Introduction to Printed Circuit Board Design, Specification, Manufacturing and Construction

(One Day Seminar)

Introduction

This course presents an introduction to the process of manufacturing a printed circuit board at the physical level. Details on incorporating logic devices and design techniques are not presented, except where necessary to illustrate why certain board materials are required for specific applications. As processing speeds increase, use of FR-4 is becoming obsolete due to physical and operational parameters of the glass/resin structure. New regulatory requirements based on RoHS (Restriction of Hazardous Substance or use of lead-free components and solder) are now playing havoc during the production process with the need for higher processing temperatures, which in turn creates functionality and manufacturing concerns.

Design, manufacturing and production engineers must now consider the type of base material along with related costs and parametric values to ensure the system will work as desired. Significant tradeoffs must be made at the definition stage prior to layout and simulation analysis.

Topics presented include: What is a printed circuit board and why we should be learn about material usage; various material, construction and parameters of greatest concern; flex and rigid-flex configurations; detailed overview of common base materials; routing topologies and impedance control; layer stackup assignments; manufacturing concerns; vias; buried capacitive structures; embedded passives and material laminates; and use of commercial test systems to evaluate the finished product.

Course Objective

This course presents an overview on what it takes to design a printed board for both signal integrity and electromagnetic compatibility prior to fabricating an assembly and populating it with expensive components, only to learn that system wide failure results. The use of a particular substrate material is usually never considered during the troubleshooting phase. Much time can be spent to redesign circuits and build prototypes with limited success if one does not know what the problem was in the first place. By changing FR-4 to another material for basically the same cost, may allow one to enter the market earlier which means achieving significant revenue and a higher quality product.

Due to the complexity of producing a printed circuit board, fabricators must consider many parameters. If fundamental concepts of what needs to be considered during the specification period of the design are remembered, great success can be easily achieved.

Who Should Attend

The course targets printed circuit board designers, signal integrity, EMC, and manufacturing/production engineers responsible for the design and procurement of an operational printed circuit board assembly. No formal training in electronic theory is required.

Benefits of Attending

- Increased job knowledge
- Allows bringing up a printed circuit board to occur quickly
- Reduces design time and manufacturing costs
- State-of-the-art material usage and the future of design engineering will be illustrated

About the Instructor

Mark Montrose is principle consultant of Montrose Compliance Services, Inc., a full service regulatory compliance firm specializing in Electromagnetic Compatibility with 30 years of applied EMC experience. Prior to becoming a consultant, Mark was responsible for regulatory compliance for several high-technology companies in Silicon Valley, California. His work experience includes design, test and certification of both Information Technology (ITE) as well as Industrial, Scientific and Medical products (ISM). He is assessed by a European Competent Body to perform CE compliance approval and in situ testing and certification of industrial products.

Mark is a Senior Member of the IEEE and a past member of the *Board of Directors* of the IEEE as Division VI Director (2009-2010). He is also a long-term past Board member of the IEEE EMC Society plus Champion and First President of the IEEE Product Safety Engineering Society. He was a popular distinguished lecturer for the IEEE EMC Society and is considered an expert in printed circuit board design and system level applications for EMC compliance. He has presented numerous papers based on sophisticated research related to printed circuit boards and the field of EMC at International EMC Symposiums and Colloquiums worldwide. Mark also provides personalized in-house seminars and consulting services to corporate clients worldwide in addition to the University of California, Santa Cruz extension program.

Mark has authored the following best-selling text/reference books published by Wiley/IEEE Press.

- *Printed Circuit Board Design Techniques for EMC Compliance*, 1996-1st ed / 2000-2nd ed.
- *EMC and the Printed Circuit Board - Design, Theory and Layout Made Simple*, 1999.
- *Testing for EMC Compliance – Approaches and Techniques*. 2004.
- Contributing author to the *Electronics Packaging Handbook*, Chapter 6, 2000 (CRC/IEEE Press).

