Picotest's Power Integrity Workshop

Course Overview
In this workshop, taught by leading author ("Power Integrity -- Measuring, Optimizing and Troubleshooting Power Systems") and Test Engineer of the Year nominee, Steve Sandler, you will learn the **How to Design for Good Power Integrity**. Steve Sandler, who has been bringing the popular *Power Integrity Bootcamp* to engineers worldwide, has personally developed in-depth hands-on 2 and 3 Day workshops to provide you with an understanding of power integrity, why it is important, and how to design for it.

In addition, this workshop teaches you techniques for high-fidelity measurement, design, and simulation. Hands-on lab exercises let attendees learn and explore key component, VRM, and PDN tests including the 2-port shunt through impedance measurement, and much more.

The goal is to enable you to better design, troubleshoot, and optimize power and PDN related issues.

Power Distribution Network concerns?

This course covers the basics of why you should be concerned with your PDN and how to best measure it.

Learn

- Why clean power matters and how to get it
- How to set the power supply noise budget
- What frequency you should be measuring to
- How to measure each portion (VRM, decoupling, planes, loads) of the PDN
- How to measure & model VRMs and decoupling components
- How to design a flat impedance VRM in 5 seconds or less
- How to make Impedance and Ripple measurements
- What test data you are missing because your test equipment is just not good enough

Benefits

- Improve your first pass design quality
- Improve the reliability of high performance digital and RF circuitry
- Reduce board spins
- Improve your power integrity models
- Gain a better understanding of why power integrity is important
- Get the latest tips and techniques for flat impedance design

Target Audience and Prerequisites: Anyone involved with designing or testing high speed digital or RF systems, anyone using or designing power systems. Attendee should be an electrical or test engineer or technician.

PCB designers, power supply designers, signal integrity engineers, power integrity engineers and anyone involved in PDN design will receive an introduction to power integrity and the latest tips and techniques for flat impedance designs.

Hands-On Measurements

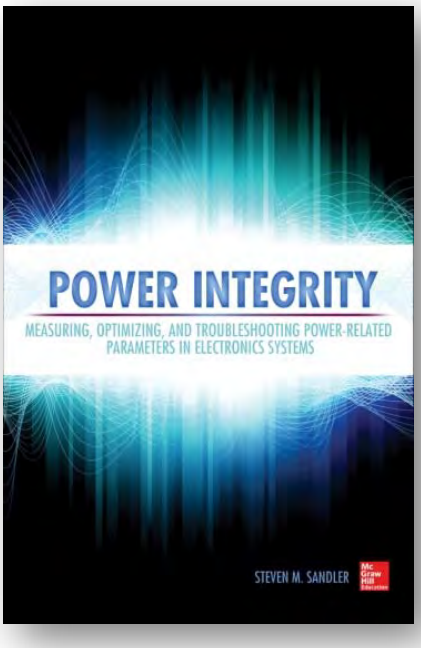
- Impedance – Output, 1-Port, 2-Port, Impedance Adapters
- Stability – Traditional Bode and Non-Invasive
- Step Loading and Transient Excursions
- Ripple and Noise
- Dealing with High Speed Edges
- PSRR and Bode Plots
- EMI and Troubleshooting with Near Field Probes

Test equipment will be provided for the hands-on portion of the class. This includes Oscilloscopes, VNAs, Spectrum Analyzers, EMI and PDN probes, and other support instruments.

VRTS3 and other test boards will be made available for use within the class environment.

Class Materials

- Text Book – "**Power Integrity** – Measuring, Optimizing and Troubleshooting Power Systems" (334 pages, $99 Value)
- Class Notes and Slides
- Hands-On Lab Exercises
- Discounts on Picotest Products



PICOTEST

Workshop Syllabus

The workshop is split into alternating lecture and interactive hands-on sessions designed to reinforce the lecture material. More than half of the time will be spent performing hands-on lab exercises. The following syllabus discusses the topics covered; though not necessary the workshop flow.

