# Power System Quality: Analysis and Problem Solving

## Course general description:

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 that contribute to poor power quality in Distribution Networks are being connected.

## Audience:

This course is designed for:

1- Electrical supervisors
2- Electrical Engineers
3- Anyone involved in the maintenance of power plants

## 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

## Course duration:

5 days

## Course location:

Cairo-Dubai-Istanbul

## Course contents:

**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 lose
- 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
- Short Circuit Conditions – Balanced and Unbalanced Faults
- Earthling 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:**

- System 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
- Voltage Control in Industrial Networks*

- Topology
- Acceptable Profiles – Equipment Issues
- Power Factor Correction Issues
- Induction
- Synchronous
- Motor Starting Conditions
- Under-voltage Protection issues

**Day-4:**

- Generator Governors and Droop Settings
- Effects of Loss of Generating Units
- Power Frequency Constants (Kg and Kl)
- Adequate Spinning Reserve Criteria
- Under Frequency Protection of Generating Units
- Under Frequency Load Shedding
- Worked Examples and Case Studies
- (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 Thruster Control Systems e.g. Variable Speed Drives
- Rectifiers
- Arc Furnaces
- Monitoring and Metering Issues
- Online Monitoring and Computer-based systems
- Example Waveforms and Discussions

**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
- Filtering Devices
- Active Power Line Conditioners
- Principles for Controlling Harmonics

- Modeling 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

**Methodology:**

- 50% lectures & concepts
- 10% Videos
- 10% Case studies
- 10% Exercises
- 10% Discussions
- 10% Software (if applicable or examples)

**Course code: (TEEI005)**