Department: Electrical Engineering

PROGRAM: M. TECH. POWER SYSTEMS

PO, PSO, CO, SCHEME, SYLLABUS

Masters in Technology (Power Systems)	
Programme Outcome	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	
Programme Specific Outcome	Able to apply the knowledge gained during the course of the program from Mathematics, Basic Computing, Basic Sciences and Social Sciences in general and all electrical courses in particular to identify, formulate and solve real life problems faced in industries and/or during research work.	
	Able to provide socially acceptable technical solutions to complex electrical engineering problems with the application of modern and appropriate techniques for sustainable development.	
	Able to apply the knowledge of ethical and management principles required to work in a team as well as to lead a team.	
Course Code	**Course Name**	**Course Outcomes**
EE 501	Advanced Power System Analysis	Understand and analyse the behaviour of the power systems under different fault conditions. Understand and analyse the behaviour of induction machines under unbalanced operations Understand the mathematical model for synchronous machines. Understand the concept of linear graph theory and its use to solve electrical problems. Solve and analyse the load flow problems Calculate fault parameters in any 3-phase Induction machine or Synchronous machine in a Power System.
EE 502	Advanced Power System Stability	Student will be able to model various synchronous machines. Solve swing equation and understand various stability, Able to develop SMIB system & solve coherent non coherent system, Give solution to various stability problems eg fault clearing time, critical clearing angle etc.
EE 504	HVDC Transmission	Measure and calculate the switching behaviour of thyristor and IGBT valves Design power electronic converters (AC- DC, DC - DC) Understand control schemes for HVDC systems and their control Measure and remove harmonics. Understand the application of MTDC systems. Work on and design the widespread HVDC Power Systems in the industry.
EE 505	Advanced Power Electronics	Student will be able to understand the application of phase controlled converter , Understand the different type of chopper and their application, Understand the 1 phase and 3 phase inverters and their applications and harmonic reduction techniques, Understand AC voltage controller

EE 506	Power System Transients and Protection	Understand the transient wave phenomenon in power systems Understand the impact of grounding on the behaviour of power systems Understand the working of static relays in power systems Understand the working of comparators in static relays and to use them in various protective schemes. Understand the operation of switchgear in power systems. To be able to understand the above related field problems. Calculate the values of Power System Transients in any basic scenario, and suggest the appropriate protective relay or circuit breaker for that case.
EE 508	Advanced Power System	Student will be able to analyse voltage stability Understand distribution automation and SCADA Able to apply FACTS devices Able to audit electrical utilities. Understand superconductivity and applications Understand the methods to charge for the transmission line uses and for the power losses in transmission system. Work on the relatively newer components of Power Systems in industry, like SCADA, FACTS and Superconductors.
EE 512	Smart Grid: Design & Applications	.Acquire in-depth understanding on recent development of power grids, i.e. smart grid; Apply advanced analysis tools in planning and operation of smart grids, Acquire skills in presentation and interpretation of results.
EE 553	Power System Design using PSCAD	Apply the theory covered in courses to obtain working simulations of advanced Electrical Engineering circuits. Will be able to use PSCAD for designing of circuits/systems that have been covered in their theoretical topic thus far. Through the project development, students will be able to showcase their skills in modelling an Electrical Engineering/Power System through PSCAD. Understand the process of implementing design in the simulation. Simulate any Power System component or scenario in the industry.
EE 601	Power System Planning and Reliability	Perform reliability analysis on electrical systems. Evaluate possible sources of unreliability in the system and its possible causes. Perform analysis using the Reliability concept for systems under study. Plan an electrical system with proper reliability analysis while taking into consideration the future loads.

		Evaluate Reliability of different components of Power System in industry, like Static Generating Capacity, Spinning Generating Capacity and Transmission Capacity.
EE 603	Operation and Control of Power System	Student will be able to analyze various constraints of optimal power system operation Solve the unit commitment problem Solve the optimal generation scheduling Understand the speed governing system of steam turbine and analyse steady state and dynamic response. Understand power system security and AGC Suggest and implement methods for various aspects of Optimal Power System operation in the Power System industry.
EE 609	Restructured Power Systems	Understand the need of restructuring of the power industry and the behaviour of affected parties. Understand how the electricity is different from other commodities and how the mathematical tools be used to manage the congestion of the transmission lines using PTDF and LODF. Understand the basics of the methods to determine the electricity price at different nodes. Understand the concept of ancillary services in restructured power systems which are required to run the power system in a smooth manner.
EE 611	Solar Radiation & Energy Conversion	To familiarize students with the characteristics of solar radiation, its global distribution, and conversion methods of solar energy to heat and power

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GYAN VIHAR SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

Teaching and Examination Scheme for M. Tech. FULL-TIME (Core) (Power System)

EFFECTIVE FROM ACADEMIC SESSION 2019 – 2020

Year I **Semester – Autumn**

S. No.	Course Code	Course Name	Credits	Contact Hrs/Wk.			Exam Hrs.	Weightage (in%)	
				L	T/S	P		CIE	ESE
A		**University Core**							
1	PC 501	Proficiency in Co-curricular Activities-I	2						100
2	MA501	Advanced Mathematics	3	3			3	40	60
3	HS 501	Technical Writing for Engineering(Seminar)	1			2	3	60	40
4	EM 501	Employability Skills	1		2				
5	SM 501	Review Seminar 1	2			3		60	40
6	FD 102	Foundation Course							
B		**Program Core**							
1	EE 501	Advanced Power System Analysis	3	3			3	40	60
2	EE 551	MATLAB Programming Lab	2			3	3	60	40
3	EE 505	Advanced Power Electronics	3	3			3	40	60
4	EE 553	Power System Design using PSCAD	2			3	3	60	40
C		**Program Elective (any 1)**							
1	ME 527	Energy Conservation Technologies	3	3			3	40	60
2	ME 521	Modelling & Planning of Energy Systems	3	3			3	40	60
3	ME 523	Wind Energy Utilization	3	3			3	40	60
4	ME 525	Energy Management	3	3			3	40	60
D		**University/Open Elective**							
		Opt from the list of University Electives							
		Total	**22**	**12**	**2**	**11**			

L= Lecture **T=Tutorial** **CIE=Continuous Internal Evaluation**

S= Seminar **P= Practical** **ESE= End Semester Examination**

Members of BoS, EE **Convener, BoS Engg.**

SURESH GYAN VIHAR UNIVERSITY
Accredited by NAAC with 'A' Grade

GYAN VIHAR SCHOOL OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL ENGINEERING
Teaching and Examination Scheme for M. Tech. FULL-TIME (Core) (Power System)
EFFECTIVE FROM ACADEMIC SESSION 2019 – 2020

