Course Title: Flexible AC Transmission Systems
Course Code: EPEG 417
Credit Hours: 3

Course Description:
This course will develop an understanding in students the various types of FACTS devices in use. Focus will be made in understanding the working principle, construction, behavior and applications. They will also learn the application of power electronics in HVDC, distributed energy systems and power quality, reliability and security issues of power systems

Course Contents:

Unit 1: Introduction
FACTS Concepts: Transmission interconnections power flow in an AC system, loading capability limits, Reactive power control in electrical power transmission lines--uncompensated transmission line – series and shunt compensation, Dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers.

Unit 2: Static Shunt Compensation
Static shunt compensation: Objectives of shunt compensation, mid-point voltage regulation voltage instability prevention, improvement of transient stability, Power oscillation damping.

Unit 3; Methods of controllable var generation
Variable impedance type static var generators: Thyristor Controlled and Thyristor Switched Reactor (TCR and TSR), Thyristor Switched Capacitor (TSC), Fixed Capacitor Thyristor Controlled Reactor Type Var Generator FC-TCR, Thyristor Switched Capacitor- Thyristor Controlled Reactor Type Var Generator; Switching converter type var generators, Hybrid var generators.

Unit 4: SVC and STATCOM
Static Var Compensators: SVC and STATCOM-The Regulation Slope, Transfer Function and Dynamic Performance-Transient Stability Enhancement and Power Oscillation Damping; Comparison between STATCOM and SVC: V-I and V-Q Characteristics, Transient Stability, Response Time, Capability to Exchange Real Power, Operation with Unbalanced AC System, Loss Versus Var Output Characteristic.

Unit 5: Static Series Compensation
Concept of series capacitive compensation, improvement of transient stability, power oscillation damping; Variable Impedance Type Series Compensators-GTO Thyristor-Controlled Series Capacitor-(GCSC), Thyristor-Switched Series Capacitor(TSSC), Thyristor-Controlled Series Capacitor(TCSC), Basic Operating Control Schemes For GCSC,TSSC and TCSC.

Unit 6: Switching Converter Type Series Compensators
Static Synchronous Series Capacitor(SSSC), Transmitted Power Versus Transmission Angle Characteristic, Control Range and VA Rating, Capability to Provide Real Power Compensation, Internal Control; External Control for Series Reactive Compensators.

Unit 7: Static Voltage and Phase Angle Regulators: TCVR and TCPAR
Voltage and Phase Angle Regulation, Power Flow Control by Phase Angle Regulators, Real and Reactive Loop Power Flow Control; Approaches to Thyristor –Controlled Voltage and PhaseAngle Regulators (TCVRs and TCPARs)-Continuously Controllable Thyristor Tap Changers.

Unit 8: Unified Power Flow Controller (UPFC)
Introduction: The Unified Power Flow Controller-Basic Operating Principles, Conventional Transmission Control Capabilities, Independent Real and Reactive Power Flow Control, Control Structure, Basic Control System for P and Q Control.

Unit 9: Distributed Energy Systems (DER)
Power electronic inverters for interfacing PV, fuel cells, micro turbines, micro-hydro, interfaces for wind and wave energy systems, PWM and control techniques, effect of DG on power distribution systems

Unit 10: Power Electronic Converters for Power Quality, Reliability and Security
Concept of custom power, Dynamic voltage regulators, uninterruptible power supplies, DG for power quality, active filters, solid state circuit breakers

References:

1. M. Mathur and R.K. Varma, *Thyristor-Based FACTS Controllers for Electrical Transmission Systems*, Wiley-IEEE Press, 2002. ISBN 0-471-20643-1
2. N.G.Hingorani&L.Gyugyi, *Understanding FACTS*: *Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, 1999.
3. X.P. Zang, C. Rehtanz and B. Pal, *Flexible AC Transmission Systems: Modeling and Control*, Birkhauser, 2006.
4. Y. H. Song and A. T. Johns, *Flexible AC Transmission Systems*, IET, 1999.
5. Mohan Mathur, R., Rajiv. K. Varma, "*Thyristor – Based Facts Controllers for Electrical Transmission Systems*", IEEE press and John Wiley & Sons, Inc.

Evaluation:
In-Semester Evaluation: 50%
End-Semester Evaluation: 50%