Applied Measurements

Course No. 166

FOR WHOM INTENDED Engineers, scientists, and managers. This course will be of interest to personnel involved in making or understanding experimental test measurements.

BRIEF COURSE DESCRIPTION The course provides participants with engineering concepts for the whole measurement system. It covers climatic measuring systems and reviews dynamic theory, which is essential for a better understanding of the measurand under consideration.

Transducers are discussed, as are the principles of the Wheatstone bridge, a basic tool for many measurement applications. The problems of signal noise, accuracy and error are covered in some depth before continuing on to spectral analysis, sampling and discussion of aliasing problems, filter types and anti-aliasing solutions.

The uncertainty surrounding the value of the measurand is discussed and an introduction to statistics as applied to engineering is covered.

One of the most difficult tasks for the measurement engineer is the selection of the proper instrumentation system. A procedure for attaining this goal is discussed and a typical instrumentation selection list developed.

While calibration is beyond the scope of this course, a procedure for calibrating a sensor device is developed and discussed.

DIPLOMA PROGRAMS This course is required for TTi's Data Acquisition & Analysis Specialist (DAS), Electronic Telecommunications Specialist (ETS), Instrumentation Test Specialist (ITS), Mechanical Design Specialist (MDS) and Metrology/Calibration Specialist (MCS) Diploma Programs, and may be used as an elective for any other TTI specialist diploma program.

RELATED COURSES Course 166/164 combines most of Course 166 with most of Course 164. Course 166/164 is available as a complete internet OnDemand course.

PREREQUISITES Students should have completed TTi's Course 163 "Instrumentation for Test and Measurement" or the equivalent. This course is aimed toward individuals actively involved in related technical fields. Knowledge of basic measurement 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 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.

COMPLETE INTERNET OnDEMAND COURSE 166 features over 8 hours of video as well as more in-depth reading material. All course 166 chapters are also available as OnDemand Internet Short Topics. See the on-line course outline for details.

Course Outline

Introduction to Measurement Engineering
- Definitions • Preparing to Make Measurements • Open and Closed Loop Systems
- Analog and Digital • Transfer of Energy • Measurement System Responses

Understanding Decibels (dB) and Octaves
- Decibels • Power and Voltage Ratios • Conversions • Adding in dB
- Reference Levels for decibel Notation • Octaves • $^1/_3$ Octave Bandwidth Levels

Climatic Measurements: Temperature • Humidity • Pressure • Flow

Review of Dynamic Theory: Laws of Motion • Weight, Mass and Gravity
- Force, Mass and Acceleration • Work, Power • Energy
- Linear and Angular Displacement; Linear Velocity • Tangential Acceleration • Torque
- Stress and Strain • Simple Tension or Compression • Shear Strain

Transducers: Mechanisms • Displacement • Principles • Force Summing
- Piezoelectric Transduction • Dynamic Sensors • Frequency Response
- Acceleration Response • Vibration Transducers

Wheatstone Bridges: Basic Laws of Networks • Voltage Divider Circuit • Methods of Measurement • Voltage-Sensitive and Current-Sensitive Bridges • Constant-Current Bridges • Bridge Sensitivity • Three-Wire Bridge • Effects of Temperature • Shunt Calibration • Voltage Insertion Calibration • Strain Gage Compensation • AC Bridges—Classic Inductance, Capacitance Bridges

Reducing Signal Noise: Unwanted Signals • Shield Strategies • Twisted Pair • Electrical Noise: High Signal Source Impedance • Low Signal Source Impedance • Source Shunting • Parallel Conductors • Twisted Conductors • Microvolt-Level Signal Cables Ground Loops • Eliminating Multiple Grounds • A Stable System Ground Amplifier Guard Shield • Common-Mode Rejection

Accuracy and Error: Accuracy, Calibration and Error Assessment • Common Terms: Accuracy vs. Precision • Classification of Errors • Error Assessment • Improper Functioning of Instruments • Effect of Transducer on Process • Dual Sensitivity Errors Minimizing Error

Spectral and Fourier Analysis: Spectral Analysis • Sinusoidal, Complex and Random Signals • Phase of Frequency Domain Components • Time and Frequency Domain Fourier Analysis • Adding Two Signals—Using RMS Values • The Fourier Transform Discrete Fourier Analysis • FFT • Classification of Types of Data • Random Signals Correlation • Cross-Correlation, Coherence • Auto Spectral Density (ASD) Power Spectral Density • Calculating RMS From PSD

Signal Analysis and Aliasing: Signal Acquisition • Shannon's Theorem and Corollaries Aliasing Viewed as Folding • Where Does the Aliased Data Appear? Example .. Sine Signal • Aliasing/Multiple Folding • Digitizing "Rules" Interpolation ..When is it Needed?

Filters: Integrating and Differentiating Circuits • Acoustic Weighting • Bandpass Filter Undamped (high Q) vs. Damped (low Q) Filters • Selective Filtering Characteristics of Butterworth, Chebyshev and Bessel Filters • RC and LR Circuits Anti-Alias Filters • Brick-Wall vs Real Filters • Aliasing Analysis Anti-Alias Filters—Hardware • Filter "Construction" • How Filters Behave • Group Delay Filter Cutoff Frequency • Sampling Ratio Calculation • FR/FD Ratio

Measurement Uncertainty and Introduction to Statistics
- Error and Uncertainty • ISO Definitions • Simple Statistics of Measurement
- Probability—Definitions • Data Distributions • Cumulative Frequency Curve Summation
- Degrees of Freedom (ν) • Mean, Median and Mode • Standard Deviation (s or σ)
- Variance (s^2) • Normal Distribution • Gaussian Curve • Confidence
- Gaussian (s-Normal) Distribution • Special Definitions for Random Vibration
- Computing the Standard Deviation—Example • Confidence Levels
- Type B — Evaluations other than Statistical

Summary, Final Quiz, Award of Certificates for Successful Completion

Technology Training, Inc.
(a tti group company)
Toll-free tel: 866-884-4338 (866-TTi-4edu)
International: 805-845-5050
E-mail: Training@ttiedu.com
www.ttiedu.com