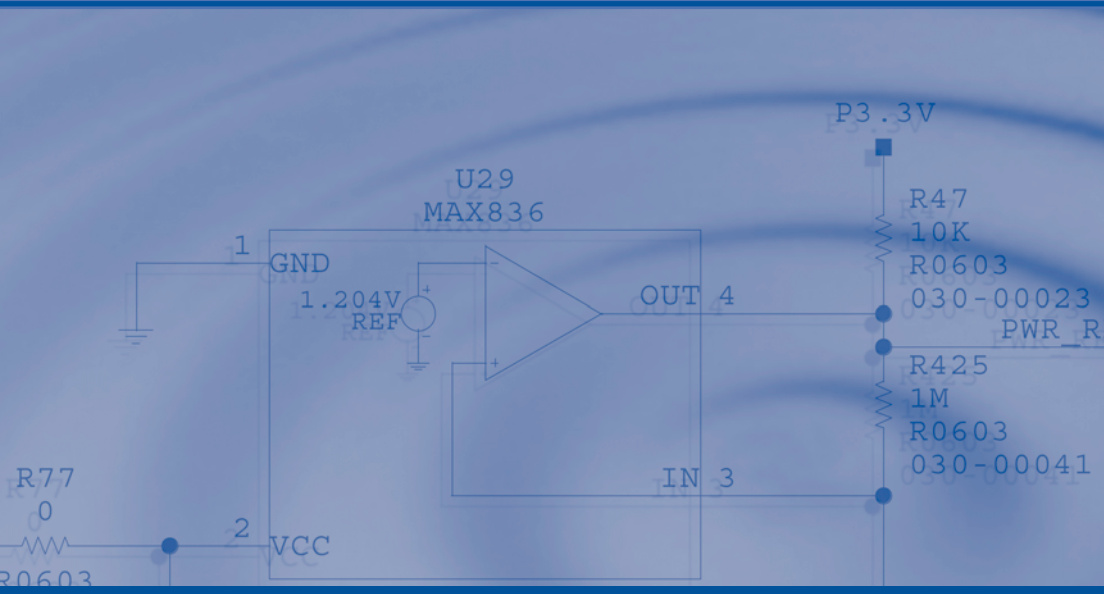

Practical Hardware Design and Troubleshooting Engineering Workshops for Electrical and Mechanical Design Engineers as well as EMC Engineers and PCB Designers

- Electronic Product Design and Retrofit For EMC
- Printed Circuit Board Design for EMC
- Mechanical Design for EMC
- Circuit-to-Circuit Interference Hands-on Laboratory
- Grounding for EMC, Signal Integrity & Instrumentation

SILENT

Solutions for your noisy world.

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99% of our students would recommend SILENT to a friend or colleague and many of them come back to stay fresh.

Listen to what they're saying about us...

"Our employees work in an atmosphere where they are encouraged to ask questions, no matter how silly they might seem, and this class was no exception. The course was excellent. The sessions were refreshing because Lee encouraged questions and spent whatever time was required to answer them."

E. E. LANDSMAN, SC.D.
CONSULTING ENGINEER, FOUNDER
AMERICAN POWER CONVERSION

"In general, labs and testing facilities lack the knowledge and skills necessary to resolve elusive noise problems. Lee and Randal's workshops combine practical information with supporting theory and math. Their courses helped me understand the key issues behind EMI."

JEFF MAYOROS
PROJECT MANAGER
WITTERN GROUP

"After helping us resolve a complex problem, Lee returned to our facility to discuss Randal's work within the framework of a two-day class for the benefit of the entire team. The workshop added significant value and will better prepare us for future programs."

MIKE AMBROGI
GENERAL MANAGER
DEKA RESEARCH AND DEVELOPMENT

"Many engineers view EMI as black magic. Lee made it simple and easy to understand. He clearly explained the math and physics behind EMC and RF design which are critical to successful implementations."

RICH COLLINS
PRODUCT DESIGNER
CROSSBEAM SYSTEMS

TABLE OF CONTENTS

At SILENT, we scream success.

