

**21BEEE8E04****Power Quality and FACTS****3H-3C**

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**Instruction Hours / week: L:3 T: 0 P: 0****Marks: Internal: 40****External: 60 Total: 100****End Semester Exam: 3 Hours****Course Objectives**

- To understand the concept of power and power factor in single phase and three phase systems supplying non linear loads
- To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
- To understand the active compensation techniques used for power factor correction.
- To understand the active compensation techniques used for load voltage regulation.

**Course Outcomes (COs)**

At the end of this course, students will demonstrate the ability to

- 1.Evaluate the characteristics of ac transmission
- 2.Reproduce the effect of shunt and series reactive compensation.
- 3.Justify the working principles of FACTS devices and their operating characteristics.
- 4.Reproduce the basic concepts of power quality.
- 5.Rewrite the concept of Harmonics
- 6.Reproduce and justify the working principles of devices to improve power quality.

**UNIT I TRANSMISSION LINES AND SERIES/SHUNT REACTIVE POWER COMPENSATION (9)**

Basics of AC Transmission. 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.

**UNIT II THYRISTOR-BASED FLEXIBLE AC TRANSMISSION CONTROLLERS (FACTS) (9)**

Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.

### **UNIT III : VOLTAGE SOURCE CONVERTER BASED (FACTS) CONTROLLERS (9)**

Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.

### **UNIT- IV APPLICATION OF FACTS AND POWER QUALITY PROBLEMS IN DISTRIBUTION SYSTEMS (9)**

Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.

Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve.

### **UNIT V DSTATCOM (9)**

Reactive Power Compensation, Harmonics and Unbalance mitigation in Distribution Systems using DSTATCOM and Shunt Active Filters. Synchronous Reference Frame Extraction of Reference Currents. Current Control Techniques in for DSTATCOM.

### **SUGGESTED READINGS**

1. N. G. Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and Technology of FACTS Systems", Wiley-IEEE Press, 2011.
2. K. R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd. 2007.
3. T. J. E. Miller, "Reactive Power Control in Electric Systems", John Wiley and Sons, New York, 2010.
4. R. C. Dugan, "Electrical Power Systems Quality", McGraw Hill Education, 2012.
5. G. T. Heydt, "Electric Power Quality", Stars in a Circle Publications, 2005

### **WEB REFERENCES**

1. <https://nptel.ac.in/courses/108/106/108106025/>
2. <https://nptel.ac.in/courses/108/107/108107114/>