Instrumentation for Test and Measurement

Course No. 163

Course 163 offers understanding of modern instrumentation and systems, with which data can be acquired with a speed, volume and accuracy unknown a few decades 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.

DIPLOMA PROGRAMS This course is required for TTi's Environmental Engineering Specialist (EES), Dynamic Test Specialist (DTS) and Climatic Test Specialist (CTS) Diploma programs. It may be used as an optional course for any other Specialist Diploma program.

RELATED COURSES See Course 164, Instrumentation for Electrical Test and Measurement.

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 180 days access to the on-line electronic course workbook. Renewals and printed textbooks are available for an additional fee.

COURSE HOURS, CERTIFICATE & 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 163 features almost 15 hours of video as well as more in-depth reading material. All chapters of course 163 are also available as OnDemand Internet Short Topics. See the on-line course outline for details

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.

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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