SILENT is an independent consulting firm specializing in electromagnetic compatibility (EMC) and RF design and troubleshooting with emphasis on analysis and the resolution of EMI emissions, immunity, electrostatic discharge (ESD) and circuit-to-circuit interference problems. SILENT has a proven track record of achievement servicing global manufacturers in a wide array of markets including computer, consumer, network and telecommunications, industrial process control, automotive, medical and scientific instruments, and military and aerospace. SILENT ensures time-to-market with solutions in electrical noise reduction that are intelligent, cost-effective and manufacturable.

SILENT's real world knowledge enables us to quickly sort through complex issues. As EMC and RF design engineers, we work collaboratively with you and your staff to develop solutions that ensure rapid time-to-market and reduce risk to your organization's product development schedules.

Our services include upfront design consultation, rapid response problem resolution, pre-compliance testing, and RF design. We can work with you onsite or at our facility near Boston, Massachusetts. Or, if you prefer, we can work one-on-one with your engineering staff online using real-time collaborative applications. We also offer a rich training curriculum through many educational venues including the University of Oxford, Freescale Semiconductor, General Motors University, the IEEE EMC Society, and numerous annual technical conferences. Our classes and seminars provide a unique blend of practical demonstrations of EMI issues in real hardware, supporting electrical engineering concepts and theory, and proven advice to eliminate noise in analog, digital, and RF designs.

Practical training in noise reduction for better job performance.

The globe may not be spinning any faster but if you're a design engineer at a global manufacturer it certainly feels that way. Chances are your world is rapidly accelerating. Shorter design cycles. Faster processors. Denser circuits. And fewer resources to do the same job are the hallmarks of today's commercial and industrial design environments.

Even the best designs can be compromised by electrical noise problems that arise in the eleventh hour. Elusive and problematic EMI and self-interference can be difficult to identify and even more challenging to eliminate.

Lee Hill and Randal Vaughn have been successfully tackling electrical noise for over twenty years. They have serviced global manufacturers in a wide variety of industries including computer, consumer, network and telecommunications, industrial process control, automotive, medical and scientific instruments, and military and aerospace. In the process, they have accumulated a depth of experience that has been distilled into a series of workshops that are packed with practical design and troubleshooting techniques.

SILENT's EMC classes are presented at several venues during the year including University of Oxford, Freescale Semiconductor, General Motors University and our Engineering Workshops in the Boston area. Our popular "in-house" class program brings a SILENT instructor and the classes of your choice on-site to your associates at your facility.

Whichever venue you prefer, you can be assured that you will gain a lot from our focused and practical workshops on electromagnetic interference.

WORKSHOP

Electronic Product Design and Retrofit For EMC

INSTRUCTOR Lee Hill

LENGTH 2-day or 3-day class, 8:30 - 5:00
(depending on class options selected)

This two- or three-day class gives engineering professionals the ability to successfully recognize, solve and avoid common EMI problems. The real-time demonstrations use a spectrum analyzer, oscilloscope and signal generators to illustrate concepts such as radiated emissions, high frequency antennas, radiated and conducted immunity and crosstalk in connectors, cables and IC packages. Integrating over 30 years of hands-on troubleshooting experience and the latest EMC research, this class is appropriate for experienced circuit and system design engineers, EMC engineers, as well as those who are new to EMI problem solving.

I. Measuring and Inducing Noise

- Electromagnetic Compatibility
- Radiated emissions & associated measurements + DEMONSTRATION
- Uncertainty in measurements. Underlying problems in predicting results
- Conducted emissions - electrical schematic and the purpose of LISNs
- Function and purpose of immunity tests with simplified schematics

II. Lumped and Parasitic Capacitance, Inductance, and Current Paths

- Capacitance - in ESD, PC boards, decoupling networks, filter networks, cables + DEMONSTRATION
- Inductance - in PC boards, connectors, ICs, high speed signal paths, decoupling networks, filter networks
- Behavior of current paths at low and high frequencies + DEMONSTRATION

III. The Four Noise Coupling Paths, Functions of "Ground", and "Ground" Loops

- Common impedance - in PCB power planes, ground planes, cables
- Capacitive - in PCB power filtering, transformers, heatsinks, connectors + DEMONSTRATION
- Inductive - in PCB ground planes, connectors, and IC packages
- Radiative - from small electronic products + DEMONSTRATION
- Ground - the three distinct functions, ground loop problems, + DEMONSTRATION