Year I **Semester – Spring**

S. No.	Course Code	Course Name	Credits	Contact Hrs/Wk.			Exam Hrs.	Weightage (in%)	
				L	T/S	P		CIE	ESE
A		**University core**							
1	PC 502	Proficiency in Co-curricular Activities-II	2						100
2	EM 502	Employability Skills	1		2				
3	SM 502	Review Seminar 2	2			3	3	60	40
4	FD 104	Foundation Course							
B		**Program Core**							
1	EE 502	Advanced Power System Stability	3	3			3	40	60
2	EE 504	HVDC Transmission	3	3			3	40	60
3	EE 508	Advanced Power System	3	3			3	40	60
4	EE 552	Power System Modelling and Simulation Lab	2			3	3	60	40
5	EE 554	Power System Lab 2	2						
C		**Program elective (any 1)**							
1	EE 512	Smart Grid: Design & Applications	3	3			3	40	60
2	EE 506	Power System Transients and Protection	3	3			3	40	60
3	EE 510	Advanced Circuit Analysis and Design	3	3			3	40	60
D		**University/Open elective**							
		Opt from the list of University Electives							
		Total	**21**	**12**	**2**	**6**			

L= Lecture **T=Tutorial** **CIE=Continuous Internal Evaluation**
S= Seminar **P= Practical** **ESE= End Semester Examination**

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GYAN VIHAR SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

Teaching and Examination Scheme for M. Tech. FULL-TIME (Core) (Power System)

EFFECTIVE FROM ACADEMIC SESSION 2019 – 2020

Year II **Semester – Autumn**

S. No.	Course Code	Course Name	Credits	Contact Hrs/Wk.			Exam Hrs.	Weightage (in%)	
				L	T/S	P		CIE	ESE
A		**University core**							
1	PC 601	Proficiency in Co-curricular Activities-III	2						100
B		**Program Core**							
1	EE 601	Power System Planning and Reliability	3	3			3	40	60
2	EE 653	Advanced Computer Based Power System Design Lab	2			3	3	60	40
3	DI 601	Pre-dissertation/ Minor Project	5			6	3	60	40
4	PE 601	Industrial Training	4			6	3	60	40
C		**Program elective (any 1)**							
1	EE 609	**Restructured Power Systems**	3	3			3	40	60
2	EE 605	Advanced Theory and Analysis of AC Machines	3	3			3	40	60
3	EE 607	Excitation of Synchronous Machines & Control	3	3			3	40	60
4	EE 611	Solar Radiation & Energy Conversion	3	3			3	40	60
5	EE 613	Smart Grid: Technology & Applications	3	3			3	40	60
6	EE 603	Operation and Control of Power System (moved to elective)	3	3			3	40	60
D		**University/Open elective**							
		Opt from the list of University Electives							
		Total	**19**	**6**	**0**	**15**			

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L= Lecture **T=Tutorial** **CIE=Continuous Internal Evaluation**

S= Seminar **P= Practical** **ESE= End Semester Examination**

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GYAN VIHAR SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

Teaching and Examination Scheme for M. Tech. FULL-TIME (Core) (Power System)

EFFECTIVE FROM ACADEMIC SESSION 2019 – 2020

Year II **Semester – Spring**

S. No.	Course Code	Course Name	Credits	Contact Hrs/Wk.			Exam Hrs.	Weightage (in%)	
				L	T/S	P		CIE	ESE
A		**Practical & Sessional**							
1	DI 602	Industry Major Project/Dissertation	18			3		60	40
		Total	**18**			**3**			
		Total Teaching Load	**3**						

L= Lecture **T=Tutorial** **CIE=Continuous Internal Evaluation**

S= Seminar **P= Practical** **ESE= End Semester Examination**

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Course Title: **Advanced Power System Analysis**		Course Code	: EE 501
Semester	: I(M.Tech)	Core / Elective	: **Core**
Teaching Scheme in Hrs (L:T:P)	: **3:0:0**	Credits	: **3 Credits**
Type of course	: **Lecture + Assignments**	Total Contact Hours	: **36**
Continuous Internal Evaluation	: **40 Marks**	ESE	: **60 Marks**
Programmes: M.Tech **(PS)**			

Pre-requisites:

Graduate level Electrical Engineering Course of Indian Universities.

Course Objectives:

1. To understand and analyse the abnormal working of the power systems in form of faults.
2. To understand the behaviour of induction machines under unbalanced conditions.
3. To understand the mathematical model of synchronous machines.
4. To understand the concepts of linear graph theory.
5. To study and analyse the load flow problems.
6. Make students familiar with Fault Analysis techniques used for 3-phase Induction Machines and Synchronous Machines.

Course Content:

Topic and Contents	**Hours**	**Marks**
UNIT-1: **Fault Analysis**	6	20
Positive, Negative and Zero Sequence equivalent circuits of lines, two and three winding transformers, induction machines and synchronous machines. Analysis of shunt and series faults, effect of neutral grounding.		
UNIT-2: **Unbalanced Operation of 3-phase Induction Motors**	6	20
Characteristics with application of unbalanced voltage to a balanced motor and with application of balanced voltage to a motor having unbalanced impedances in the rotor circuit.		
UNIT-3: **Synchronous Machines**	8	20
Short circuit currents and reactance of synchronous machine. Modelling of synchronous machine at no load and symmetrical load under steady state conditions, Sequence impedance of synchronous machines.		
UNIT-4: **Linear Graph Theory**	8	20
Study of linear graph theory, Network topology, incidence, Cut-set and Tie-set matrices and their interpretation. Calculation of Z-bus, Y-bus, Z-branch and Y loop matrices by singular and non-singular transformations. Algorithm for the calculation of Y-bus and Z-bus. Fault calculations using Z-bus.		
UNIT 5: **Load Flow Studies**	8	20

Formulation of load flow problem. Various types of buses. Gauss-Siedel, Newton-Raphson and Fast Decoupled Algorithms. Calculation of reactive power at voltage controlled buses in the Gauss-Seidel iterative method using Y-bus, Phases, Representation of transformers - Fixed tap setting transformer, Tap changing under load transformers shifting transformers, Tie line control, Comparison of methods for load flow.		
TOTAL	**36**	**100**

Reference:

1) J.J. Grainger, William, D. Stevenson Jr., Power system Analysis.