MEASUREMENT FUNDAMENTALS

- Making high fidelity measurements
- Overcoming common obstacles
- Why we need to measure – What's missing from datasheets and reference designs
- Measurement tools for power systems
    - VNAs vs. Scopes vs. Spectrum Analyzers

INTRODUCTION TO DISTRIBUTED POWER SYSTEMS

- What is Power Integrity and Why it matters
- Noise paths within a voltage regulator
- How poor stability propagates through the system
- Why everything is related to impedance
- Power Distribution Network (PDN) impedance and noise

TESTING FOR POWER INTEGRITY

- Measuring Impedance
    - Stability vs. Transient Response
    - 1-Port and 2-Port Impedance Measurements
- Measuring Step Load Excursions, Ripple, and Noise
- Basic Capacitor Measurement and Parameter Extraction
    - What are S-parameters and why we use them
    - Most of what you think you know about capacitors is wrong
    - Techniques for measuring capacitors
    - Extracting a broadband (SPICE compatible) capacitor model

KEY INTERACTIONS BETWEEN THE VRM, LOADING, AND EVERYTHING IN BETWEEN

- The role of the VRM, the printed circuit board, and the decoupling in Power Integrity
    - How the VRM design can cost system engineers time and money
- Achieving and maintaining flat power rail impedance
    - Why flat impedance is so important
    - How high in frequency do we need to measure?

- Why we use frequency domain and not time domain measurements

- Understanding and specifying regulator requirements
  - Determining target impedance
  - High speed dynamic loads, di/dt
  - PDN requirements of Regulators, FPGAs, CPUs, and other sensitive circuits
- A simple guide to printed circuit board decoupling
  - The 3 methods of decoupling (Big V, MPD, and FLAT)
  - How to optimize decoupling capacitors
  - The art and science of getting power from point A to point B
  - Decoupling is not just about high-power FPGAs
  - Why some FPGAs require hundreds of decoupling capacitors and others only need a few
- VRM Characteristics and Extraction of a Measurement Based Model
  - Voltage mode vs current mode
  - Testing feedback amplifiers & compensation with Bode, Nyquist and NISM
  - The two (3) critical measurements – PSRR and Output impedance (and PSGFS)
  - Error Amp, Power Stage Transconductance
- Measurement based model optimization - VRM and Decoupling

MEASUREMENT + SIMULATION – THE PATH TO DESIGN OPTIMIZATION

- Measurement is essential, but so is simulation
- What a VRM characterization board should look like
- Why EM simulation of the PCB is needed for PI
- Making co-simulation accurate and valuable
- Case Studies in Power Integrity
- Troubleshooting Power Integrity issues

HANDS-ON - POWER INTEGRITY MEASUREMENT DETAILS

- **Instrument Basic**
  - Noise Floor
  - Impedance Matching
  - Calibration

- **Measuring Components**
  - 1-Port, 2-Port, 2-Port Extended
  - Resistors, Capacitors (Ceramic and Tantalum), Inductors
  - Impedance Adapters

- **Measuring Impedance**
  - Probe Selection
  - Voltage Reference
  - Opamps
  - Voltage, LDO, and POL Regulator

- **Measuring Stability and PSRR**
  - Non-Invasive Stability Measurement via Output Impedance

- **Time Domain Measurements**
  - Input and Output Ripple
  - Step Load
  - Time Domain Reflectometry – TDR Cable and PCB Trace Measurement

- **PDN and Flat Impedance Measurement**
  - Two-Port Shunt-Through
  - Extended Two-Port Shunt-Through
  - Extracting the Capacitor Mount
  - VRM Impedance – Plane – Decoupling Impedance Matching
  - Flat Impedance VRM