IV. Optimum Use of EMI Control Components

- Control components: capacitors, inductors, ferrite beads, common-mode filters + DEMONSTRATION
- Coping with and improving non-ideal characteristics such as interconnect inductance, DC bias

V. Measuring and Diagnosing Effects of Common & Differential-Mode Sources & Filters

- Differential-mode current, voltages
- Common-mode currents, voltages, + DEMONSTRATION
- Understanding the common-mode current and antenna path for emissions and immunity
- Antenna currents and relevance to filter networks and troubleshooting
- Common and differential-mode filtering. Filter network topology and function
- Inherent difficulties in EMC filter design. Effects of filters on intended and unintended signals
- Where to use common-mode filters – application circuits
- Where to use differential-mode filters – application circuits

VI. Modern Power Decoupling Theory and Applications

- The need for and function of decoupling capacitors - time and frequency domain
- Understanding two-sided and multilayer PCB decoupling networks
- Interplane capacitance. Power plane resonance. Latest research

VII. 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 paper's concepts of current and voltage driven emissions
- Designing PCBs for low emissions and high immunity

VIII. 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

IX. "Shielding" Electronic Products (3-day class only)

- Why the shielding theory taught by EMC experts is not correct or applicable to the control of radiated emissions
- Transfer impedance, resonant cavities, and the true function of metal enclosures. Practical design applications
- Near and far field shielding, absorption, reflection. Shielding effectiveness testing

WORKSHOP

Grounding for EMC, Signal Integrity and Instrumentation

INSTRUCTOR Lee Hill

LENGTH 1-day class, 8:30 - 5:00

Theory, applications and hardware demonstrations in this one-day class describe effective design and troubleshooting techniques. The real-time demonstrations use a spectrum analyzer, oscilloscope and signal generators to illustrate inductance, common-impedance coupling, and ground loops. Specific examples of single-point, multi-point, “good” and “bad” grounds will be discussed.

I. The Noise Coupling Model and “GROUND”

- The noise coupling model
- Conducted and radiated emissions
- Conducted and radiated immunity
- Bad "grounds" as dipole antennas
- Inductive versus common-impedance noise voltages + DEMONSTRATION

II. Inductance in PCBs, Cables, Connectors, & Systems

- Physical, lumped, and parasitic inductance - how to recognize hidden noise problems
- Mutual inductance - how to recognize and reduce
- Current paths at low and high frequencies - how to locate and control return currents and noise currents
- How to predict & calculate common-impedance noise coupling
- How to approach D/A & A/D converter grounding
- The fallacy of "ground bounce"
- How to assign signals to connectors to minimize self and mutual inductance

III. Ground and Associated Noise Coupling

- How to clearly define and identify grounds and signal returns
- Conductive and magnetic ground loops
- Ground loops in low frequency systems
- A scientific approach to debunking single-point and multi-point grounding ideas
- Recognizing good versus bad integrated circuit signal pin assignments

IV. Review of Real Integrated Circuit Application Notes

- In-class practice analyzing application notes
- How to recognize bad versus good grounding recommendations

V. Grounding Shielded Cables (Bonus Section - Time Permitting)

- Low frequency versus high frequency shields
- Methods and physics behind poor and optimum shield terminations
- Frequency domain demonstration of shield terminations

WORKSHOP

Printed Circuit Board Design for EMC

INSTRUCTOR Lee Hill

LENGTH 2-day class, 8:30 - 5:00

This two-day class will provide you with a unique blend of theory, applications, and numerous hardware demonstrations to describe effective and sometimes not-so-effective PCB design advice that we often hear from electrical engineers and EMC “experts.” The real-time 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.