2) C.L. Wadhwa, Electrical power system, New Age international publishers.

3) B.R. Gupta: Power system Analysis and Design.

Course outcomes:

On successful completion of the course, the student will be able to:

1. Understand and analyse the behaviour of the power systems under different fault conditions.
2. Understand and analyse the behaviour of induction machines under unbalanced operations
3. Understand the mathematical model for synchronous machines.
4. Understand the concept of linear graph theory and its use to solve electrical problems.
5. Solve and analyse the load flow problems.
6. Calculate fault parameters in any 3-phase Induction machine or Synchronous machine in a Power System.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S
6	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, and self-study cases.

Method	What		To whom	When/where (Frequency in the course)	Max Marks	Evidence collected	Contributing to course outcomes
DIRECT ASSMENT	CIE	Mid Term Test	Student	Two tests	20	Midterm Answer books	1 to 5
		Weekly Test		Two Weekly Test	10	Weekly Test Copies	1 to 5
		Graded Assignments		Two Assignments	10	Log of record	1 to 5
				Total	**40**		
	ESE	End Sem Evaluation		End of the course	60	Answer scripts at BTE	1 to 5
INDIRECT ASSESSMENT	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 2, delivery of the course
	End of Course survey			End of course		Questionnaire	1 to 5, Effectiveness of delivery of instructions and assessment methods

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Model Question Paper:

M.TECH (PS) – III Semester / DUAL DEGREE (EE + PS) – IX Semester
Restructured Power System (EE-608)

Time: 3 Hours **Maximum Marks: 60**

Instructions to candidates: ▪ Attempt over all 5 questions selecting one question from each unit.

▪ All questions carry equal marks.

UNIT-I

Que.1. A double line to ground fault occurs on phase ‘A’ and ‘C’ of an unloaded generator in a power system. Represent this fault condition by sequence networks. Determine the fault current and the voltages across all the phases.

OR

Que.2. A 20 MVA, 11 kV generator is supplying a resistive load of 10 MW at 1.1 kV through a 22kV line. A single line to ground fault occurs at load side bus of the line (before step down transformer). Determine the fault current. The equipment parameters are as follows:

Generator – $X_1 = X_2 = 0.1$ pu; $X_o = 0.15$ pu;

Step up transformer – 30 MVA, 11/22 kV; $X_1 = X_2 = X_0 = 0.12$ pu

Line - $X_1 = X_2 = X_0 = (1 + j5)\ \Omega$

Step down Transformer – 20 MVA, 22/1.1 kV; $X_1 = X_2 = X_0 = 0.05$ pu

Fault resistance – 6.6 Ω

Unit II

Que.3. An induction motor is running at balanced three phase supply. If the phase sequence is reversed, what will be the performance of the motor? Describe in detail the impact on current and torque.

Que.4. An induction motor is fed from non sinusoidal voltage supply. Analyze its performance. How various harmonics affect the performance?

Unit III

Que.5. While analysing a power system, the effect of load current flowing just prior to fault occurrence, in short circuit studies, is neglected. In case it is not to be neglected, explain how it can be considered for such short circuit studies.

OR

Que.6. A three-phase salient pole synchronous generator has a terminal voltage of 1.0 pu. If the generator armature supplies a current of 0.8 pu at lagging power factor of 0.8, determine the excitation voltage and the load angle. Also calculate the real and reactive power generated. Neglect the armature resistance and assume $X_d = 1.1$ pu and $X_q = 0.8$ pu.

Unit IV

Que.7. Derive the equation $Y_{bus} = A^t Y A$

Where Y_{bus} = Bus admittance matrix,

A = Bus incidence matrix

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A^t = Transpose of A,

Y = Primitive admittance matrix.

OR

Que.8. What is an incidence matrix. Describe the properties of complete incidence matrix? Draw the oriented graph from the complete incidence matrix A_a given below:

$$A_a = \begin{Vmatrix} -1 & 0 & 0 & 1 & -1 & 0 \\ 1 & -1 & 0 & 0 & 0 & -1 \\ 0 & 1 & -1 & 0 & 1 & 0 \\ 0 & 0 & 1 & -1 & 0 & 1 \end{Vmatrix}$$

Unit V

Que.9. Draw flow chart of Newton Raphson method for load flow studies including PV buses. Explain each block of the chart.

OR

Que.10. A line with resistance 0.4 pu is supplying a load of 0.5 pu from bus 1 to bus 2. Assuming bus 1 as slack bus having a voltage of 1.0 pu, using the N-R iterative method , determine in pu (i) voltage at load bus 2, (ii) current in line 1-2, (iii) The slack bus power, and (iv) power loss in the line.

Course Title: **SMART GRID: DESIGN & ANALYSIS**		Course Code	: EE 512
Semester	: **I**	Core / Elective	: **Elective**
Teaching Scheme in Hrs (L:T:P)	: **3:0:0**	Credits	: **3 Credits**
Type of course	: **Lecture + Assignments**	Total Contact Hours	: **48**
Continuous Internal Evaluation	: **40 Marks**	SEE	: **60 Marks**
Programmes: **M.Tech Power System**			

Objectives:

1. To provide students with a comprehensive understanding on design and analysis of smart grids;
2. To ensure the students aware of the current state-of-the-art on design, operation and control of smart grid;
3. To acquire knowledge on the components in smart grids and their functions; and
4. To enable students to apply advanced analysis tools in planning and operation of smart grids

Outcomes:

Upon completion of the subject, students will be able to:

a. Acquire in-depth understanding on recent development of power grids, i.e. smart grid;
b. Apply advanced analysis tools in planning and operation of smart grids; and
c. Acquire skills in presentation and interpretation of results in written form.

Topic and Contents	Hours	Marks
UNIT I	10	20
Introduction to smart grid (1.5 week): Overview of power system operation; Comparison between existing grid and smart grid; Objectives; Benefits; Challenges; Basic structure and functions of components.	5	
Communications and measurement (1.5 weeks): Latest technologies; Wide Area Monitoring Systems (WAMS), Phasor Measurement Units (PMU), Smart Meters, Smart Appliances, and Advanced Metering Infrastructure (AMI); GIS and Google Mapping Tools; Multiagent Systems Technology.	5	
UNIT II	8	20
. Micro-grid (2 weeks): Concept of micro-grid; design and analysis; distributed generation; distributed automation.	8	
UNIT III	8	20
Renewable energy and storage (2 weeks): Renewable energy resources and options for smart grid including solar energy, wind energy, fuel cell, biomass etc.; Penetration and variability; Demand Response; Electric vehicles and plug-in hybrid; Battery energy storage systems.	8	
UNIT IV	12	20
Interoperability, standards and cyber security (2 week): State-of-the-art, Benefits, Challenges, Risks.	8	
Application examples and its trends (1 week): Demonstration projects; Testbeds and benchmark systems; Future trends; Research, education and training.	4	
UNIT V	10	20
Analysis tools (3 weeks): Power/load flow studies; Static security assessment; State estimation and stability assessment; Reliability assessment; Decision support tools; Advanced optimization and control; Environmental impacts; Pathway for designing smart grid.	10	
TOTAL	**48**	**100**

Reference Books:

1. P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy," Elsevier Inc., 2012.
2. J.A. Momoh, "Smart Grid: Fundamentals of Design and Analysis," 2012 IEEE, John Wiley & Sons, Inc., 2012.

