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ANALYTICAL HEAVY LIFTING

Introduction to Worst Case Circuit Analysis For the Aerospace Engineer

Course Overview:

This intensive course focuses on the fundamental skills required to perform a **Worst Case Circuit Analysis (WCCA)**. Participants learn the importance of this analysis and the different methods which can be utilized. The proper documentation format for communicating the analysis results is explained with detailed examples allowing the participant to gain a full understanding of the methods, requirements and resources needed to complete a WCCA. Component tolerances for most common electronic components are studied in depth. Methods of correlating models, including critical power supply testing techniques, are explored in a hands-on demonstration. Each class member is provided with a complete WCCA for a power supply and the opportunity to discuss aspects of interest in detail.

Learn first hand from Steve Sandler, distinguished author and one of the top power electronics industry consultants. Mr. Sandler combines the teaching of theoretical and practical concepts and years of hands-on experience with tried and tested methodologies for improving your reliability analysis procedures. These WCCA techniques are accepted by virtually every aerospace manufacturer as the standards in the industry.

Benefits:

- Understand when and to what level a worst case circuit analysis should be performed
- Match appropriate analysis methods to the situations in which they should be used
- Define and maintain a global tolerance database
- Understand how to perform and document key WCCA analyses
- Be able to review and critique a WCCA
- Understand the difficulties in developing and correlating circuit models including obtaining test data
- Satisfies the requirements of TOR and MIL-STD-785B, “Electronic Parts/Circuits Tolerance Analysis”

Key Program Topics:

1. Introduction to Worst Case Circuit Analysis
2. WCCA Structures, Templates, and Methodologies
3. Component Tolerances
4. TOR Compliance, Standards and Practices
5. Knowing what to analyze and how to analyze it
6. Analog, Digital, and RF WCCA Guidelines
7. Documentation and Essential Formats
8. Reviewing a WCCA
9. Analysis Tools and Techniques
10. Component and Power Supply Testing Techniques

Course Duration: 8 hours per day, 2 days

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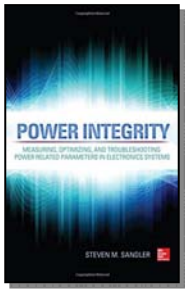
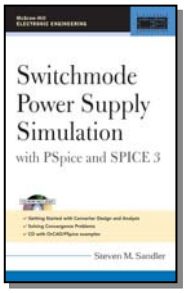


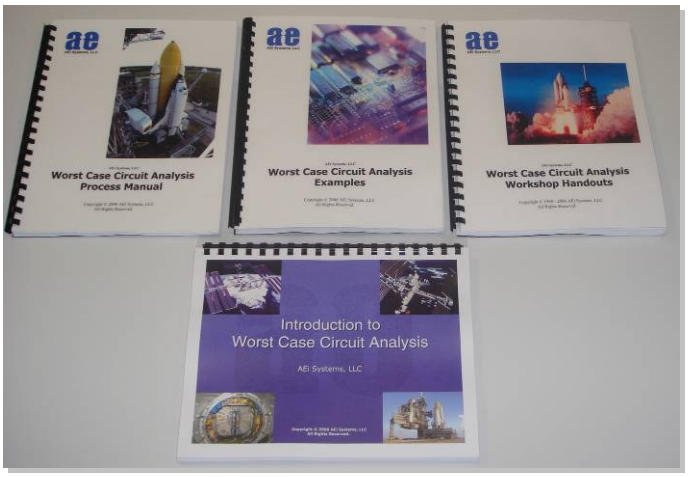


Course Materials:

- WCCA Workshop Handouts Book (300+ Slides and Notes pages)
- WCCA Workshop Examples Book (300+ pages)
- Additional Applicable Articles and Source Materials
- Door Prizes - "Switchmode Power Supply Simulation with PSPICE" and "Power Integrity" books

Course Instructor: **Steve Sandler, Founder and Principal Engineer, AEi Systems**
Mr. Sandler has over 35 years' experience in the analysis of power conversion equipment for military and space applications. In his current position Mr. Sandler is responsible for worst case and power integrity analysis, reliability analysis, and FMECA analysis of satellite & power electronic systems.

Mr. Sandler is author of several books and numerous articles on power supply modeling and simulation including, "Switchmode Power Supply Simulation with PSpice", "SPICE Circuit Handbook" and most recently "Power Integrity: Measuring, Optimizing, and Troubleshooting Power Related Parameters in Electronics Systems." He has held positions with ST Keltec Corp., Telephonics Corp. Signal Technology, Aerospace Avionics Inc., and Lambda Electronics.



Mr. Sandler is a Best in Test, Test Engineer of the Year Finalist (2012-2014) and winner of the Jim Williams ACE Contributor of the year award.