I. PCB Noise Models

- Review of the noise coupling model
- Review of the four noise coupling paths
- Emissions and immunity

II. Capacitance, Inductance and Current Paths in PC Boards

- Good and bad capacitance
- Good and bad inductance
- Current loops
- Low versus high frequency current paths
- Inductance and low versus high frequency current paths + DEMONSTRATION
- “Ground plane” splits - appropriate and inappropriate uses

III. Signals on PC Boards

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

IV. Power Distribution

- Functions of PCB “grounds”
- Vcc noise
- Decoupling and filtering
- Board layer stack-ups
- Funny design ideas, current research, new design applications

V. General Design Techniques and Examples

- Component placement
- Signal routing
- Bad application notes
- Connectors, cables, and I/O wires connected to the PCB

WORKSHOP

Mechanical Design for EMC

INSTRUCTOR	Lee Hill
LENGTH	2-day class, 8:30 - 5:00

This two-day class for mechanical engineers provides clear applications, theory and demonstrations for the successful design of mechanical enclosures for good system emissions and immunity performance. Key topics include grounding at the PCB and enclosure, system ground maps, PCB component placement and control drawings, enclosure and cable shielding, PCB device “cans”, resonant slots and enclosures, heat sinks, unintentional antennas, as well as connector, screw, and conductive gasket placement.

I. Measuring and Inducing Noise

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

II. “Ground”

- Definitions and illustrations of the three electrical concepts of “ground”
- Some examples of “bad grounds” for mechanical engineers
- Which “grounds” matter and which ones can be ignored

III. PCB Mechanical Control Drawings

- Optimum PCB component placement of:
  - Connectors
  - Heatsinks
  - Daughterboards
  - Filters
- Reference “Ground” maps

IV. Shielding Electronic Products

- Why EMC shielding math in textbooks is wrong
- Transfer impedance (Zt)
- Applications of Zt to gaskets, base materials, connectors, shielding in general
- Cable shields + DEMONSTRATION
- Shielding at low and high frequencies
- Shielding effectiveness testing
- Slot and cavity antenna structures
- Recent research on effectiveness of multi-aperture cooling arrays

WORKSHOP

Circuit-to-Circuit Interference

A Hands-on Laboratory Class

INSTRUCTOR	Randal Vaughn
LENGTH	1-day class, 8:30 - 5:00

This unique one-day class is for electrical design engineers at all levels challenged by electrical noise problems in products containing RF (wireless), analog, switching power supply and digital electronics. During this hands-on class, each group of two or three students will be provided with a noise “tackle box” to build noise source and victim circuits. Each student will apply noise reduction concepts as they master the ability to anticipate and solve electrical noise problems in new product designs.

I. Root Causes of Noise

- Noise coupling model
- Four noise coupling mechanisms
- Classes of noise solutions

II. Predicting and Solving Noise Problems

- Noise analysis of circuit schematics by estimation
- Estimate noise problems using only datasheet info
- Noise measurements on circuits + Demonstrations
- Identify source and victim circuits using the energy exchange diagram
- Noise solutions + Demonstrations

III. Hands-on Experiments 1 & 2

- Noise analysis of schematic
- Identify noise source and victim circuits
- Identify possible paths
- Develop and test likely solutions

IV. Next Steps

- Proactive noise prevention in the design process
- Develop a customized source/victim/coupling-factor list of your company’s designs
- Improving your skills – additional topics

Lee Hill Founding Partner

lhill@silent-solutions.com

Lee Hill is Founding Partner of SILENT, an independent electromagnetic compatibility (EMC) and RF design firm established in 1992 that specializes in design for EMC and RF design, troubleshooting, and training services to commercial and industrial manufacturers with global distribution in the computer, consumer, network and telecommunications, industrial process control, automotive, medical and scientific instruments, and military and aerospace. Previously Lee was Principal EMC and Systems Engineer at Digital Equipment Corporation's Workstation Systems Engineering Group in Palo Alto, California.

Lee received the Master of Science Degree in Electrical Engineering & Electromagnetics with highest honors from the University of Missouri-Rolla, (now Missouri University of Science and Technology) and the Bachelor of Science Degree in Electrical Engineering from the Rochester Institute of Technology. Mr. Hill was awarded the 1993 IEEE EMC Society President's Memorial Scholarship and the 1994 Missouri Collegiate Entrepreneur Award.