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Peter Fox-Penner, “Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities,” Island Press, 2010.

Course Title: **ADVANCED POWER ELECTRONICS**		Course Code	:EE 505
Semester	: **M. Tech 2nd SEM**	Core / Elective	: **Core**
Teaching Scheme in Hrs (L:T:P)	: **3:0:0**	Credits	: **3 Credits**
Type of course	: **Lecture + Assignments**	Total Contact Hours	: **36**
Continuous Internal Evaluation	: **40 Marks**	SEE	: **60 Marks**
Programmes: **M.TECH POWER SYSTEM + DUAL DEGREE POWER SYSTEMS**			

Pre-requisites:

Basics of power electronics and modern power electronics

Course Objectives:

1. Help the learner to understand basic principles of converters.
2. Understand the principle and application of chopper.
3. Understand the basic principles of inverters and PWM.
4. Learn about different type of AC voltage controller and their application.
5. Learn about cyclo-converters.
6. Make students familiar with various types of Power Electronic devices, like Converters, Choppers, Inverters, AC Voltage Controllers and Cyclo-converters.

Course Content:

Topic and Contents	Hours	Marks
UNIT-1: Analysis of switched circuits	8	20
Thyristor controlled half wave rectifier – R, L, RL, RC load circuits, classification and analysis of commutation.		
UNIT-2: AC to DC Converters	7	20
Single-Phase and Three-Phase AC to DC converters- half controlled configurations- operating domains of three phase full converters and semi-converters – Reactive power considerations.		
UNIT-3: DC to DC Converters	6	20
Analysis and design of DC to DC converters- Control of DC-DC converters, Buck converters, Boost converters, Buck-Boost converters, Cuk converter		
UNIT-4: Inverters	8	20

Single phase and Three phase inverters, Voltage source and Current source inverters, Voltage control and harmonic minimization in inverters.		
UNIT 5: Power Conversion (Additional Techniques)	7	20
AC to AC power conversion using voltage regulators, choppers and cycloconverters, consideration of harmonics.		
TOTAL	**36**	**100**

Reference:

1. M.H. Rashid: Power Electronics, circuit devices and applications, PRENTICE HALL OF INDIA, 1988.
2. V Subrahmanyam: Power electronics, New Age Inc. Publishers, New Delhi,1996
3. P.C. Sen: Power electronics Tata McGraw-Hill 1987
4. CW Lander: Power electronics,2nd edition, McGraw Hill 1987
5. P.S. Bimbhra: Power electronics, 2nd Ed. Khanna Publishers,1987
6. M.D. Singh and K.B. Khanchandani: Power electronics, TATA MCGRAW HILL,1998
7. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design", John Wiley and sons.Inc, Newyork, 1995.

Course outcomes:

On successful completion of the course, the student will be able to:

1. Student will be able to understand the application of phase controlled converter
2. Understand the different type of chopper and their application
3. Understand the 1 phase and 3 phase inverters and their applications and harmonic reduction techniques
4. Understand AC voltage controller
5. How to change frequency with the help of cyclo-converter
6. Calculate the performance parameters of various Power electronic devices, and work on them in industry.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S
6	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, exercises and self-study cases.

Method	What	To whom	When/where (Frequency in the course)	Max Marks	Evidence collected	Contributing to course outcomes

DIRECT ASSMENT	CIE	Practical Performance	Student	1 experiment/ week for 10 experiments	40	Lab Record	1to 5
		Project		1 Project in the lab	20	Project + Project Report	1 to 5
				Total	**60**		
	ESE	End Sem Evaluation		End of the course	40	Viva + Final performance	1 to 5
INDIRECT ASSESSMENT	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 4, delivery of the course
	End of Course survey			End of course		Questionnaire	1 to 9, Effectiveness of delivery of instructions and assessment methods

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Model Question Paper:

Enrolment No.................................

M.Tech Dual Degree

(Elect. Engg)

Semester (II)M. TECH CORE

ADVANCED POWER ELECTRONICS (EE 503)

MAIN/BACK EXAMS-NOV/DEC-2015

Time:3 Hours Max.marks:-70

Instructions to candidate:

Attempt overall 5 questions selecting one question from each unit.

All questions carry equal marks

UNIT 1

Q1.Describe the working of a single phase full converter in the inverter mode with RLE load. Illustrate your answer with waveforms for source voltage, E, load voltage and current, source current and voltage across one SCR. Assume continuous conduction.

OR

Q2.For a 3 phase full converter , sketch the input voltage waveforms for Vab , Vac,Vbc and voltage variation across any one thyristor for one complete cycle for a firing angle delay of (a) 60^0(b) 120^0

UNIT 2

Q3.For type a chopper circuit, source voltage Vs = 220 V,chopping period T = 2000 micro seconds, on period = 600 micro seconds, load circuit parameters: R=1 ohm, L= 5m H and E = 24 V

(a) Find wheather load current is continuous or not
(b) Calculate the value of average output current
(c) Compare the maximum and minimum values of steady state output current
(d) Find rms values of the first , second and third harmonics of the load current
(e) Compute the average value of supply current
(f) Compute input power, power absorbed by the load counter emf and the power loss in the resistor

OR

Q4. A series motor used for a rapid transit system is fed through a dc chopper. The series motor has total circuit resistance of 2 ohm and inductance of 2 m H. What external inductance should be inserted in series with the armature circuit to 10 % for a duty cycle ratio of 0.5. the chopping frequency is 1 k HZ

UNIT 3

Q5.Explain the different methods of voltage control in three phase inverter

OR

Q6. Explain PWM and harmonic reduction techniques in inverter

UNIT 4

Q7.A single phase voltage controller, with two thyristor s arranged in anti –parallel, is connected to RL. Discuss its working when firing angle is more than the load pf angle. Illustrate your answer with waveforms of source voltage , gate signals , load and source currents, output voltage and voltage across both thyristor

OR

Q8.The three phase full wave controller supplies a star connected resistive load of R = 10 ohm and the line to line input voltage is 208 V (rms) , 60 Hz. The delay angle is $\alpha = \pi/3$ determine (a) the rms output phase voltage Vo (b) the input PF , (c) the expression for the instantaneous output voltage of phase a.