Mr. Sandler is the holder of US Patent Number 4,541,039, Magnetic Modulator, Sept. 1985. Mr. Sandler received his BSEE degree from Pacific Western University.

Assistant Instructor: **Charles Hymowitz, AEi Systems Managing Director**
Mr. Hymowitz has over 30 years of experience in the EDA software and analog simulation industries. Mr. Hymowitz has been Chairman of AEi Systems, LLC since its re-organization in 2002. In 2012, Mr. Hymowitz was recognized as the only independent (not employed directly by a prime aerospace contractor) SME (subject matter expert) on Worst Case Circuit Analysis ("WCCA"). Mr. Hymowitz was a key contributor to Aerospace Corporations' industry guidelines ("TOR") for WCCA. In 1985, Mr. Hymowitz co-founded Intusoft, a leading CAE/EDA software corporation where he was a Director and held several positions, including Vice President, Product Development and, most recently, Chief Operating Officer. Mr. Hymowitz created and edited the Intusoft Newsletter the industry standard SPICE publication. He has co-authored the "SPICE Circuits Handbook", "Simulating with SPICE", "The SPICE Cookbook", "Power Specialist's App Note Book" and "The SPICE Applications Handbook."

Mr. Hymowitz is a graduate of the Rutgers University, with a BS degree in Electrical Engineering, and the Stanford University Executive Institute program for Management of High-Technology Companies.

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2 Day WCCA Workshop Course Outline:

DAY 1

1. **Introduction to Worst Case Analysis**
   - What is a WCCA?
     - Why do we do it?
     - When do we do it?
     - To what extent do we do it?
     - Who should perform it/Review it?
     - Why is it so important to validate it?
     - WCCA as Failure Analysis
   - Cost of doing or not doing a WCCA
     - WCCA Costs and Timeframes
   - Electrical test methods and limitations

2. **WCCA Methodologies**
   - Methods of analysis
     - Sensitivity
     - EVA, RSS, Monte Carlo
   - Comparison of methods and templates
   - Tolerance Database Setup
   - Determining Critical Parameters
   - Dealing with Poorly Defined Tolerances
   - Computing EVA-RSS Results
   - Example: Three Terminal Regulators
     - Accounting for SAT's
   - Correlating Hardware-WCCA Results

3. **Part tolerances / Design Concerns**
   - Tolerance Database Structures
   - Calculating Tolerances
     - Aging and Radiation Tolerances
     - SEE, SEU, SET, SEL, SEGR, SEB
   - Extrapolation (Arrhenius models)
   - Mean Shifts
   - Tolerances for Resistors, Capacitors, Diodes, Zeners, BJTs, Mosfets, Magnetics, Digital ICs, Analog ICs
   - Low Beta (hFE) Analysis

4. **Selected Examples**
   - Oscillators
   - Switching Frequency Analyses
   - Control Loop Stability
   - Signal Integrity/IBIS Simulation
   - Gate Drive
   - VRM Design
   - Clock Jitter and Crystals
   - Opamp Stability Analysis
   - Signal Integrity Analysis
     - Decoupling, FPGA SSO, PDN

DAY 2

5. **Analysis Task Compilation**
   - What to Analyze
   - WCCA Task Description Pitfalls
   - Digital, Analog, RF Guidelines
   - Handling Compliance Requirements

6. **Documentation**
   - Why is documentation important?
   - Formatting a report
   - What must be included in a report?
   - Example: Report
   - Document and File Storage
   - Reviewing a WCCA
   - Dealing with Non-Compliances
   - Dealing with Design Changes

7. **Analysis tools**
   - Digital, Analog, RF
   - SPICE Simulation Pitfalls
   - Modeling
     - Reviewing Vendor libraries
     - Modeling Pitfalls
     - What to look for in a vendor model
   - Solving Convergence Problems

8. **Testing for WCCA/Model Correlation**
   - What and Where to Test
   - Problems with data sheet data
   - Testing Components & Power Supplies
   - Stability, PSRR, Load Step
   - Non-Invasive Phase Margin
   - PDN Impedance Assessment
   - Hands-on Demonstration
     - 3-Terminal Regulator Testing and Compensation

9. **Aerospace TOR for WCCA Compliance**
   - Complying with TOR-2011(3905)-9
   - Analyses, Tolerances, Model Correlation
   - Requirements for TOR Parameters; Circuits and Parts
   - Generating a WCCA Plan
   - Upcoming TOR Requirements, Standards and Practices

10. **Extended Topics & Examples**
    - CLR79/Alum. Elec. Capacitor Modeling
    - Discrete LDO Design and Modeling
    - Magnetics Modeling
    - Stress and Derating Analysis
    - MTBF and FMECA