

10 Northern Blvd, Suite 1, Amherst, NH 03031-2328 USA

T: +1 (603) 578-1842 [www.silent-solutions.com](http://www.silent-solutions.com)

## Advanced Printed Circuit Board Design for EMC + SI

This course provides a unique blend of theory, applications, and numerous hardware demonstrations to describe effective PCB design strategies to eliminate EMC problems such as radiated emissions & immunity, and ESD, and to improve low and high frequency signal integrity of analog and digital sensors.

The real-time hardware demonstrations use a spectrum analyzer, oscilloscope and signal generators to illustrate inductance, common-impedance coupling, and ground loops in PCBs, cables, and systems. Specific examples of single-point, multi-point, "good", and "bad" grounds will be discussed. We will also apply the course learning by discussing and examining actual SILENT client case histories as well as examples of integrated circuit application notes that give bad EMC design advice.

## Course Instructor



Lee Hill is Founding Partner of SILENT, an independent EMC and RF design firm established in 1992 that specializes in EMC and RF design, troubleshooting, and training. Lee received his MSEE from the Missouri University of Science & Technology EMC Laboratory, [emclab.mst.edu](http://emclab.mst.edu). He teaches a graduate course in EMC as a member of adjunct faculty at Worcester Polytechnic Institute (WPI), and is also an EMC course instructor for Texas Instruments, the University of Oxford (England) and the IEEE EMC Society's Global University, which he currently chairs. He is a past EMC instructor for UC Berkeley, Agilent, and Hewlett Packard.

With over 30 years of EMC design and troubleshooting experience, Lee consults and teaches worldwide, and has presented courses in Taiwan, China, Poland, Singapore, Mexico, Norway, Canada, South Korea, France, Germany and United Kingdom. Lee is a past member of the IEEE EMC Society's Board of Directors (2004-2007).

## After Attending This Course, You Will Be Able To:

- Place decoupling capacitors to obtain best performance for a given layer stackup, based on the latest university research
- Explain the pros and cons of different PCB stackups, and know where to route and not to route high frequency noise sources
- Control trace inductance for signal integrity and low noise design
- Correctly identify the possible noise paths that can disrupt PCB operation and choose appropriate solutions
- Explain the problems that split ground planes cause and how to use them correctly
- Choose & place connectors and assign signals for lowest crosstalk, best signal integrity, and lowest EMI
- How to identify mutual inductance and improve the effectiveness of filter capacitors
- Identify good and bad design practices when viewing actual PCB layout screenshots

**SILENT**

Solutions for your noisy world.

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## Advanced Printed Circuit Board Design for EMC + SI

### Day 1

#### Section 1: **Measuring and Inducing Noise**

- 1) The electrical noise model
- 2) Distinguishing the four noise paths by name, electrical driving function, necessary physical features, and impact of source to victim distance
- 3) Troubleshooting techniques based on the noise model
- 4) Far-field versus Near-field coupling + DEMONSTRATION
- 5) Practical antenna theory for radiated emissions and immunity + DEMONSTRATION
- 6) Problems inherent in predicting radiated emissions and radiated immunity test results
- 7) Conducted emissions—mode separation, LISNs, troubleshooting
- 8) Practical applications

#### Section 2: **Understanding the Physics and Root Causes of Noise Problems**

- 1) Capacitance—in ESD, PD boards, decoupling networks, filter networks, cables + DEMONSTRATION
- 2) Electrostatic discharge (ESD). IC and system ESD tests. Problems with test repeatability. Design techniques to improve PCB ESD immunity + DEMONSTRATION
- 3) Inductance—in PC boards, connectors, ICs, high speed signal paths, decoupling networks,
- 4) How to use connectors for improved signal quality, reduced emissions, & improved immunity
- 5) Behavior of current paths at low and high frequencies + DEMONSTRATION

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## Advanced Printed Circuit Board Design for EMC + SI

### Day 2

#### Section 1: PCB Noise Models

1. Review of the noise coupling model
2. Review of the four noise coupling paths
3. Emissions and immunity

#### Section 2: Capacitance, Inductance and Current Paths in PC Boards

1. Good and bad capacitance
2. Good and bad inductance
3. Current loops
4. Low versus high frequency current paths
5. Inductance and low versus high frequency current paths + DEMONSTRATION
6. "Ground plane" splits - appropriate and inappropriate uses
7. Connectors, cables, and I/O wires connected to the PCB

#### Section 3: Signals on PC Boards

1. Which signals are important?
2. What do they look like? + DEMONSTRATION
3. Transmission lines, characteristic impedance, terminations + SIMULATIONS
4. Harmonic content versus duty cycle + DEMONSTRATION

#### Section 4: Power Distribution

1. Functions of PCB "grounds"
2. Vcc noise
3. Decoupling and filtering
4. Board layer stack-ups
5. Funny design ideas, current research, new design applications

#### Section 5: Design Techniques and Examples

1. Component placement
2. Signal routing + stackup
3. Examining vendor applications notes that give bad EMC advice for PCB design
4. Examining past SILENT PCB design review findings

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