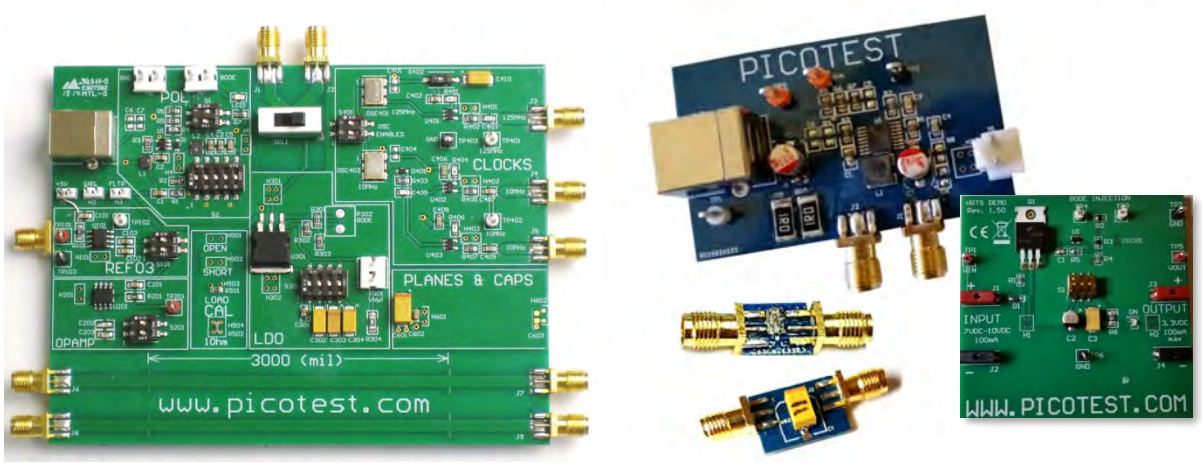
- **Demonstration Examples**
  - Clock Jitter/Spectrum Analysis
  - Noise Density

- ***Bonus Measurements If Time Permits – Covered in 3 Day Classes***
  - Bode Plots
  - PSRR Measurement
  - Clock Jitter
  - EMI and Troubleshooting with Near Field Probes

HANDS-ON ACTIVITIES SUMMARY

- Frequency and Time Domain Measurements
- VRTS3, VRTS1p5, Flat Impedance and Decoupling- Custom Class Test Boards

CLASS SUPPLIED CIRCUITS	Class Measurements
2.8MHz POL switching regulator	• Frequency: Impedance, 1-Port, 2-Port, PDN, Decoupling, Resistors, Inductors • Stability (Bode, Non-Invasive) • VRM Measurements: Output Impedance, PSRR • Time: Ripple, Load Step • Spectrum: EMI, Noise, Clock Jitter
Flat Impedance VRM	
OPAMP	
LDO Regulator	
10MHz and 125MHz Clocks	
PCB Planes and Micro-strip	
Passive Elements - Decoupling	
Cables and Transmission Lines	



The VRTS3 demonstration board is designed to support a wide range of typical power supply measurements. It provides an excellent test bed for demonstrating non-invasive, in-system measurement, optimization and troubleshooting techniques along with many of the measurements documented in the Power Integrity text book.

The VRTS3 is designed to accompany the class topics and provide a wide variety of measurement examples that both enhance the lecture topics and provide a detailed practical learning experience.

Other boards used in the class, which are available for purchase, include the VRTS1p5, Flat Impedance VRM board, decoupling boards, and calibrated component test boards (both blank and populated with de-embed files).

Lead Instructor

Steve Sandler, CEO - Picotest

Mr. Steve Sandler is the CEO of Picotest.com, a company that designs and distributes test equipment including the new Signal Injector product line designed for testing power systems. Steve is a recent winner of the Jim Williams ACE Contributor of the Year award (2015). He was named a finalist for Test & Measurement World's Test Engineer of the year two years in a row (2012-2013). Steve is the author of the book "Power Integrity – Measuring, Optimizing and Troubleshooting Power Systems" which is used as the basis for the Test and Measurement workshop. Steve has also a Keysight certified ADS expert.

Mr. Sandler is the also founder and former CEO of Analytical Engineering, Inc., the predecessor of AEi Systems. He has over 35 years' experience in the design and analysis of power conversion equipment for military and space applications. In his current position, as Chief Engineer of AEi Systems, Steve is responsible for the design, worst case analysis, reliability analysis, and FMECA analysis of satellite & power electronic systems.

Steve has also authored several books and numerous articles on power supply modeling and simulation including, "Switchmode Power Supply Simulation with PSpice", and "SPICE Circuit Handbook". He is the holder of US Patent Number 4,541,039, Magnetic Modulator, Sept. 1985. Mr. Sandler received his BSEE degree from Pacific Western University.