Lee has over twenty years of experience in the EMC design and retrofit of complex electronic systems. He has been teaching short courses on EMC design and troubleshooting for fifteen years. Lee consults and teaches worldwide, and has presented classes in Taiwan, Singapore, Mexico, Norway, Canada, South Korea, France, and United Kingdom. He is also a regular EMC course instructor for Oxford University (England), Freescale Semiconductor, and General Motors University. He has completed a three-year term on the Editorial Review Board of Printed Circuit Design Magazine and served as an EMC instructor for HP and Agilent. Lee holds a US patent for EMI control in portable electronics, and provides expert witness services for patent litigation.

Lee is currently serving as Chair of the IEEE EMC Society's Awards Committee, and is a recent member of the Society's Board of Directors (2004-2007). In 1994, Lee was appointed to serve a two year term as an IEEE EMC Society Distinguished Lecturer (DL), and from 1999-2006 he served as chair of the DL program. In 2003 he served as Co-Technical Chair of the IEEE Symposium on EMC in Boston, Massachusetts. He is a past Vice-Chair of the Central New England Chapter of the IEEE EMC Society. In the past seven years he has been a frequent featured speaker at IEEE EMC Society fundraising events in cities throughout the US including Seattle, Portland, Chicago, Milwaukee, Dallas/Fort Worth and Detroit. He has also provided technical presentations to Society chapters in Los Angeles, San Diego, Santa Clara, Boston, Austin, Colorado Springs, Pittsburgh, and Orange County, CA. In 1999 Lee received a Certificate of Appreciation from the EMC Society for significant contributions to education through his annual participation in the Demonstrations and Experiments portion of annual IEEE EMC Symposia. Lee was a member of the original IEEE P1180 ad-hoc committee on low frequency magnetic field measurement for video display terminals. In 2008 Lee wrote a guest column for Howard Johnson in Electronic Design Magazine.

Randal Vaughn Partner
rvaughn@silent-solutions.com

Randal Vaughn is a Partner in SILENT, an independent consulting firm that specializes in EMC and RF design, troubleshooting, and training services to commercial and industrial manufacturers with global distribution in the computer, consumer, network and telecommunications, industrial process control, automotive, medical and scientific instruments, and military and aerospace. Previously Randal was a Lead Engineer at Motorola Cellular Infrastructure Group in Arlington Heights, Illinois. In that role he was responsible for providing RF and EMC design consulting in the development of cellular base stations from the PC board to the system level. Mr. Vaughn developed high speed frequency synthesizers containing mixed signal analog, digital, and RF technologies for Northrop Defense Systems. He also designed and developed unique frequency control systems for the medical equipment and semiconductor test equipment industries. He received the Bachelor of Science degree in physics from Louisiana State University in 1982 and advanced training in electromagnetic compatibility in 1997 from the University of Missouri-Rolla (UMR).

Randal has twenty-five years of RF design and EMC experience including a variety of high performance industrial and military radio system and circuit designs, as well as RF & EMC design and troubleshooting of many product types including high speed digital controllers, cellular base stations, and high frequency/high power RF transmitters.

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UC Berkeley
Vutek, Inc.
WalkAbout Computers
Waterpik Techs
Waters Corp

What did attendees like most about SILENT EMC Classes?

"Demonstrations, loved all of it. Excellent presentation, great content, very intuitive and easy to understand, very practical very applicable A+++"

"Theory backed by practical demos"

"Design issues and underlying electrical principles. Very effectively demystified EMC phenomena that other courses tend to gloss over and try to dance around the real root causes."

"The methodology of how to identify the four paths backed up with practical examples and fixes."

More students scream about SILENT EMC Classes

"Excellent course! Highly recommend it to others! Quite an eye opener! I've been working in EMC and have fallen victim to the many EMC myths that have been propagated within the EMC community – The course really helped blast those myths!"

"Very good class! I'm very lucky my company asked me to attend."

"This course was well designed and provided good real life situations to help clear any misunderstandings of different coupling/interference and will help to convey this information to our customers when issues arise."

SILENT
10 Northern Blvd, Suite 1
Amherst, NH 03031

Phone: +1 (603) 578-1842
Fax: +1 (603) 578-1843

www.silent-solutions.com