# Grounding and Shielding Techniques

## for EMI, EMC and ESD

## Course No. 161

**APPLICATIONS** In modern electronics, as component size continues to decrease and complexity to increase, electrostatic and magnetic fields and their interactions are becoming increasingly important. As problems have arisen, creative solutions have been developed. This course pulls together the latest tools and techniques for overcoming problems related to electrostatic and magnetic coupling. An understanding of the principles and recent developments in this growing field is essential to many individuals in both commercial and military electronics industries.

**FOR WHOM INTENDED** This course is intended for individuals whose work requires an understanding of the effects of interacting electrostatic and magnetic fields on electrical and electronic equipment. Circuit designers, electronics packaging specialists, systems engineers, and electronic test specialists will find this course helpful.

**OBJECTIVES** To help participants to understand grounding and shielding concepts and terminology. To provide an overview of the newest and most effective techniques for overcoming problems through proper use of grounds and shields.

**BRIEF COURSE DESCRIPTION** The course is not an in-depth electrical engineering course but rather is aimed at individuals who require an intensive overview of basic principals, potential pitfalls and practical techniques, without the assumption of much prior knowledge of the topic.

The course is fast paced and as non-mathematical as possible. After a review of electrostatic concepts, such as charges, fields and forces, it takes up the basic theory of electrostatic and electromagnetic fields and field coupling. Armed with an understanding of the problem-causing mechanisms, students are prepared to devise solutions. The course addresses practical considerations such as cabling choices and the proper design and use of grounds. Effective grounding and shielding of amplifiers, voltmeters and enclosures will be covered. Techniques for measuring shielding effectiveness will be addressed. Electrostatic Discharge (ESD) is covered as it relates to equipment design. Comprehensive units on circuit board layout and switching power supplies conclude the course.

**DIPLOMA PROGRAMS:** This course is required for TTi's Data Acquisition & Analysis Specialist (DAAS), Electronic Design Specialist (EDS), Electronic Telecommunications Specialist (ETS), Instrumentation Test Specialist (ITS) and Metrology Calibration Specialist (MCS) Diploma Programs and is an optional course for any other TTi specialist certificate program.

**PREREQUISITES:** Students should have completed TTi's Course No. 104, "Electronics for Non-Electronic Engineers" or the equivalent. This course is aimed toward individuals actively involved in related technical fields. An understanding of basic electrical theory is required.

**TEXT** Each student will receive 180 days access to the on-line electronic course workbook. Renewals and printed textbooks are available for an additional fee.

**COURSE HOURS, CERTIFICATE AND CEUs** Class hours/days for on-site courses can vary from 14–35 hours over 2–5 days as requested by our clients. Upon successful course completion, each participant receives a certificate of completion and one Continuing Education Unit (CEU) for every ten class hours.

**INTERNET COMPLETE COURSE** 161 features over 13 hours of video as well as more in-depth reading material. All chapters of course 161 are also available as OnDemand Internet Short Topics. See the online course outline for details.

**Course Outline**

Course Introduction, Quiz for Evaluation of Class
Review of Electrostatics: Charges, fields, and forces
Electric Fields • Capacitance definitions • Self and mutual concepts
Screening and shielding concepts • Electric Field Coupling • Crosstalk
Capacitive Coupling • Crosstalk from Pulses • Using Ground to Reduce Capacitance • Electrostatic Shielding • Voltage sources
The Earth Plane • Room Pickup
Magnetic Field Coupling: Coupling Between Lines • Loop Area • Mutual Inductance Between Wires • Ground Plane and Wire Position, Orientation • Inductor Coupling • High-μ Material • Inductors
Mixed Coupling • Impedance Effect on Coupling Type
Dual Analysis • Superposition Model • Coupled Response Extended Model • Typical Response • Line Termination
Cables • Magnetic Coupling in a Loop • Cable Types • Large and Small Mutual Inductance • Poor Cable Grounding • Ground Current Shielding • Termination of Shield • Conductor Shielding Magnetic Shield • Alternate Current Paths • Shield Cutoff Loop Analysis • Ground Current • Shield Connection Methods High Freq. Current Flow • Ferrite Choke
Grounding: Types of Grounds • Electrical Safety • Single and Multi point Signal Grounds • Common Impedance Coupling • Hybrid Signal Grounds • Separation of Grounds • Hardware Grounds • Single Ground Reference • Amplifier Shields • Signal Input - Shield Enclosure • Capacitance Between Shield and Ground • Shield Connection
Low Frequency Grounding • Ground Loop Isolation
Differential Amplifiers: Induced Noise • Isolation Amplifier
Common-Mode Rejection • Differential Amplifier Response to Inputs
Guarded Voltmeter: Guard Shields • Grounded Measurement
Grounded Measurement with Common-Mode Voltage
Floating Measurement • Guarded Voltmeter • Connecting the Guard
Bridge Measurement • Connecting Guard for Bridge Measurements
Enclosure Shielding: Absorption Loss • Electric and Magnetic Fields
Low-Frequency Magnetic Fields • Multi-Layer Shields • Orientation
Conductive Gaskets • Measuring Shield Effectiveness • Plastics
Cabling to Shields • Transformer Shielding
Electrostatic Discharge: Triboelectric Series • Inductive Coupling
Charge Storage • Human Body Model • Discharge into Ideal Ground
Types of ESD Damage Common ESD Myths • ESD Prevention
ESD Protection in Equipment Design • Coupling Mechanism
Interface Cables and ESD • Guard Ring
Circuit Board Layout: Behavior of Ground Impedance • Initial Layout
Termination • Connectors • Resets • Quiet Designs • I/O Circuits
Test • Trace Discontinuities • Segment Ground and Power Planes?
Critical Circuits • Susceptibility • Input/Output • Selecting Devices
Red Flag: High-speed CMOS • Five-five Rule for Multilayer Boards
Image Plane Effect • Placement of Signal Traces • Parallel Planes
Switching Power Supplies: Rectifier Diode Recovery Time
Capacitively-Coupled Ground Circuit • Returning Stray Switching Current to Primary Common • Conventional Secondary Filter
Low-Emission Secondary Filter • Transformer Resonance
Transformer Snubber • Snubber Design
Possible Snubber Locations in the Secondary
Summary • Final Review • Certificates for Successful Completion

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