Montrose Compliance Services, Inc.
Electromagnetic Compatibility and Product Safety

2353 Mission Glen Drive
Santa Clara, CA 95051-1214
☎ and FAX (408) 247-5715
mark@montrosecompliance.com

Introduction to Printed Circuit Board Design, Specification, Manufacturing and Construction
(One Day Seminar)

DESCRIBING THE PRINTED CIRCUIT BOARD
- What is a Printed Circuit Board
- When Does A PCB Become Part Of The Circuit?
- Primary Concerns When Designing A PCB
- Basic PCP Board Construction Types

BOARD MATERIAL AND CONSTRUCTION PARAMETERS OF GREATEST CONCERN
- Primary Board Materials
- Bonding and Tolerances
- Concerns Related to Electrical and Physical Parameters
- Base (Laminate) Material
- Construction Process of a Typical Multilayer PCB
- Multilayer Construction Guidelines
- Dielectric Comparison of Core vs. Prepreg
- Copper Clad and Foil Laminates
- Current Carrying Capacity of Copper
- Electro-Deposited and Rolled Copper Forming Process
- Surface Material Finish
- Prepreg
- Relative Permittivity (Dielectric Constant)
- *Tg* – Glass Transition Temperature and Characteristics
- Coefficient of Thermal Expansion (CTE)
- Resistive Losses
- Dielectric Losses (Dissipation Factor or Loss Tangent)
- Soldermask and Conformal Coating
- Finished Trace Width Dimensions After Etching

FLEX AND RIGID-FLEX CONFIURATIONS
- Thermoplastic vs. Thermoset Flex Circuit Base Material
- Circuit Adhesives
- Properties of Metallic Foils for Flex Circuits
- Current Carrying Capability of Copper
- Conductor Configuration Comparison
- Stiffener Materials for Flexible Circuits
- Characteristic Impedance for Flex Circuit Transmission Lines
- Embedded Resistors
- Via Configurations
- Flexing and Bending Possibilities
- Typical Manufacturing Process

OVERVIEW OF COMMON BASE MATERIAL

ROUTING TOPOLOGIES AND IMPEDANCE CONTROL
- Signal Integrity Issues
- Microstrip and Stripline Topologies
- Impedance Control
- Factors Affecting Impedance
- Controlled Impedance Design Concerns

LAYER STACKUP ASSIGNMENTS

MANUFACTURING CONCERNS
- Film and Manufacturing Verification (Quality Control)
- Test Coupons and Cross Section Impedance
- Issues Related to Manufacturing and Testing
- Sample Design Specification Report from Fabricator
- RoHS Initiative and Lead-Free Concerns
- Lead Free Impact and Material Specification
- Lead Free Assembly and Thermal Properties
- Circuit Board Fabrication and Tolerances
- Component and Connector Pinouts
- Thermal Effects on Material Usage

VIAS
- Types of Vias
- High Interconnectivity
- Types of Via Utilization
- Relative Price/Density Tradeoffs for Via Structures

BURIED CAPACITIVE STRUCTURES
- Why Embedded Capacitance?
- Concept of Buried Capacitance
- Calculating Power and Ground Plane Capacitance
- Performance Range - Discrete Versus Planar Capacitance
- Buried Capacitance Constructional Details
- Power Distribution Performance
- Application Guidelines for Buried Capacitance
- Implementation of Buried Capacitance
- Types of Buried Capacitance Material Available
- Input Impedance of Various Buried Capacitive Structures
- Power Bus Noise Comparison Between Buried Capacitance Structures

EMBEDDED PASSIVES AND MATERIAL LAMINATES
- Considerations When Deciding To Use Embedded Passives
- Buried Resistors and Resistive Films
- Buried Capacitive Materials
- Buried Multiple Passive Elements
- Lossy Power and Ground Planes
- Combined Embedded Buried Resistor/Capacitor Laminates
- Advantages of Using Combined Embedded Material
- Electrical Parameters for Combined Material Use
- Processing of a Combined R/C Embedded Laminate
- Design Methodology to Capture Material Properties
- High Density Interconnects for Embedded Passives
- Buried Resistor and Capacitor Material Vendors

COMMERCIAL TEST SYSTEMS