
Instrumentation for Test and Measurement

Course No. 163

Some organizations are wasting time and money using archaic, unreliable instrumentation. They are using technologies of the 'thirties to monitor today's products and processes. Course 163 offers understanding of modern instrumentation and systems, with which data can be acquired with a speed, volume and accuracy unknown a decade ago.

FOR WHOM INTENDED Engineers, aides and technicians. Some background in electronics is helpful but is not essential. The course will be tailored to student objectives.

OBJECTIVES To provide a basic understanding of measurement systems. To alert the students to the many varieties of transducers available, their operating principles, strengths and weaknesses. To give students enough applications information that they can select optimum transducer, amplifier, recording and readout devices to assemble a system for routine measurements of environmental and dynamic phenomena.

BRIEF COURSE DESCRIPTION Mainly lectures, supported by slides, transparencies, videotapes and sample hardware. Students are expected to participate in classroom discussions and in a small group case study exercise, as well as read text materials and class notes. See syllabus.

Course 163 presents basic information on selection, application, calibration and usage of modern measurement systems to measure electrical, environmental and dynamic phenomena. The course emphasizes a non-mathematical approach to understanding concepts and mechanisms. A variety of measurands and transducer types is covered, as well as signal conditioning, recording and analysis.

Participants are encouraged to bring a specific measurement problem to class for use as a case study. The instructor will introduce one or more student problems (and/or a preselected case) on the first day. Each day's course material will further develop the case study. A solution will be given at the end.

CERTIFICATE PROGRAMS This course is required for several of TTI's [Specialist Certificate programs](#).

PREREQUISITES There are no definite prerequisites, but participation in TTI's course "[Electronics for Non-Electronic Engineers](#)" or the equivalent would be helpful.

TEXT Each student will receive a [course workbook](#) including most of the viewgraphs used in the presentation.

COURSE HOURS, CERTIFICATE AND CEUs Open courses meet seven hours per day. Upcoming presentation dates can be found on our current [open course schedule](#). 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.

AUTOMOTIVE APPLICATIONS Course No. 165, "Instrumentation for Noise, Vibration and Harshness (NVH) Measurement and Test," is also available for on-site presentation. Ask for an outline and proposal.

For [schedules](#), [general information](#) and [registration forms](#), see TTI's web site.

Course Outline

Introduction; Class "Case Study" Project
Review of Electrical Fundamentals: Fields & Potentials
Conductors, Current, voltage, resistance, capacitance, inductance
Sinusoidal waveforms and AC • Reactance, impedance, series and parallel resonance • Periodic, transient and complex signals
Mutual inductance • Transformers • AC power Distribution • Safety
Understanding decibels and Octaves • Logarithmic scale in graphs
Noise: Gaussian Distribution • Weak Signal • Noise Calculations
Suppression for Sensor Signals • Noise Figure and Distortion
Electronic Noise Measurements • Phase Noise • Phase Noise Display •
Noise Types: Shot (or Schottky), Thermal (or Johnson), Flicker (1/f),
Burst, Avalanche • Noise Viewed as a Vector
Parameters of linear systems • Non-linearity and Distortion • Filters
Accuracy, Calibration, Error Assessment: Statistics • Gaussian
Distribution • Probability Density • Measurement Error
Transducers: Ideal Transducer • Mechanisms • Environmental Effects
Temperature Sensors, Measurements, Effects • Thermoelectric
Transducers • Thermocouples • Temperature Sensor Attributes,
Advantages, Disadvantages • Strain Gauge • Displacement Meas.
Silicon Semiconductor Transducers • Pressure Transducers •
Accelerometers: Frequency, Acceleration Response
Seismic and Vibration Transducers • Piezoelectric Accelerometers •
Mounting • Stress and Strain • Torque • Flow Meters • Velocity
Sensing • LVDT • Pressure Sensors • Potentiometric Transducers
Amplifiers and signal conditioners: DC and FM carrier amplifier
Capacitive and Resistive Source Impedance • Bridge circuits • Filters
Avoiding unwanted signals: Electrical Noise • High or Low Signal Source
Impedance • Source Shunting • Parallel or Twisted Signal Conductors •
Basic Amp Types • Grounding, Shielding • Common Mode Rejection
System considerations: Amplifier-Source Compatibility • Source Shunting
Zero Suppression • Amp types, characteristics • RC Time Constant
Integrating, differentiating and filters • Integrating, Differentiating Circuits
Filtering • Acoustic Weighting • Bandpass Filter • Filter damping
Filter Characteristics: Butterworth, Chebyshev, Bessel • RC and LR
Working with Digital Signals: Waveform Reproduction and Sample Rate
Analog to Digital and Digital to Analog Conversion
Quantization Error • Aperture Error • Number of Bits and LSB
Digital analytical techniques: Fourier Without Pain • Adding Sine Waves
Time and Frequency Domain • Fourier Analysis • Phase
Dynamic Signal Analyzer • Spectrum Analyzers
Analog and Digital Frequency Analyzers • Parallel Filter Analyzer
Random Frequency Analysis • Aliasing • Windowing • Correlation
Oscilloscopes: Display Subsystem
Measuring Voltage, Time & Frequency, Phase and Pulse
Lissajous Patterns • Digital Oscilloscopes
Shock Measurement: Force Sensors • Load Cells • Motion Trackers
EM Induction • Velocity & Acceleration Sensors • Seismic Transducers
Cabling • Accelerometer attachment • Calibration
Digital Instruments and Data Recorders: Setting up and operating
Digital Multimeters • Calibrators • Current-to-Voltage Converters
Function Generators • Portable Data Acquisition Recorders
LabView Graphical Solutions
Digital Multimeter Operation: Interface Bus, Display, Functions, Calibration
Making Measurements • Connection Configuration • Guarding •
Measuring AC and DC Voltage and Current • Measuring Resistance
Summary and overview • Final presentation of "case study" project
Final Review • Award of certificates for successful completion



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