ICTD

المركز العالمي للتدريب والتطوير

International Centre For Training & Development

POWER QUALITY

Earthing & Bonding

Course Introduction:

The rapidly increasing installation of electronic equipment such as digital controls, computers and sensitive process control equipment has increased the susceptibility of utility end-users to supply disturbances. In addition, the application of power electronic equipment with its higher energy efficiency and more effective control features has in turn often increased the level of disturbances that might affect end-user equipment.

Both electric utilities and end users of electric power are becoming increasingly concerned about the quality of electric power. The term power quality has become one of the most prolific buzzwords in the power industry especially in the second half of the 1990s. It is an umbrella concept for a multitude of individual types of power system disturbances. The issues that fall under this umbrella are not necessarily new. What is new is that engineers are now attempting to deal with these issues using a system approach rather than handling them as individual problems.

This course is designed to provide participants with a comprehensive and up-to-date understanding of the causes of power quality problems and how to prevent them. It discusses every essential aspect of basic power quality and methods used to protect electronic systems. This course will cover all power quality problems including voltage sags, harmonics, transients and light flicker. Delegates will learn analysis fundamentals, instrumentation techniques and methods of improving power quality by both network and plant modifications. Delegates will review the causes of various types of power quality problems in commercial and industrial environments. The effect of these problems on power system components and end-user equipment will also be addressed. Commercially available tools for identifying these problems will be discussed and demonstrated as well as how to interpret their results. Further, delegates will evaluate ground connections and solve many common grounding problems.

Course Objectives:

Upon the successful completion of this course, participants will be able to know:

- How to protect against voltage sags and interruptions
- The principles of harmonics and filtering
- Common wiring and grounding problems, along with solutions
- Transient over voltages due to lightning and switching
- The technical impact of problems on various load equipment
- Utility and end-user strategies for improved power qualities

Who Should Attend?

Managers, electrical engineers, utility specialists and senior electrical technical staff who wish to advise end-users on power quality concerns, or who service large end-users or who wish to understand aspects of network design, construction and maintenance techniques for maximizing quality of supply. Personnel working in all areas of power system design who wish to know how the system interacts with the end-user will also gain from this course.

Course Outline:

Introduction, Terms and Definitions

- What is Power Quality?
- Power Quality = Voltage Quality
- Why Are We Concerned about Power Quality?
- The Power Quality Evaluation Procedure
- Need for a Consistent Vocabulary
- General Classes of Power Quality Problems
- Transients
- Impulsive Transient
- Oscillatory Transient
- Long-Duration Voltage Variations
- Overvoltage
- Undervoltage
- Sustained Interruptions
- Short-Duration Voltage Variations
- Interruption
- Sags (Dips)
- Swells
- Voltage Imbalance
- Waveform Distortion
- Voltage Fluctuation
- Power Frequency Variations
- Power Quality Terms
- Ambiguous Terms
- CBEMA and ITI Curves

Voltage Sags and Interruptions

- Sources of Sags and Interruptions
- Estimating Voltage Sag Performance
- Area of Vulnerability

- Equipment Sensitivity to Voltage Saga
- Transmission System Sag Performance Evaluation
- Utility Distribution System Sag Performance Evaluation
- Fundamental Principles of Protection
- Solutions at the End-User Level
- Ferroresonant Transformers
- Magnetic Synthesizers
- Active Series Compensators
- On-Line UPS
- Standby UPS
- Hybrid UPS
- Motor-Generator Sets
- Flywheel Energy Storage Systems
- Superconducting Magnetic Energy Storage (SMES) Devices
- Static Transfer Switches and Fast Transfer Switches
- Evaluating the Economics of Different Ride-Through Alternatives
- Estimating the Costs for the Voltage Sag Events
- Characterizing the Cost and Effectiveness for Solution Alternatives
- Performing Comparative Economic Analysis
- Motor Starting Sags
- Motor-Starting Methods
- Estimating the Sag Severity during Full-Voltage Starting
- Utility System Fault-Clearing Issues
- Overcurrent Coordination Principles
- Fuses
- Reclosing
- Fuse Saving
- Reliability
- Impact of Eliminating Fuse Saving
- Increased Sectionalizing
- Midline or Tap Reclosers
- Instantaneous Reclosing
- Single-Phase Tripping
- Current-Limiting Fuses
- Adaptive Relaying
- Ignoring Third-Harmonic Currents
- Utility Fault Prevention
- Fault Locating

