GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering
Level: Diploma
Branch: Electrical Engineering / Renewable Energy
Subject Code: DI05000191
Subject Name: Power System Operation and Management

w. e. f. Academic Year:	2026-27
Semester:	5th
Category of the Course:	PEC-03

Prerequisite:	Basic knowledge of electrical engineering, electrical machines and power generation, transmission and distribution systems.
Rationale:	This course provides practical knowledge of operation and management of electrical power systems at diploma level. It focuses on the basic structure and representation of power systems, power system operation and load dispatch, HVAC and HVDC transmission concepts, FACTS devices, demand side management, and modern concepts such as smart grid and microgrid. The course helps students understand the practical methods used for efficient, reliable and economical operation of power systems and develops awareness about modern technologies used in transmission, control, monitoring and energy management.

Course Outcomes: After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level*
01	Explain the fundamentals of power system structure, representation and basic operating quantities.	R, U
02	Explain power system operation, voltage control and load dispatch methods.	U, A
03	Explain the basic concepts and applications of HVAC system, HVDC system and FACTS devices in power systems.	U, A
04	Explain the principles and applications of demand side management for efficient utilization of electrical power.	U, A
05	Explain the basic concept, components and applications of smart grid and microgrid in modern power systems.	R, U

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	30	20	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Unit 1: Power System Fundamentals and Representation** • Structure of generation, transmission and distribution system • Single line diagram of power system • Impedance / reactance diagram • Single-phase representation of balanced three-phase system • Per unit system and simple examples • Active power, reactive power, apparent power and power factor	**8**	**18%**
2	**Unit 2: Power System Operation, Control and Load Dispatch** • Need for power system operation and control • Transmission line voltage control • Real and reactive power transfer in transmission lines • Conventional methods of power system control • Automatic Generation Control (AGC) • Functions of load dispatch center / SLDC • Introduction to economic load dispatch • Basic idea of unit commitment	**8**	**18%**
3	**Unit 3: HVAC/HVDC Systems, FACTS Devices and Reactive Power Management** • Introduction to HVAC transmission system • Need of high voltage transmission • Merits and limitations of HVAC transmission • Introduction to HVDC transmission system • Basic components of HVDC system • Merits and limitations of HVDC transmission • Basic comparison of HVAC and HVDC systems • Need for reactive power compensation • Series, shunt and series-shunt compensation • Introduction to FACTS devices • Types of FACTS controllers like SVC, STATCOM, TCSC, SSSC, UPFC etc. • Applications of FACTS devices in voltage control, power flow control and stability improvement	**12**	**27%**

	• Advantages and limitations of FACTS devices		
4	**Unit 4: Demand Side Management (DSM)** • Introduction to Demand Side Management • Need and objectives of DSM • Load curve and load duration curve • Maximum demand • Demand factor, diversity factor and load factor • Peak clipping • Valley filling • Load shifting • Energy conservation through DSM • Tariff-based demand control • Consumer participation in load management • Applications of DSM in domestic, commercial and industrial sectors	**8**	**18%**
5	**Unit 5: Smart Grid and Microgrid** • Introduction to smart grid • Need and objectives of smart grid • Elements of smart grid • Smart meter and Advanced Metering Infrastructure (AMI) • Communication and monitoring in smart grid • Demand response concept • Introduction to distributed generation • Introduction to microgrid • Components of microgrid • Grid-connected mode and islanded mode of microgrid • Role of renewable energy sources in microgrid • Role of battery energy storage in microgrid • Advantages and applications of smart grid and microgrid	**9**	**20%**
		45	**100%**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
15%	45%	40%	00	00	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Reference Books:

- V.K. Mehta and Rohit Mehta, Principles of Power System.
- I.J. Nagrath and D.P. Kothari, Modern Power System Analysis.
- Nagrath and Kothari, Power System Engineering.
- C.L. Wadhwa, Electrical Power Systems.
- S. Rao, Power System Operation and Control.
- K.R. Padiyar, FACTS Controllers in Power Transmission and Distribution.
- James Momoh, Smart Grid: Fundamentals of Design and Analysis.
- Hadi Saadat, Power System Analysis.
- J.B. Gupta, Utilization of Electrical Power and Electric Traction.
- V.K. Mehta and Rohit Mehta, Principles of Power System.
- I.J. Nagrath and D.P. Kothari, Modern Power System Analysis.
- Nagrath and Kothari, Power System Engineering.