UNIT 5

Q9..Draw the control circuit block diagram of cyclo- converter

(b) Show that the fundamental RMS value of per phase output voltage of low frequency for an m –pulse cyclo-converter is given by $E_{or} = E_{ph}$ (m/π) sin (m/π) also express E_{or} in terms of voltage reduction factor r.

OR

Q10. What is basic basic principle of cyclo –converter. Discuss why three phase to single phase cyclo -converter requires positive and negative group phase controlled converters. Under what conditions, the group work as inverter or rectifiers?

Course Title: **ADVANCE POWER SYSTEM STABILITY**		Course Code	: EE 502
Semester	: M.Tech. Sem-II/ Summer IX	Core / Elective	: CORE
Teaching Scheme in Hrs (L:T:P)	: **0:0:3**	Credits	: **2 Credits**
Type of course	: **Experiment + File**	Total Contact Hours	: **30**
Continuous Internal Evaluation	: **60 Marks**	SEE	: **40 Marks**
Programmes: **M.Tech Power System + Dual Degree EE + PS**			

Prerequisite	Power System Analysis, AC machines
Objective:	The objective of the course are:
	1. Help the learner to model the synchronous machine and visualize flux linkage
	2. Understand the Steady state and transient stability
	3. Learn about SMIB and multi machine system.
	4. Learn about solution of various stability problems
	5. Learn various factors affecting stability
Expected Outcome:	The student will be able to
	1. Student will be able to model various synchronous machines.
	2. Solve swing equation and understand various stability
	3. Able to develop SMIB system & solve coherent non coherent system
	4. Give solution to various stability problems eg fault clearing time,critical clearing angle etc.
	5. Know the factors affecting stability and their remedy
Unit -1 (7 Hours)	**Modeling of synchronous machines**
	Modeling of cylindrical rotor salient pole synchronous machines, flux linkage equations, voltage equations, Park's transformation, various inductances and time constraints of synchronous machines, vector diagrams for steady state and transient conditions, power angle curves.
Unit -2 (7 Hours)	**Stabilities**
	Steady state and transient stabilities, their definitions and methods of determination. Development of Swing equation.
Unit -3 (6Hours)	**Machine Systems**
	Steady state stability of single machine connected to an infinite bus by the method of small oscillations. Two machine systems. Coherent and non-coherent machines.
Unit -4 (9 Hours)	**Study of various stability methods**
	Equal area criterion of determining transient stability, fault clearing time and critical clearing angle. Solution of Swing equation by step by step method. Euler's Method and Runga-Kutta Method, Application of Computers in the study of transient stability using these methods. Introduction to steady state and transient Stability using these methods. Introduction to steady state and transient stabilities of multi-machine system without controller.
Unit -5(7 Hours)	**Factors affecting Stabilities**
	Factors affecting steady state and transient stabilities, methods of improving steady state and transient stabilities, high speed circuit breakers, auto-reclosing circuit breaker, single pole operation, excitation control, and bypass valving.
List of Expt.	Nil
Text Book	1C L Wadhwa, Electrical power system.New Age international publishers.
Reference book	1. B.R.Gupta: Power system Analysis and Design.

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JAIPUR

Mode of Evaluation	Continuous evaluation (Weekly test,Graded Assignments, Mid term test, End sem exam)
Recomm. by BOS on	
Approved by AC on	

Course Title: **POWER SYSTEM DESIGN USING PSCAD I**		Course Code	: EE 553
Semester	: M.Tech. Sem-II/ Summer IX	Core / Elective	: CORE
Teaching Scheme in Hrs (L:T:P)	: **0:0:3**	Credits	: **2 Credits**
Type of course	: **Experiment + File**	Total Contact Hours	: **30**
Continuous Internal Evaluation	: **60 Marks**	SEE	: **40 Marks**
Programmes: **M.Tech Power System + Dual Degree EE + PS**			

Pre-requisites:

Basics of Power Systems (Generation, Transmission & Distribution)

Course Objectives:

1. To learn the design of power system applications in software other than MATLAB.
2. To learn and understand the working of PSCAD software.
3. Understand the application of the Software in the practical Power System World.
4. Learn modelling and simulation through PSCAD of various components and scenarios of Power System, like Rectifier circuits, fault analysis, DC-DC Converters, induction motors, transformers, etc.

Course Content

	Topic and Contents	Hours	Marks
1.	Introduction to PSCAD – Installation and use in Power System Modelling	3	10
2.	Introduction to PSCAD – Basics of PSCAD	3	10
3.	Design and implementation full wave rectifier circuit with R and RL Load	3	10
4.	L-L Fault Analysis of a simple AC System using PSCAD	3	10
5.	L-L-G Fault Analysis of a simple AC System using PSCAD	3	10
6.	Simulation of DC-DC Converter with a simple AC system as input	3	10
7.	Design of a VFD for a squirrel cage induction motor and an AC Voltage source.	3	10

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8.	Simulation of a VFD for a squirrel cage induction motor and an AC Voltage source using PSCAD.	3	10
9.	Modelling of 3 phase transformer using PSCAD.	3	10
10.	Modelling and simulation of DC Series and Shunt Motors using PSCAD	3	10
		30	**100**

Reference:

Course outcomes:

On successful completion of the course, the student will be able to:

1. Apply the theory covered in courses to obtain working simulations of advanced Electrical Engineering circuits.
2. Will be able to use PSCAD for designing of circuits/systems that have been covered in their theoretical topic thus far.
3. Through the project development, students will be able to showcase their skills in modelling an Electrical Engineering/Power System through PSCAD.
4. Understand the process of implementing design in the simulation.
5. Simulate any Power System component or scenario in the industry.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	**Program outcomes**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, exercises and self-study cases.