Transient Overvoltages

- Sources of Transient Overvoltages
- Capacitor Switching
- Magnification of Capacitor-Switching Transients
- Ligthning
- Ferroresonance
- Other Switching Transients
- Principles of Overvoltage Protection
- Devices for Overvoltage Protection
- Surge Arresters and Transient Voltage Surge Suppressors
- Isolation Transformers
- Low-Pass Filters
- Low-Impedance Power Conditioners
- Utility Surge Arresters
- Utility Capacitor-Switching Transients
- Switching Times
- Preinsertion Resistors
- Synchronous Closing
- Capacitor Location
- Utility System Lightning Protection
- Shielding
- Line Arresters
- Low-Side Surges
- Cable Protection
- Scout Arrester Scheme
- Managing Ferroresonance
- Switching Transient Problems with Loads
- Nuisance Tripping of ASDs
- Transients from Load Switching
- Transformer Energizing
- Computer Tools for Transients Analysis

Fundamentals of Harmonics

- Harmonics Distortion
- Voltage versus Current Distortion
- Harmonics versus Transients
- Power System Quantities under Nonsinusoidal Conditions
- Active, Reactive, and Apparent Power
- Power Factor: Displacement and True

- Harmonic Indices
- Total Harmonic Distortion
- Total Demand Distortion
- Harmonic Sources from Commercial Loads
- Single-Phase Power Supplies
- Fluorescent Lighting
- Adjustable-Speed Drives for HVAC and Elevators
- Harmonic Sources from Industrial Loads
- Three-Phase Power Converters
- Arcing Devices
- Saturable Devices
- Harmonic Phase Sequences
- Triplen Harmonics
- Locating Harmonic Sources
- System Response Characteristics
- System Impedance
- Capacitor Impedance
- Parallel Resonance
- Series Resonance
- Effects of Resistance and Resistive Load
- Effects of Harmonic Distortion
- Impact on Capacitors
- Impact on Transformers
- Impact on Motors
- Impact on Telecommunications
- Impact on Energy and Demand Metering
- Interharmonics

Applied Harmonics

- Harmonic Distortion Evaluations
- Concept of Point of Common Coupling
- Harmonic Evaluations on the Utility System
- Harmonic Evaluation for End-User Facilities
- Principles for Controlling Harmonics
- Reducing Harmonic Currents in Loads
- Filtering
- Modifying the System Frequency Response
- Where to Control Harmonics
- On Utility Distribution Feeders

- In End-User Facilities
- Harmonic Studies
- Harmonic Study Procedure
- Developing a System Model
- Modeling Harmonic Sources
- Computer Tools for Harmonic Analysis
- Harmonic Analysis by Computer - Historical Perspective
- Devices for Controlling Harmonic Distortion
- In-Line Reactors or Chokes
- Zigzag Transformers
- Passive Filters
- Active Filters
- Harmonic Filter Design: A Case Study
- Case Studies
- Evaluation of Neutral Loading and Transformer Derating
- Interharmonics Caused by Induction Furnaces
- Standards on Harmonics
- IEEE Standard 519-1992
- Overview of IEC Standards on Harmonics
- IEC 61000-2-2
- IEC 61000-3-2 and IEC 61000-3-4
- IEC 61000-3-6
- NRS 048-02
- EN 50160

Long Duration Voltage Variations

- Principles of Regulating the Voltage
- Devices for Voltage Regulation
- Utility Step-Voltage Regulators
- Ferroresonant Transformers
- Electronic Tap-Switching Regulators
- Magnetic Synthesizers
- On-Line UPS Systems
- Motor-Generator Sets
- Static Var Compensators
- Utility Voltage Regulator Application
- Line Drop Compensator
- Regulators in Series
- Capacitors for Voltage Regulation

- Shunt Capacitors
- Series Capacitors
- End-User Capacitor Application
- Location for Power Factor Correction Capacitors
- Voltage Rise
- Reduction in Power System Losses
- Reduction in Line Current
- Displacement Power Factor versus True Power Factor
- Selecting the Amount of Capacitance
- Regulating Utility Voltage with Distributed Resources
- Flicker
- Sources of Flicker
- Mitigation Techniques
- Quantifying Flicker

Power Quality Benchmarking

- Introduction
- Benchmarking Process
- RMS Voltage Variation Indices
- Characterizing RMS Variation Events
- RMS Variation PerformanceIndices
- SARFI for the EPRI DPQ Project
- Example Index Computation Procedure
- Utility Applications
- Harmonics Indices
- Sampling Techniques
- Characterization of Three-Phase Harmonic Voltage Measurements
- Definition of Harmonic Indices
- Harmonic Benchmark Data
- Seasonal Effects
- Power Quality Contracts
- RMS Variations Agreements
- Harmonics Agreements
- Example Contract
- Power Quality Insurance
- Overview of Power Quality Insurance Concept
- Designing an Insurance Policy
- Adjusting for PQ Investment Costs
- Power Quality State Estimation

