



EE156

POWER SYSTEMS QUALITY:

Analysis and Problem Solving

Course Introduction:

Concern over the "quality" of electric power has been increasing rapidly over recent years. Today's, Distribution equipment and connected loads are more sensitive to power quality variations than in the past. At the same time more load types which contribute to poor power quality in Distribution Networks are being connected.

Course Objectives:

Upon the successful completion of this course, each participant will be able to:

- ✓ Understand the importance of Power Quality
- ✓ Learn the causes of poor power quality
- ✓ Study the principles for controlling voltage and frequency in power networks
- ✓ Comprehend the reasons for harmonic distortion and study appropriate solutions

Who Should Attend?

This course is intended for engineers, designers, supervisors and other technical staff who are involved in Power Systems Quality.

Course Outline:

Day 1:

- Introduction and General Information
- Defining Power Quality – Variations from acceptable conditions
 - Voltage
 - Frequency
 - Sinusoidal Wave Distortion - Harmonics
- Significance and economic impact of inadequate power quality
- Introduction to Causes of Voltage Sags and Swells
 - Transient
 - Steady State
- Worked Examples and Case Studies
- Introduction to Causes of Frequency Variations
 - Transient
 - Significant generation losses
 - Significant demand losses
- Steady State Causes of Frequency Variations
- Worked Examples and Case Studies
- Introduction to Causes of Wave Distortions

- Generator Rotor Earth Faults
- Phase Angle Controlled Rectifiers and Inverters
- Other Harmonic Producing Loads
- Understanding Harmonics
- Revision of Basic Laws of AC
 - Current Balance in Star Windings of Three-phase power transformers
 - Harmonics from Different Types of Converters
- Network Examples and Discussions

Day 2:

- Steady State Voltage Control in Grid Systems affecting Distribution Networks
- Effects of Line and Cable R, X and B Values
- Generating Unit Capability Charts
- Alternator AVR's and Limiters
- Reactive Power Balance at Peak Loads
- Reactive Power Balance at Minimum Loads
- Reactive Compensation Equipment
- On-load Tap-changers – Automatic Voltage Control (AVC/LTC)
- **Worked Examples and Case Studies**
 - Transient Voltage Conditions on Grid Systems affecting Distribution Networks
- Short Circuit Conditions – Balanced and Unbalanced Faults
- Earthing Policies
- Circuit-breaker clearance times
- Switching Over-voltages and Resonance Effects
 - Introduction to Power Application Software for Power Quality Analysis
- **Example – Real Grid Network Modeled using Power Application Software**
 - Overview of Voltage Control in Distribution Networks with Grid Infeed(s)
- With Embedded Generation
- Without Embedded Generation
 - Overview of Voltage Control in Isolated Distribution Networks¹
- **Network Examples and Discussions**

Day 3:

- Voltage Control in Utility Radial Distribution Feeders¹
 - Topology
 - Three-phase (Three-wire)
 - Single-phase
 - Two-phase
 - Hybrid (4-wire systems)
 - Load typology and modeling
 - Residential

- Commercial
 - Industrial
 - Other
 - Distributed Loads
 - Spot Loads
- Load Flow and Feeder Voltage Drop Profiles
- Voltage Regulators
- Capacitor Placement and Economic considerations
- Multiple Feeder Considerations and choice of open points
- Practical Solutions
- Practical Session at individual workstations using Power Application Software
 - Voltage Control in Industrial Networks*
 - Topology
 - Acceptable Profiles – Equipment Issues
 - Power Factor Correction Issues
- Motor Loads
 - Induction
 - Synchronous
 - Motor Starting Conditions
 - Under-voltage Protection issues

Day 4:

- Frequency Control in Transmission Systems affecting Distribution Networks
- Generator Governors and Droop Settings
- Effects of Loss of Generating Units
- Power Frequency Constants (K_g and K_L)
- Adequate Spinning Reserve Criteria
- Under Frequency Protection of Generating Units
- Under Frequency Load Shedding
- Worked Examples and Case Studies
 - Frequency Control in Isolated Distribution Networks1
- (Same items as above)
- Worked Examples and Case Studies
 - Sources of Harmonics in Distribution Systems
- Unbalanced Transformers
- Transformer Saturation
- Non-linear reactors e.g. Ballasts in Fluorescent Lighting
- Equipment Thyristor Control Systems e.g. Variable Speed Drives
- Rectifiers
- Arc Furnaces

- Example Waveforms and Discussions
 - Monitoring and Metering Issues
 - On-line Monitoring and Computer-based systems

Day 5

- Malfunctioning or Failure due to poor power quality
 - Excessive neutral current
 - Incorrect readings on meters
 - Reduced true Power Factor
 - Overheating in transformers
 - Bearing failure from shaft currents through un-insulated bearings of motors.
 - Generator problems
 - Nuisance operation of protective devices
 - Incorrect operation or failure of electronic equipment
 - Light flicker
- Planning and Performing a Power Quality Survey
 - Locating Sources of Harmonics
 - Identifying unacceptable conditions
- Principles for Controlling Harmonics
 - Filtering Devices
 - Active Power Line Conditioners
- Modelling Harmonics and Problem Solving with Power Application Software
- Converter and generalized current sources
- Arc Furnaces
- Passive shunt filters
- Single tuned
- High-pass
- Double tuned
- C-type
- Induction motors
- Transformers
- Other User Defined Filters and Sources
- Worked Examples and Case Studies
- Utility Distribution Networks¹
- Industrial Consumer Networks¹
- Practical Sessions¹ at individual workstations using Power Application Software
- Further Case Studies, Course Review and Final Question/Answer Session
- Review and Course Evaluation

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 Questionnaires
- 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 location. 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