Method	**What**		**To whom**	**When/where (Frequency in the course)**	**Max Marks**	**Evidence collected**	**Contributing to course outcomes**
DIR ECT ASS ME	CIE	Practical Performance	Student	1 experiment/ week for 10 experiments	40	Lab Record	1 to 5

		Project		1 Project in the lab	20	Project + Project Report	1 to 5
				Total	**60**		
	ESE	End Sem Evaluation		End of the course	40	Viva + Final performance	1 to 5
INDIRECT ASSESSMENT	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 4, delivery of the course
	End of Course survey			End of course		Questionnaire	1 to 9, Effectiveness of delivery of instructions and assessment methods

1. **CIE** – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Course Title: **HVDC TRANSMISSION**		Course Code	: EE 504
Semester	: **M.Tech Sem-II, Summer DD (PS) IX-Sem**	Core / Elective	: **Core**
Teaching Scheme in Hrs (L:T:P)	: **3:0:0**	Credits	: **3 Credits**
Type of course	: **Lecture + Assignments**	Total Contact Hours	: **36**
Continuous Internal Evaluation	: **40 Marks**	SEE	: **60 Marks**
Programmes: **Common for M.Tech Power System + Dual Degree EE + PS**			

Pre-requisites:

- B.Tech in Electrical Engineering
- Power Electronics

- Transmission & Distribution

Course Objectives:

1. Help the learner to understand basic principles and operation of HVDC Systems and the main switching devices, thyristor and IGBT Valves
2. Understand the application of Power Electronics Converters HVDC Systems
3. Understand and implement basic design concepts for HVDC Systems
4. Investigate the use of filters and how they may be used to remove the identified harmonics from the HVDC system.
5. Understand how MTDC systems function and their future applications.
6. Make students familiar with the various components of HVDC Power System and its advantages over HVAC systems.

Course Content:

Topic and Contents	Hours	Marks
Unit 1 Thyristor & IGBT Valves	7	20
Thyristor device, Steady state and switching characteristics, Light activated power thyristor, LED, fibre optics, valve firing, parallel and series connections of thyristors. IGBT Device		
Unit 2 Converter Circuits	7	20
Rectification and inversion, effect of reactance, six pulse and twelve pulse converter circuits.		
Unit 3 DC Link Control	8	20
Principles of DC link control, Converter control characteristics, System control hierarchy, Firing angle control, Extinction angle control, starting, stopping and power flow reversal of DC link, Power control, and Parallel operation of DC link with AC transmission line. Converter faults, commutation failure, valve blocking and bypassing. Protection against over currents, over voltages. DC circuit breakers. Reactive Power Control: Reactive power requirement in steady state, Sources of reactive power and reactive power control.		
Unit 4 Harmonics & Filters	7	20

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HOD
Electrical Department
JAIPUR

Generation of harmonics, AC and DC side harmonics, Characteristics and non-characteristics harmonics. Types of AC filters – single tuned and double tuned filters, high pass filter, DC Smoothing reactor and filters. (ii) Scheme of a HVDC converter station and components of HVDC transmission system.		
Unit 5 Multi-Terminal DC Drives	7	20
Types of MTDC systems, Comparison of series and parallel MTDC systems, Control and protection of MTDC systems, Application of MTDC systems.		
TOTAL	**36**	**100**

Reference:

1. K.R. Padiyar - HVDC Power Transmission System
2. Power System Engineering by C.M. Arora
3. Power Electronics, M.H. Rashid
4. Electrical power system. C.L. Wadhwa, New Age international publishers.

Course outcomes:

On successful completion of the course, the student will be able to:

1. Measure and calculate the switching behaviour of thyristor and IGBT valves
2. Design power electronic converters (AC- DC, DC - DC)
3. Understand control schemes for HVDC systems and their control
4. Measure and remove harmonics.
5. Understand the application of MTDC systems.
6. Work on and design the widespread HVDC Power Systems in the industry.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S
6	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

1. The Course will be delivered through lectures, class room interaction, exercises and self-study cases.

Method	What	To whom	When/where (Frequency in the course)	Max Marks	Evidence collected	Contributing to course outcomes

Suresh Gyan Vihar University HOD Electrical Department JAIPUR

DIRECT ASSMENT	CIE	Practical Performance	Student	1 experiment/ week for 10 experiments	40	Lab Record	1 to 5
		Project		1 Project in the lab	20	Project + Project Report	1 to 5
				Total	**60**		
	ESE	End Sem Evaluation		End of the course	40	Viva + Final performance	1 to 5
INDIRECT ASSESSMENT	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 4, delivery of the course
	End of Course survey			End of course		Questionnaire	1 to 9, Effectiveness of delivery of instructions and assessment methods

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Course Title: **Power System Transients and Protection**	Course Code : EE 506
Semester : M.Tech II-Sem, Summer(DD) VIII-Sem	Core / Elective : **Core**
Teaching Scheme in Hrs (L:T:P) : **3:0:0**	Credits : **3 Credits**
Type of course : **Lecture + Assignments**	Total Contact Hours : **36**
Continuous Internal Evaluation : **40 Marks**	ESE : **60 Marks**
Programmes: **M.TECH POWER SYSTEM + DUAL DEGREE EE + PS**	

Pre-requisites:

Graduate level Electrical Engineering Course of Indian Universities.

Course Objectives:

1. To understand the wave phenomenon in power systems.
2. To understand the grounding and its impact on the behaviour of power systems and on insulation coordination
3. To understand the working of static relays, their advantages and the disadvantages and their reliability.
4. To understand the working of various types of comparators, being used in static relays.
5. To understand the role of switchgear in power systems.
6. Make students familiar with the various causes of Power System Transients and various protective Relays and Circuit Breakers used to prevent them.

Course Content:

Topic and Contents	Hours	Marks
UNIT-1: **Travelling waves & Over-voltages**	6	20
Wave terminology, development of wave equations, terminal problems, lattice diagrams. Origin and nature of power system surges, wave shapes, attenuation, effect of shielding by ground wires and masts, tower footing-resistance. Traveling waves, multi-velocity waves, methods of measuring tower footing resistance, voltages across insulator strings. Dynamic over voltages during surges and system faults, system recovery voltage characteristics.		
UNIT-2: **Neutral Grounding & Insulation**	6	20
Methods of neutral grounding and their effect on system behaviour. Insulation coordination, requirement in surge protection of lines and equipment.		
UNIT-3: **Static Relays**	8	20
Introduction, advantages of static relays over electromagnetic relays. Limitation of static relays, Reliability and Security of static relays, Recent Developments of static relays.		
UNIT-4: **Comparators & Digital Relays**	8	20
Comparators and Level Detectors: Static Relay Functional circuits, Amplitude and Phase comparators, level detectors. Digital Relays, Microprocessor based protective relays.		
UNIT 5: **Circuit Breakers**	8	20
Switchgear: Types of circuit breakers and their constructional features, operating mechanism Application of Circuit breakers, speed of circuit breakers, Auto reclosing, selection of circuit breakers, Rating of circuit breakers, Testing of circuit breakers, SF_6 Insulated Metal clad Switchgear (CIS), Advantages, Demerits, Design aspects, Bus bar modules, SF_6, Insulated EHV Transmission Cables (GIC).		
TOTAL	**36**	**100**

Reference:

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1) M. Chander: Switchgear protection.
2) S.S. Rao: Switchgear and protection.
3) T.M.S. Rao: Static Relays.
4) C.L. Wadhwa - Electrical Power system.
5) J.B. Gupta: Switchgear protection. Kataria Publications, New Delhi.