- General Approach
- Number of Monitors
- Estimating RMS Variations
- Simulation Engine Requirements
- Including Power Quality in Distribution Planning
- Planning Process
- Risk versus Expected Value
- System Simulation Tools
- Fault Incidence Rates
- Overcurrent Device Response
- Customer Damage Costs

Distributed Generation and Power Quality

- Resurgence of DG
- Perspectives on DG benefits
- Perspectives on Interconnection
- DG Technologies
- Reciprocation Engine Genst
- Combustion (Gas) Turbines
- Fuel Cells
- Wind Turbines
- Photovoltaic Systems
- Interface to the Utility System
- Synchronous Machines
- Asynchronous (Induction) Machines
- Electronic Power Inverters
- Power Quality Issues
- Sustained Interruptions
- Voltage Regulation
- Harmonics
- Voltage Sags
- Operating Conflicts
- Utility Fault-Clearing Requirements
- Reclosing
- Interference with Relaying
- Voltage Regulation Issues
- Harmonics
- Islanding
- Ferroresonance

- Shunt Capacitor Interaction
- Transformer Connections
- DG on Low-Voltage Distribution Networks
- Fundamentals of Network Operation
- Summary of Network Interconnection Issues
- Integration Techniques for DG on Networks
- Siting DG
- Interconnection Standards
- Industry Standards Efforts
- Interconnection Requirements
- A Simple Interconnection
- A Complex Interconnection

Wiring and Grounding

- Resources
- Definitions
- Reasons for Grounding
- Typical Wiring and Grounding Problems
- Problems with Conductors and Connectors
- Missing Safety Ground
- Multiple Neutral-to-Ground Connections
- Ungrounded Equipment
- Additional Ground Rods
- Ground Loops
- Insufficient Neutral Conductor
- Solutions to Wiring and Grounding Problems
- Proper Grounding Practices
- Ground Electrode (Rod)
- Service Entrance Connections
- Panel Board
- Isolated Ground
- Separately Derived Systems
- Grounding Techniques for Signal Reference
- More on Grounding for Sensitive Equipment
- Summary of Wiring and Grounding Solutions

Power Quality Monitoring

- Monitoring Considerations
- Monitoring as Part of a Facility Site Survey

- Determining What to Monitor
- Choosing Monitoring Locations
- Options for Permanent Power Quality Monitoring Equipment
- Disturbance Monitor Connections
- Setting Monitor Thresholds
- Quantities and Duration to Measure
- Finding the Source of a Disturbance
- Historical Perspective of Power Quality Monitoring Equipment
- Power Quality Measurement Equipment
- Types of instruments
- Wiring and Grounding Testers
- Multimeters
- Digital Cameras
- Oscilloscopes
- Disturbance Analyzers
- Spectrum Analyzers and Harmonic Analyzers
- Combination Disturbance and Harmonic Analyzers
- Flicker Meters
- Smart Power Quality Monitors
- Transducer Requirements
- Assessment of Power Quality Measurement Data
- Off-Line Power Quality Data Assessment
- On-Line Power Quality Data Assessment
- Application of Intelligent Systems
- Basic Design of an Expert System for Monitoring Applications
- Example Applications of Expert Systems
- Future Applications
- Power Quality Monitoring and the Internet
- Summary and Future Direction
- Power Quality Monitoring Standards
- IEEE 1159: Guide for Power Quality Monitoring
- IEC 61000-4-30: Testing and Measurement Techniques--Power Quality Measurement Methods

Course Methodology:

A variety of methodologies will be used during the course that includes:

- (30%) Based on Case Studies
- (30%) Techniques
- (30%) Role Play
- (10%) Concepts
- Pre-test and Post-test
- Variety of Learning Methods
- Lectures
- Case Studies and Self Questionaires
- Group Work
- Discussion
- Presentation

Course Certificate:

International Center for Training & Development (ICTD) will award an internationally recognized certificate(s) for each delegate on completion of training.

Course Fees:

To be advised as per course locations. This rate includes participant's manual, Hand-Outs, buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Course Timings:

Daily Course Timings:

08:00 - 08:20	Morning Coffee / Tea
08:20 - 10:00	First Session
10:00 - 10:20	Coffee / Tea / Snacks
10:20 - 12:20	Second Session
12:20 - 13:30	Lunch Break & Prayer Break
13:30 - 15:00	Last Session