GROUNDING AND SHIELDING OF ELECTRONIC SYSTEMS

(How to diagnose and solve Electromagnetic Interference and Signal Integrity problems)

A 2-day Lecture/Demonstration presentation
by
Dr. Tom Van Doren

Professor of Electrical & Computer Engineering
Electromagnetic Compatibility Laboratory
Missouri University of Science & Technology
573-341-4097
vandoren@mst.edu

INTRODUCTION

- Has variable frequency drive noise ever overwhelmed your thermocouple microvolt level signal?

- Has a nearby digital circuit ever desensitized your global positioning system receiver?

- Has your computing device ever failed emissions testing for Federal Communications Commission certification? Did you agonize over the cause?

- Have strong switching power supply noise or data burst signals contaminated the low level analog signals on your circuit board?

Whether you have experienced one of the problems described above or another interference problem just as difficult, attending the Grounding and Shielding Course will give you invaluable insight into reducing these problems or avoiding them altogether.

Dr. Van Doren will discuss the correct answers to these questions:

* What path does current take?
* Does current go to ground?
* Does a straight wire have inductance?
* Is ground the current return path?
* What generates a magnetic field?

If you can correctly answer these five questions, you can solve the vast majority of electrical interference problems occurring at kHz, MHz, and GHz frequencies. Dr. Van Doren's presentation includes some surprising, profound demonstrations and practical examples.

Many engineers and technicians using or designing electronic systems have not been formally trained in proper grounding and shielding techniques. Learning how to solve electromagnetic interference and signal integrity problems on the job can be very frustrating for the engineer and very expensive for the employer. Most of the electromagnetic and circuit principles employed are simple. However, the complexity of many systems masks the logic and simplicity of possible solutions.

In his presentation, Dr. Van Doren will help engineers and technicians

- recognize the four basic coupling mechanisms (conduction, magnetic fields, electric fields, and electromagnetic waves) causing all electrical interference problems
- reduce noise using logical procedures rather than "trial-and error" methods
- determine the optimum grounding technique for both safety and low noise
- determine the correct connection for the shield on a twisted-pair cable
- improve signal integrity of high-speed digital waveform
- reduce the time and cost required to meet emission and susceptibility specifications

He will

- treat signals as currents
- explain fundamental grounding, shielding, and signal routing principles
- demonstrate many techniques for identifying and fixing electrical interference problems
- describe principles as concepts rather than theoretical equations, making the course far more applicable and useful to an audience having a wide range of experience

- demonstrate several interference mechanisms and shielding techniques
- clarify troublesome terminology.

First-Day Outline

1. **Introduction**

2. **Current Routing and Least Impedance**
   Understanding wiring inductance
   DEMONSTRATION: Path of least impedance
   Controlling the current return path

3. **Interference Coupling Mechanisms**
   Reviewing the four coupling mechanisms
   Ways to recognize the dominant coupling mechanism
   Equivalent circuit for each mechanism

4. **Field Containment, Bandwidth, Balance, and Resonance**
   Using routing to contain the field
   DEMONSTRATION: Fields emitted by a coaxial cable
   Relating bandwidth to transition time
   Common mode currents and impedance imbalance
   Resonances in lumped and distributed circuits
   DEMONSTRATION: Predicting and reducing resonances

5. **Grounding for Safety and Noise Reduction**
   Signal routing is NOT the same as grounding!
   Characteristics of a ground structure
   Safety grounding examples
   Single point versus a ground grid
   Avoiding kHz ground loops
   Grounding analog and digital circuits
   Grounding signals to chassis for RF and ESD immunity and RF emission reduction

6. **Interference Diagnostic Techniques**
   Diagnostic analysis and measurement tools
   Determining the Dominant Mechanism
   The influence of circuit impedance
   Diagnostic measurement techniques
   Using Current probes, E-field probes, and H-field probes

Second-Day Outline

7. Review of First Day

8. Filtering to Reduce Conducted Noise
Current blocking and diversion Strategies
Filter types
Common mode and differential mode filter techniques
GHz filtering techniques
Reducing capacitor mutual inductance
When to use ferrite beads

9. Field Containment Using Self-Shielding
The low-cost and wide-bandwidth approach
Signal routing provides the containment
DEMONSTRATION: Twisted pair versus coaxial cable
Misuses of twisted pair

10. Reducing Capacitively-Coupled Noise
DEMONSTRATION: Capacitive shielding example
Capacitive noise reduction options
DEMONSTRATION: Shield connection for twisted pair

11. Reducing Inductively-Coupled Noise
Reducing mutual inductance
Eddy current shielding
Magnetic flux shunting
DEMONSTRATION: Magnetic shielding options

12. Electromagnetic Wave Shielding
Skin effect and RF containment
Making cable shields effective at GHz
Sizing air flow openings
Controlling common mode currents
Containing EM is more important than grounding it

Attending the course earns 15 PDHs (Professional Development Hours).
COST: IEEE Members - $800 Non-IEEE Members - $950