Course outcomes:

On successful completion of the course, the student will be able to:

1. Understand the transient wave phenomenon in power systems
2. Understand the impact of grounding on the behaviour of power systems
3. Understand the working of static relays in power systems
4. Understand the working of comparators in static relays and to use them in various protective schemes.
5. Understand the operation of switchgear in power systems.
6. To be able to understand the above related field problems.
7. Calculate the values of Power System Transients in any basic scenario, and suggest the appropriate protective relay or circuit breaker for that case.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S
6	S	S	S	S	S	M	M	M	M	M	S
7	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, and self-study cases.

Method	What		To whom	When/where (Frequency in the course)	Max Marks	Evidence collected	Contributing to course outcomes
DIRECT ASSESSME	CIE	Mid Term Test	Student	Two tests	20	Midterm Answer books	1 to 5

		Weekly Test		Two Weekly Test	10	Weekly Test Copies	1 to 6
		Graded Assignments		Two Assignments	10	Log of record	1 to 5
				Total	**40**		
	ESE	End Sem Evaluation		End of the course	60	Answer scripts at BTE?	1 to 5
INDIRECT ASSESSMENT	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 3, delivery of the course
	End of Course survey			End of course		Questionnaire	1 to 6, Effectiveness of delivery of instructions and assessment methods

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and ESE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Model Question Paper:

M.TECH (PS) / DUAL DEGREE (EE + PS) **Power System Transients and Protection (EE-506)**

Time: 3 Hours **Maximum Marks: 60**

Instructions to candidates: ▪ Attempt over all 5 questions selecting one question from each unit.

▪ All questions carry equal marks.

UNIT-I

Que.1. What are the surges in a power system. How these are generated. Discuss the effect of the ground wires and tower footing resistance on various types of surges. (4+4+4)

OR

Que.2. An overhead line with surge impedance 600 ohm bifurcates into two lines of surge impedance 600 ohm and 50 ohm, respectively. If a surge of 45 kV is incident on the overhead line, determine the magnitudes of voltage and current which enter the bifurcated lines. (12)

Unit II

Que.3. What is the role of neutral grounding? How various methods of neutral grounding do affect the impact of surges in a power system? (6+6)

Que.4. What do you understand by the insulation coordination. How volt - time curve for various components in a power system, to be protected are related with that of protecting equipment. Discuss critically. (5+7)

Unit III

Que.5. In static relays, which device is used to combine more than one signal. Describe the device, with its working and its use in static relays. (4+8)

OR

Que.6. Discuss the use of logic gates in protective relaying. With the help of logic gates, explain clearly the relay logic. (6+6)

Unit IV

Que.7. Name different types of static amplitude comparators. Discuss their working with relative advantages and disadvantages. (5+7)

OR

Que.8. Show that the amplitude and phase comparators are dual to each other. In static relays how these functions are achieved. (8+4)

Unit V

Que.9. What do you understand by symmetrical breaking current, asymmetrical breaking current, and making current as applied to circuit breakers. Can these be determined from oscillograms taken short circuit tests on a three phase circuit breaker? Explain. What is meant by the rated MVA breaking capacity of such a breaker? (2+2+2+3+3)

OR

Que.10. What is the principle of breaking dc currents? In what respect does it differ from ac current breaking? What are the practical limitations of breaking high voltage direct current and how can these be overcome? (3+3+3+3)

Guidelines for Question Paper Setting:

1. The question paper must be prepared based on the blue print without changing the weigh age of model fixed for each unit.
2. The question paper pattern provided should be adhered to
3. The paper should have 10 questions in all, wherein it will have 2 questions from each unit.

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4. Student shall be asked to attempt in all 5 questions, 1 Question from each unit.

5. Student shall be given internal choice in every Unit.

6. Questions should not be set from the recapitulation topics.

Course Title: **POWER SYSTEM MODELLING AND SIMULATION LAB**		Course Code	: EE 552
Semester	: II	Core / Elective	: CORE
Teaching Scheme in Hrs (L:T:P)	: **0:0:3**	Credits	: **2 Credits**
Type of course	: **Experiment + File**	Total Contact Hours	: **30**
Continuous Internal Evaluation	: **60 Marks**	SEE	: **40 Marks**
Programmes: **M.Tech Power System + Dual Degree EE + PS**			

Pre-requisites:

Torque equation and impedances of inductor and capacitor

Course Objectives:

1. To learn MATLAB software and its various applications.
2. Learn to implement advanced power system and electrical engineering problems to obtain a solution through MATLAB/ETAP analysis.
3. Obtain a better understanding of advanced theoretical concepts covered in M.Tech courses through mathematical modelling.
4. Make students familiar with the use of MATLAB in modelling and simulation of various components and equations of Power System, like Swing Equation, DC machines, Induction machines, Synchronous machines, FACTS devices, etc.

Course Content

	Topic and Contents	Hours	Marks
1.	Simulate Swing Equation in Simulink (MATLAB)	3	10
2.	Modelling of DC Series Motor and DC Shunt Motor.	3	10
3.	Simulate DC Series Motor and DC Shunt Motor (Simulink).	3	10
4.	Modelling of Induction Machine.	3	10
5.	Simulation of Induction Machine. (Simulink)	3	10
6.	Modelling of Synchronous Machine with PSS	3	10
7.	Simulation of Synchronous Machine with PSS (Simulink)	3	10

Suresh Gyan Vihar University
HOD
Electrical Department
JAIPUR

8.	Modelling of Synchronous Machine with FACTS device	3	10
9.	Simulation of Synchronous Machine with FACTS devices (Simulink)	3	10
10.	FACTS Controller designs with FACT devices for SMIB system.	3	10
		30	**100**

Reference:

1. Fundamentals of Electric Dives, G.K. Dubey, Narosa Publishing House, New Delhi 1995
2. Lab Manuals

Course outcomes:

On successful completion of the course, the student will be able to:

1. Apply the theory covered in courses to obtain working simulations of advanced Electrical Engineering circuits.
2. Will be able to use MATLAB/ETAP for designing of circuits/systems that have been covered in their theoretical topic thus far.
3. Through the project development, students will be able to showcase their skills in modelling an Electrical Engineering/Power System through MATLAB.
4. Simulate various components and equations using MATLAB to be used in the Power System industry.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, exercises and self-study cases.

