

# Electrical Instrumentation Calibration Procedures

## Course No. 136

**FOR WHOM INTENDED** This course is intended for personnel involved in metrology, instrumentation and various testing activities. It is an elective for TTI's [Metrology Specialist Certificate Program](#) and is designed to provide a basic understanding of the methodology of calibration of electrical measuring and test equipment.

**BRIEF COURSE DESCRIPTION** The course commences with a brief review of some basic terminology, systems of units, measurement standards, traceability and types of error. The course then covers calibration standards and documents affecting the calibration of electrical items. A brief review is made of measurement uncertainty.

The course then covers calibration equipment and techniques in detail, starting with a discussion of electrical instrument calibration with precision instruments such as VOM devices, oscillators, counters, function generators, power supplies, RF power instrumentation, temperature simulation and measuring equipment, and fiber optic instruments.

Electrical working standards are discussed, such as meter calibrators, oscilloscope calibrators, multi-function calibrators, distortion analyzers, counters, LF Spectrum Analyzers, RCL Meters and substitution boxes, and more.

Attention will focus more on generic processes and theory of individual measurements than on how to calibrate a specific instrument. We will explore the background and theory of precision measurements in voltage, current, resistance, capacitance, inductance, frequency, and LF/RF power. Further discussion of measurement and theory in noise, total harmonic distortion, phase angle, modulation, and rise time will be pursued in detail.

The instructor presents the course aided by overhead Power Point slides. Students are expected to participate in classroom discussion and exercises.

**CERTIFICATE PROGRAMS** This course is required for TTI's [Instrumentation Test Specialist Certificate Program](#). A recommended elective for the [Metrology Specialist Certificate](#), it may be an elective for any other TTI certificate program.

**PREREQUISITES** There are no definite prerequisites, but TTI's courses [Electronics for Non-Electronic Engineers](#), [Metrology Concepts](#) and [Instrumentation for Electrical Test and Measurement](#) would be helpful.

Supervisors are invited to telephone or e-mail TTI on prospective attendees' backgrounds and needs.

**TEXT** Each participant will receive a [course workbook](#), which contains most of the PowerPoint slides used during the presentation. The appendix includes metrology reference information.

**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.

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

## Course Outline

### Introduction and Focus • Metrology Terminology

Scope of Metrology • Measurement Processes • Units  
Measurement error • Classification of Error • Error vs. Accuracy

### Measurement Standards and Traceability

Measurement Standards • Traceability • Definition of the Second Coordinated Universal Time (UTC) • Definition of the Ampere Voltage Reference • Josephson Junction • Standard Resistor

### Technical Requirements in Calibration Standards

US Government Agencies • Calibration Program—Operations  
Historical requirements: MIL-STD 45662A • ANSI Z540-1-1994  
Compliance Documents • NIST • Calibration Procedure Template  
Handling, Records, Certificates & Reports • Accreditation  
Technical and Calibration requirements in ISO 9000

### Types of Standards: Oscilloscope Calibrators

Multifunction Calibrators • Distortion Analyzers • Counters  
LF Spectrum Analyzers & FFTs • RCL Devices

### Measurement Uncertainty

Purpose of a Measurement • Accuracy Concept  
Error types: Random, Instrumentation, Environmental and Observational • Reduction of Observer Bias (exercise)  
Estimating Measurement Uncertainty of a Calibration Process

### Example: Estimating Electrical Uncertainty

Calibration of a Hand-Held Digital Multi-meter at 100 V dc  
Resolution • Uncertainty Budget • Expanded Uncertainty

### Electrical Calibration

VOM Devices: Digital Multi-Meters • DMM Data Sheet • Tolerances Terminology • Two Wire and Four Wire Ohms • Processes  
Synthesizers/Sweepers: Dbm and Dbu Power  
Synthesized Sweep Oscillator Specifications • Level Specs  
Output Level Flatness • Frequency Specifications • Harmonics  
Phase Noise Display • Modulation • Measuring Power  
Mismatch Calculation and Conversions • Frequency Meter  
Harmonic Test with Spectrum Analyzer • Phase Noise Test  
Counters, Function & Pulse Generators, Power Supplies  
Counters • Frequency Standards • Counters—Functions  
Function and Pulse Generators • Pulse Characteristics  
Power Supplies • Grounding of Power Supply  
Temperature/ Humidity Simulation & Measurement  
Thermocouple • SPRT • RTD • Data Logging Types  
Humidity Calibration • Chilled Mirror Concept  
Spectrum and Network Analyzers: The Frequency Domain  
Calibration and Validation Kits  
Impedance Bridges • Amplifiers • Logic Analyzers  
Angle Position Indicators  
RF Power Measurement: RF Power Meter Use  
RF Power Meter and Sensor Calibration  
Fiber Optic Calibration: Overview • Optical Specifications  
Optical Devices: Power Meter, Sources, Spectrum Analyzers  
Wave Meters • OTDR and Back Reflection • Optical Attenuator

### Calibration of Vibration Measuring Instruments: Transducers

Strain Gages • Accelerometers • Comparison Method

### Oscilloscopes: Analog • Digital • High Bandwidth • Specifications Calibration Procedures

### Overview of ISO 17025

Material Review Boards • Corrective Action • Preventive Action  
Class Project • Summary, Final Review  
Award of certificates for successful completion



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Toll-free tel: 866-884-4338 (866-TTI-4edu)  
805/845-5050 • Fax 805/845-4674

E-mail: [Training@ttiedu.com](mailto:Training@ttiedu.com)

<http://www.ttiedu.com>