(b) Open-Source Software and Website:

Topic	Resource Type	Link
Power System Basics	Educational	NPTEL
Load Flow / Power System Simulation	Software	OpenDSS
Demand Side Management	Educational	Bureau of Energy Efficiency (BEE)
Smart Grid Basics	Resource Center	IEEE Smart Grid
HVDC / FACTS / Transmission	Educational	Electrical Engineering Portal
Renewable and Microgrid Learning	Educational	U.S. Department of Energy

Suggested Course Practical List:

Each week includes one lab sessions (2 hours), designed such that they complement theory topics, means each experiment directly supports the classroom teaching.

Suggested Software:

1. MATLAB
2. Simulink / Simscape Electrical
3. OpenDSS
4. PSCAD
5. DIgSILENT Power Factory
6. SCILAB
7. ETAP
8. MiPower

Sr. No.	Practical Outcome/Title of experiment	Unit/ CO	Approx. Hours
1	Perform per unit calculation and power quantity calculation for a simple power system.	1 / CO1	2
2	Simulation of real and reactive power control using transformer tap changer.	2 / CO2	2
3	Study of economic load dispatch for a multi-generator power system through simulation.	2 / CO2	2
4	Study of power sharing among generating units using economic load dispatch through simulation.	2 / CO2	2
5	Comparative study of HVAC and HVDC transmission systems under different transmission conditions through simulation	3 / CO3	2
6	Reactive power compensation in transmission system using series, shunt and series-shunt compensation methods through simulation.	3 / CO3	2
7	Voltage control in transmission system using FACTS devices such as SVC and STATCOM through simulation.	3 / CO3	2
8	Power flow control in transmission system using FACTS controllers such as TCSC, SSSC and UPFC through simulation.	3 / CO3	2
9	Stability improvement in power system using FACTS devices through simulation.	3 / CO3	2
10	Study of demand side management techniques such as peak clipping, valley filling and load shifting through simulation.	4 / CO4	2

11	Study of load curve and load duration curve for different load conditions through simulation	4 / CO4	2
12	Study of demand response in smart grid through simulation	5 / CO5	2
13	Study of renewable energy sources and battery energy storage in microgrid through simulation	5 / CO5	2

Subject In-charge can add performance experiment only

List of Laboratory/Learning Resources Required:

Category	Equipment / Tool	Specifications / Notes
A. Basic Models and Charts	Power system single line diagram charts	For classroom and lab demonstration
	HVAC and HVDC transmission models / charts	Introductory level
	FACTS devices charts / posters	SVC, STATCOM, TCSC, SSSC, UPFC
B. Measuring Instruments	Voltmeter, Ammeter, Wattmeter, Multimeter	Standard lab usage
	Power factor meter / power analyzer	For demonstration
	Clamp meter	Portable measurement
C. Electrical Setups	Capacitor bank / PF improvement setup	Single-phase / three-phase
	Transformer tap changing setup / model	Demonstration purpose
	Small transmission line model / panel	Basic experiment
D. Digital Tools / Software	Power system simulation software	MATLAB / Simulink or open-source tool
	Spreadsheet tools	For load curve and DSM calculations

E. Smart Grid / Microgrid Learning	Smart energy meter	With display / communication feature
	Solar PV demo kit / battery model	For microgrid demonstration
	Microgrid block model / trainer	Basic concept-level use

Suggested Activities for Students

To enhance the learning outcomes of the course, students are encouraged to participate in co-curricular activities that provide practical exposure to power system operation, control and management.

- Prepare a chart showing the structure of generation, transmission and distribution system.
- Collect and study electricity load data of home, lab or workshop and draw load curve.
- Prepare a comparison chart of HVAC and HVDC transmission systems.
- Prepare a seminar on different FACTS devices and their applications.
- Visit a substation, control room, SLDC or distribution office and prepare a report.
- Study demand side management methods used in domestic or industrial installations.
- Prepare a report on smart meter, smart grid and microgrid applications in Gujarat or India.
- Study a case of renewable energy integration in a microgrid.

Suggested Project List

Individual Level - Fundamental Activities

- Prepare a report on the power flow from generating station to end consumer.
- Develop a load curve of household or laboratory load.
- Compare HVAC and HVDC transmission systems with suitable applications.
- Prepare a case study on demand side management in a domestic consumer.
- Study smart grid applications used in modern distribution systems.

Group Level - Hands-on Projects / Circuit Implementation and Testing

- Reactive power compensation using capacitor bank.
- Mini project on load management of a laboratory or classroom.

- Simulation of simple transmission system with FACTS device concept.
- Smart meter-based monitoring of classroom electrical load.
- Prepare a model of solar-based microgrid with battery storage.

Advanced Activities (Skill-Based Activities)

- Case study on voltage control methods in transmission system.
- Load dispatch and demand response study for a small consumer group.
- Study of distributed generation and its effect on microgrid operation.
- Survey of smart metering infrastructure in local utility area.

****