESD, PCBs, connectors, cables
- Inductance in PCBs, connectors, cables, ICs
- Current paths as a function of frequency

This section illustrates the mathematical definitions of inductance and capacitance with physical geometries along low and high frequency signal paths. The class works through several simple math problems and a demonstration of current division along signal returns in PCB "ground" planes and cables at low and high frequencies.

The Four Noise Coupling Paths & Ground

- Signal return and "grounding"
- When ground loops matter and how to fix them
- Schematics, simplified equations, and case histories of the four noise coupling paths

This section discusses in detail the three different functions of signal "ground". Ground loops are formally defined, with a detailed discussion of their characteristic magnetic and common impedance immunity problems. Low frequency models for capacitance and inductance are discussed, with illustrations from case histories in PCB and cable design.

Common & Differential-Mode Noise & Filters

- Definitions and demonstrations of differential - mode and common-mode current
- Using current probes to identify common-mode and differential-mode current in real circuits
- Function of practical differential-mode versus common-mode filter components and topologies
- How to select and apply filters

An essential discussion of topics usually not taught in engineering programs, this section defines, discusses, and demonstrates the principal mechanism for radiated emissions and cable coupled susceptibility problems in digital and analog systems. Different filter configurations, along with their effects on desired and undesirable signals are explained and demonstrated.

Optimum Use of EMI Filter Components

- Ideal and physical SMT, through-hole, and retrofit capacitors, ferrites, inductors
- Interconnect inductance and its impact
- Filter and antenna theory with demonstrations of filter performance

This section discusses the limitations of real components in filter designs. Selection criteria for component values and construction are characterized in the frequency domain. Typical performance of filter elements are calculated and optimum configurations are discussed.

Modern Power Decoupling Theory and Applications

- Power distribution via traces and planes
- Low and high frequency models
- Placement and value of decoupling capacitors
- Interplane capacitance



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High Frequency Emissions From PCBs

(3 day class only)

- How attached cables of PCBs determine high frequency emissions and immunity performance
- Understand the award winning IEEE papers concepts of current and voltage driven emissions
- Designing PCBs for low emissions and high immunity

This portion of the class discusses the basic processes that determine PCB high frequency radiated emissions. Learn how to apply these concepts to create designs with high immunity to external low and high frequency noise. This section discusses stackup, component placement, and the function of specialized components.

Shielding Electronic Products

(3 day class only)

- Why EMC shielding math in textbooks is wrong
- Shielding at low and high frequencies
- Shielding effectiveness testing

Common misconceptions of shielding design and performance evaluation are discussed using real world examples and simplified math. Key design guidelines & troubleshooting techniques are given.

Choosing Cables for Noise Control

(3 day class only)

- Understanding cable shields and terminations, demonstration
- Proper use of twisted pair and shielded cables at low and high frequencies
- Strange ideas about 'hot' shields, signal returns, and "cold" grounds

The distinguishing features of various cable designs is made clear using the simple concepts of capacitance and inductance. This section shows how to choose and easily predict cable performance for a given design application.

Class Practice Examples

(3 day class only)

- Real case histories to discuss in class
- Drill problems and solutions

This section provides the class an opportunity to assimilate course material and retain key topics relevant to each student's interests and job function.

For More Information

By Internet, phone, or fax, get information and assistance for all your EMC and RF design, retrofit, and training needs.

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