Course Name: Power System III
Course Code: EE703A
Credit: 4

Prerequisites:

Sl. No.	Subject	Description	Level of Study
01	Power Electronics	Different types of converters, inverters.	6^{th} Sem
02	Power System I& II	Transmission line, Load flow, per unit system, Generation of electricity by different power plants.	5^{th} & 6^{th} Sem

Course Objective:

- To understand the electrical power plant operation and control with respect to its economic aspect.
- To know the importance of compensation in power system and study the different compensating techniques.
- Study about different transients and their protection those are introduced in power system.

Course Outcomes:

1. **Identify** and **explain** the different methods of generation, distribution, control and compensation involved in the operation of power systems.
2. **Design** the mathematical models of the mechanical and electrical components involved in the operation of power systems and demonstrate the understanding of the open loop and closed loop control practices associated with the voltage and frequency control of single area or interconnected multi area power systems.
3. **Specify** the equivalent electrical parameters of transmission line to prepare and **analyze** models to predict the range and ratings of the equipments to be used, the protection required against line transients and determine the appropriate methods of compensation required for operational stability
4. **Solve** the problems related to the economic dispatch of power, plant scheduling, unit commitment and formulate strategies to minimize transmission line losses and penalties imbibed.

5. **Devise** protection schemes required for the system to safeguard against transients after identifying and determining the severity of the transients occurring during the period of operation and design testing strategies to determine the performance characteristics of the compensating equipment to be used in the system
6. **Assess** the different methods of control and compensation to choose the best option so that social and environmental problems are minimized and recognize the need to continuously follow the advancements in technology and incorporate them in the present system to improve efficiency and increase the flexibility and quality of operation.

CO- PO mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	2	2	2	3	3	1	1	-	-	2	-	3
2	3	3	3	3	2	-	-	-	-	1	2	2
3	3	2	1	1	-	1	-	1	1	2	1	2
4	3	1	3	1	2	-	1	-	-	1	1	1
5	3	1	3	2	-	-	2	2	1	1	1	2
6	1	-	2	2	-	2	3	1	2	2	1	3

Correlation levels 1, 2 or 3 as defined above: 1: Slight (Low) 2: Moderate (Medium)3: Substantial (High) and "-" if there is no correlation.

Syllabus Indicating CO:

Module No.	Content	Relevant CO's
1	**1. Objectives of Power System Operation** Power Systems in Restructured Environment; Distributed and Dispersed Generation; Environment Aspects of Electric Power Generation.	**CO1**

2	**2. Economic Operation of Energy Generation Systems** Generation Cost Curves; Economic Operation of Thermal System; Plant Scheduling; Transmission Loss and Penalty Factor; Hydro-Thermal Scheduling; Concept of Reserves and Constraints; Unit Commitment.	**CO1, CO2**
3	**3. Automatic Generation Control** Concept of AVR and ALFC Loops, Significance of Double Loop in ALFC; Exciter and VAR Control; Single Area Load Frequency Control; Two Area Load Frequency Control; Frequency Response.	**CO1, CO2, CO3,CO4**
4	**4. Compensation in Power System** Reactive Power Sensitivity and Voltage Control; Load Compensation with Capacitor Banks; Line Compensation with Reactors; Shunt and Series Compensation; Fixed Series Capacitors; Thyristor Controlled Series Capacitors; Introduction to SVC and STATCOM.	**CO6**
5	**5. Power System Transients** Types of System Transients; Overvoltage in Transmission Lines; Propagation of Surges and Travelling Waves; Protection Against Lightning and Surges;	**CO5**

Gaps in Syllabus

S. No.	Gap	Action taken	Resource Person	No. of students	Relevance to POs, PSOs
1	**Power System Operation:** *This is a modern concept introduced in Power System useful to deal with power loss reduction as well as better consumer involvement in the power business scenario.* **Topics covered:** Smart Grid, Supervisory Control and Data Acquisition (SCADA) in power system, Application of digital communication technology to make electricity market consumer friendly.	The various topics are addressed by **lecture classes, providing notes & real case analysis.** The students are **given assignments** for solving problems.	**A.Ganguly**	**70**	**PO 1, PO 2, PO 5**
2	**Economic Operation of Energy Generation Systems:** *In the interconnected power system consisting of various types of energy resources this topic tells about the*	Additional **lecture classes** are organized to cover the topics. **Research literatures are provided for this.**	**A.Ganguly**	**72**	**PO 1, PO 5**

	objective and methods to implement a optimal and reliable operation. **Topics covered:** Optimal load scheduling, use of artificial intelligence in load flow optimization.				
3	**Voltage Stability:** *This is an ever important area which is currently of huge research initiatives.* **Topics covered:** Synchronous Phase Modifier capacity determination, sending end power circle diagram, FACTS.	These are covered by **lectures and providing research papers**.	**A. Ganguly**	**71**	**PO 1, PO 2, PO 4, PO 7**
4	**Neutral Grounding:** *Importance of neutral grounding in power system and various types of grounding practices used in industry.* **Topics covered:** Importance of grounding in a 3-phase interconnected system, solid grounding, resistance grounding, reactance grounding, practical grounding methods in sub-stations etc.	The neutral grounding concept is very important from power system protection point of view and also for industrial touch of study.	**A.Ganguly**	**66**	**PO 1, PO 3**

Lecture Plan:

SL NO	DAYS	TOPIC	REMARKS
1	DAY 1-2, 2-3, 3-4	**1. Objectives of Power System Operation** Power Systems in Restructured Environment; Distributed and Dispersed Generation; Environment Aspects of Electric Power Generation.	
2	DAY 5-6, 7, 8-9, 10, 11-12, 13, 14	**2. Economic Operation of Energy Generation Systems** Generation Cost Curves; Economic Operation of Thermal System; Plant Scheduling; Transmission Loss and Penalty Factor; Hydro-Thermal Scheduling; Concept of Reserves and Constraints; Unit Commitment.	Solve Numerical Problem
3	DAY 15-16, 17-18, 19-20, 21-22	**3. Automatic Generation Control** Concept of AVR and ALFC Loops, Significance of Double Loop in ALFC; Exciter and VAR Control; Single Area Load Frequency Control;	

		Two Area Load Frequency Control; Frequency Response.	
4	DAY 23-24, 25-30	**4. Compensation in Power System** Reactive Power Sensitivity and Voltage Control; Load Compensation with Capacitor Banks; Line Compensation with Reactors; Shunt and Series Compensation; Fixed Series Capacitors; Thyristor Controlled Series Capacitors; Introduction to SVC and STATCOM.	
5	DAY 31-32, 33-34, 35-36, 37-38	**5. Power System Transients** Types of System Transients; Overvoltage in Transmission Lines; Propagation of Surges and Travelling Waves; Protection Against Lightning and Surges;	

REFERENCE BOOK

1. Power System Engineering, Kothari & Nagrath, Mc Graw Hill
2. Power System Analysis, Granger and Stevension, Mc Graw Hill
3. Electric Power Genration operation and control, Wood and Woolenberg, Willey.
4. Power system stability and Control, P. Kundur , Mc Graw Hill
5. Modern power system analysis, Kothari & Nagrath, Mc.Graw Hill
6. Power system Analysis, Nagsarkar & Sukhija, Pearson
7. Power system analysis, operation and control, Chakrabarti and Halder, PHI
8. Book of Elgand.