Department of Electrical and Computer Engineering
Electric Power and Power Electronics Institute

3-Day Short Course

ELECTRIC POWER QUALITY

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**** Current Technology

Summary
With the increased use of nonlinear loads in the industry, customer owned computers and other sensitive electronic circuitry, Electric Power Quality has become vitally important. In particular harmonic distortion of voltages and currents can be generated either external or internal to an industrial or commercial facility.

In the present era of utility deregulation and competition, many utility and industrial customers are concerned about reliability of electrical supply and quality of power. The likelihood of power interruptions and voltage fluctuations and means of eliminating them or minimizing their effects have assumed greater importance.

This three-day course will expand on methods of analysis and provide hands-on introduction to computer tools for solving power quality problems. Course presentations presume no familiarity with basic power quality issues. Prior knowledge of computer programs for the analysis of voltage disturbances is not required.

Who should attend
Electric utility distribution and customer service engineers responsible for quality of power supply to critical customers will benefit by attending this course. Plant electrical engineers in locations having power electronic equipment, adjustable speed drives, or critical and sensitive loads, including computers and process control equipment, will likewise find this course helpful. The course will also be valuable to building designers, facility managers, equipment manufacturers, consultants, and senior technical personnel in electrical construction companies.

Attendees will have the opportunity to use the state of the art power quality monitoring instruments and various waveform distortion generators in TAMU's recently established power quality laboratory. They will also be using simulation software installed in the computer laboratory in order to analyze voltage sags, transient overvoltages and harmonics. After attending this course participants will have a better understanding of electric power quality, cause and effects of harmonics, transients such as voltage sags, interruptions, overvoltages. Reliability issues related to poor power quality, as well as power quality problems in electrical systems of buildings will be also covered.

The computer exercises will provide a unique hands on experience in simulating an example system, computing distortion limits and recommending and evaluating likely solutions to power quality problems using popular software such as EMTP/ATP, Pspice and Matlab.

Contents
Day 1

SECTION I. Introduction: What is electric power quality?

PRESENTER: John Soward, Power Quality Manager, TU Electric

- Utility perspective
- Classification of power quality issues
- Definitions of terms and standards

SECTION II. Power quality problems in industrial power distribution systems

PRESENTER: Will Gray, Toshiba Industrial Systems

- Power quality: Industry perspective
- Power quality: Adjustable speed ac drives and harmonic compliance

SECTION III. Over voltage stress on motor windings due to high dv/dt

PRESENTER: P. Enjeti and A. Abur, Texas A&M University

- Review of power quality standards (IEEE 519-1992, etc.)
- Harmonic current and voltage distortion limits- Discussion
- Measurement of voltage sags: National power quality survey data from distribution systems, characterization of voltage sag parameters
- Equipment sensitivity: Examples of equipment sensitivity to sags, CBEMA equipment tolerance curve, proposed new CBEMA curve, area of vulnerability concept
- Identify key system components to model the system and determine the field data required: Utility short circuit KVA, transformer ratings, feeders, linear and non-linear loads, existing capacitor banks / harmonic filter

SECTION IV. Effect of high common mode dv/dt at the terminals of an inverter fed induction motor

- Introduction
- Why there is common mode voltage at the inverter output ?
- Test Results
- Common mode impedance plots of typical induction motors & equivalent circuits
- Common mode dv/dt at the motor terminals is a function of Converter topology: Example motor powered by a PWM rectifier/PWM inverter system
- Shaft voltages, bearing currents and leakage currents to ground
- Equivalent circuit model
- Example experimental shaft voltages and bearing currents

SECTION V. Laboratory exercises and demonstrations

- Introduction to the power quality laboratory. Hand on experience in generating a voltage sag, voltage unbalance, distortion, flicker and short-term power interruption on a 54 KVA programmable power source.

SECTION VI. Other ASD Related Issues & Emerging trends

- Harmonics generated by ASD equipment
- Low cost clean power rectifiers for ASDs
- Nuisance tripping of ASDs for voltage sags
- Smart motors – motor mounted converters
- Emerging medium voltage (2300V, 3300V and 4160V) drive systems

Day 2

SECTION I. Power quality problems in electrical systems in buildings

PRESENTER: A. Jakwani and P. Enjeti

- Review of nonlinear loads in a typical building
- Excessive neutral current problem, voltage distortion
- Case study of typical loads in buildings
- Computer modeling of an electrical distribution system in buildings
- Determining transformer derating and K-factor calculation
- Review of passive and active filtering methods to reduce neutral current overloading and improve voltage THD
- Transient surge suppression methods in buildings- a typical case study
- Definitions of terms and standards

SECTION II. Voltage sags and interruptions

PRESENTER: A. Jakwani and P. Enjeti

- Review of voltage sag phenomena: IEEE STD. 519-1992 definitions
- Measurement of voltage sags: National power quality survey data from distribution systems, Characterization of voltage sag parameters
- Modeling and simulation of utility systems for voltage sag and interruption studies
- Solutions to voltage sag events : Power conditioning for sensitive load equipment Advanced solution technologies: DVR, static transfer switch & dual feed, battery and superconducting energy storage

SECTION III. Transient over voltages

PRESENTER: A. Jakwani and P. Enjeti

- Review of capacitor switching transients
- Modeling and simulation of transient over-voltages: Assessing the effects of capacitor switching

SECTION IV. Harmonics

PRESENTER: A. Abur

- Sources and effects of harmonics
- Harmonic analysis: Frequency and capacitor scans
- System modeling for harmonics studies
- Harmonic power flow studies
- Harmonics mitigation : use of passive filters
- Harmonics standards and compliance studies

SECTION V. Computer exercises and laboratory demonstrations

PRESENTER: A. Abur, P. Enjeti

- Computer Modeling of a typical system
- Review system impedance/ frequency scans
- Investigate the impact of system capacitors
- Meet IEEE limits by applying harmonic filters
- Harmonic Case study
- Case study - Effect of voltage sag on a Electronic Adjustable Speed Drive systems and some solutions
- Measurement of harmonics generated by an adjustable speed drive and evaluate the effects of voltage sags on the drive performance (Lab demonstration)

Day 3

SECTION I. Reliability in the presence of poor power quality for industrial and commercial distribution systems

PRESENTER: C. Singh

- Due to increased competitiveness, many systems are being operated closer to their limits, and the voltage sags/swell transients and reliability of equipment is becoming an important issue. A brief review of basic reliability analysis techniques along with examples will be presented.
- Case Study of a typical power distribution system of a telecommunication facility: determine the choice of single vs. dual feed, bus configuration, UPS selection guides, overall configuration for continuity and quality of power supply

SECTION II. Voltage sags and interruptions

PRESENTER: A. Jakwani and P. Enjeti

- Review of voltage sag phenomena: IEEE STD. 519-1992 definitions
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