

4EE43: POWER QUALITY AND FACTS

CREDITS - 3 (LTP: 3, 0, 0)

Course Objective:

To explain the basic concepts of power quality issues in power systems, and its measurement techniques. Also explain working principles of FACTS devices, their operating characteristics and understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE	CE	ESE	CE		
3	0	0	3	60	40	00	00	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Introduction to Power Quality: Terms and definitions of transients, long duration voltage variations: under voltage, under voltage and sustained interruptions; short duration voltage variations: interruption, sag, swell, voltage imbalance; notching DC offset, waveform distortion, voltage fluctuation; power frequency variations.	06
2.	Voltage Sag: Sources of voltage sag, motor starting, arc furnace, fault clearing, estimating voltage sag performance and principle of its protection; solutions at end user level- Isolation Transformer, Voltage Regulator, Static UPS, rotary UPS, introduction of active series compensator.	07
3.	Harmonics: Causes of harmonics, current and voltage harmonics, measurement of harmonics, effects of harmonics on –transformers, ac motors, capacitor banks, cables, and protection devices, energy metering, communication lines etc., harmonic mitigation techniques, IEEE 519 guideline for harmonics, harmonic analysis using computer software, Introduction to active and passive filters in power system.	08

Unit No.	Topics	Teaching Hours
4.	Power Quality Measurement: Power quality measurement devices, power quality measurements, number of test locations, test duration, instrument setup and instrument set up guidelines.	04
5.	Transmission Lines and Series/Shunt Reactive Power Compensation: Basics of EHV AC transmission line and importance of interconnections, analysis of uncompensated AC transmission lines, passive reactive power compensation, shunt and series compensation at the mid-point of an AC line. comparison of series and shunt compensation	04
6	Thyristor-based Flexible AC Transmission Controllers (FACTS): · Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), configurations/modes of operation, harmonics and control of SVC and TCSC, applications of SVC's and case studies.	06
7	Voltage Source Converter based (FACTS) Controllers: · Fundamentals of Voltage Source Converters (VSC) for FACTs, six pulse VSC, Multi-pulse and Multi-Level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination (SHE), Sinusoidal PWM and Space Vector Modulation (SVM), STATCOM: Principle of operation and applications, Static Synchronous Series Compensator (SSSC): Operation and applications, Unified Power Flow Controller (UPFC): Principle of Operation and control, GTO Controlled Series Compensator, application of FACTS devices for power-flow control and stability improvement with case studies.	10
Total		45

List of References:

1. Roger C. Dugan , Mark F. Mcgranaghan, Surya Santoso , “Electrical Power Quality”, Tata McGraw-Hill Publications.
2. Jos Arrillaga, Neville R. Watson, “Power System Harmonics”, John Wiley and Sons Ltd.
3. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, “Power Quality: Problems and Mitigation Techniques”, Wiley 2015.
4. N.G. Hingorani, L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems,” IEEE Press, N.Y., 2000.
5. R. Mohan Mathur, R K Verma, “ Thyristor-based FACTS controllers for Electrical Transmission Systems”, Wiley IEEE Press
6. Padiyar K R,, “FACTS Controllers in Power Transmission & Distribution”, New Age International Publications.

Web Resources:

1. Web course on “Power Quality in distribution systems” by Dr. Mahesh Kumar Professor Department of Electrical Engineering Indian Institute of Technology Madras, available on NPTEL at <https://nptel.ac.in/courses/108/106/108106025/>

2. Video course on “FACTS Devices” by Prof. Avik Bhattacharya, IIT Roorkee, available on NPTEL at <https://nptel.ac.in/courses/108/107/108107114/>

Course Outcomes (COs):

At the end of this course students will be able to:

1. Understand the major power quality problems.
2. Understand and analyze harmonics in power systems.
3. Use equipment that are required to measure the quality of power.
4. Understand FACTS devices and analyze reactive power requirement and management.