Method	What		To whom	When/where (Frequency in the course)	Max Marks	Evidence collected	Contributing to course outcomes
DIR ECT ASS ME	CIE	Practical Performance	Student	1 experiment/ week for 10 experiments	40	Lab Record	1 to 5

		Project		1 Project in the lab	20	Project + Project Report	1 to 5
				Total	**60**		
	ESE	End Sem Evaluation		End of the course	40	Viva + Final performance	1 to 5
INDIRECT ASSESSMENT	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 4, delivery of the course
	End of Course survey			End of course		Questionnaire	1 to 9, Effectiveness of delivery of instructions and assessment methods

1. **CIE** – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Course Title: **POWER SYSTEM LAB II**	Course Code : EE 554
Semester : II	Core / Elective : CORE
Teaching Scheme in Hrs (L:T:P) : **0:0:3**	Credits : **2 Credits**
Type of course : **Experiment + File**	Total Contact Hours : **30**
Continuous Internal Evaluation : **60 Marks**	SEE : **40 Marks**
Programmes: **M.Tech Power System + Dual Degree EE + PS**	

Pre-requisites:

Torque equation and impedances of inductor and capacitor

Course Objectives:

1. To learn MATLAB software and its various applications.
2. Learn to implement advanced power system and electrical engineering problems to obtain a solution through MATLAB/ETAP analysis.
3. Obtain a better understanding of advanced theoretical concepts covered in M.Tech courses through mathematical modelling.
4. Make students familiar with modern Simulation software like MATLAB, PSCAD, etc. for simulating various Power System scenarios, like overcurrent, Ferranti effect, Load Flow Analysis, symmetrical and unsymmetrical fault analysis, etc.

Course Content

	Topic and Contents	**Hours**	**Marks**
1.	To determine negative and zero sequence reactance of an alternator.	3	10
2.	Determine direct axis reactance (X_d) and quadrature axis reactance (X_q) of a salient pole alternator.	3	10
3.	To study the IDMT over current relay and determine the time current characteristics.		10
4.	To study Ferranti effect and voltage distribution in H.V. long transmission line using transmission line model. (May use MATLAB/PSCAD/other simulation software)	3	10
5.	To determine location of fault in a cable using cable fault locator.	3	10
6.	To study operation of oil testing set.	3	10
7.	To study percentage differential relay and develop instrumentation for obtaining automated performance characteristics of the relay	3	10
8.	To obtain formation of Y-bus and perform load flow analysis using MATLAB/PSCAD (Other simulation software).	3	10
9.	To perform symmetrical fault analysis in a power system using MATLAB/PSCAD (Other simulation software)	3	10
10.	To perform unsymmetrical fault analysis in a power system using MATLAB/PSCAD (Other simulation software).	3	10
		30	**100**

Reference:

1. Fundamentals of Electric Dives, G.K. Dubey, Narosa Publishing House, New Delhi 1995
2. Lab Manuals

Course outcomes:

On successful completion of the course, the student will be able to:

1. Apply the theory covered in courses to obtain working simulations of advanced Electrical Engineering circuits.
2. Will be able to use MATLAB/PSCAD for designing of circuits/systems that have been covered in their theoretical topic thus far.
3. Through the project development, students will be able to showcase their skills in modelling an Electrical Engineering/Power System through hardware and software.
4. Do various simulations and calculation of the Power System components in MATLAB, PSCAD, etc. to be used in industry.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, exercises and self-study cases.

Method	What		To whom	When/where (Frequency in the course)	Max Marks	Evidence collected	Contributing to course outcomes
DIRECT ASSMENT	CIE	Practical Performance	Student	1 experiment/ week for 10 experiments	40	Lab Record	1 to 5
		Project		1 Project in the lab	20	Project + Project Report	1 to 5
				Total	**60**		
	ESE	End Sem Evaluation		End of the course	40	Viva + Final performance	1 to 5
INDIRECT ASS	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 4, delivery of the course

	End of Course survey		End of course		Questionnaire	1 to 9, Effectiveness of delivery of instructions and assessment methods

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Course Title: **ADVANCED POWER SYSTEM**		Course Code	: EE 508
Semester	: M.Tech. II-Sem	Core / Elective	: **Core**
Teaching Scheme in Hrs (L:T:P)	: **3:0:0**	Credits	: **3 Credits**
Type of course	: **Lecture + Assignments**	Total Contact Hours	: **36**
Continuous Internal Evaluation	: **40 Marks**	ESE	: **60 Marks**
Programmes: M.Tech **POWER SYSTEM + DUAL DEGREE EE + PS**			

Pre-requisites:

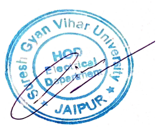
Graduate level Electrical Engineering Course of Indian Universities.

Course Objectives:

1. Help the learner to understand voltage stability
2. Understand the distribution automation system
3. Learn about various FACTS devices
4. Learn about basics of energy audit.
5. Learn superconductivity and applications
6. Imparting knowledge to students about recent advancements in Power Systems, like SCADA, FACTS, etc.

Course Content:

Topic and Contents	Hours	Marks



UNIT-1: **Voltage Stability**	6	20
Power system voltage stability concept, comparison of angle and voltage stabilities, Power system loads, generator P-Q and Q-V characteristics. Voltage collapse. Voltage stability analysis. Methods of improving voltage stability.		
UNIT-2: **Distribution Automation**	6	20
Introduction to distribution automation. Concepts of communication - power line carrier, radio communication, fibre optics, satellite communication and sensors. Introduction to supervisory control and data acquisition (SCADA). Brief description of an automation system.		
UNIT-3: **FACTS**	8	20
Problem of AC transmission systems, basic principle of power flow control of an AC transmission line. Basic types of FACTS controllers. Brief description of FACTS controllers- STATCOM, Static Voltage and phase angle regulators, thyristor switched and thyristor controlled series capacitors, Unified Power Flow Controller.		
UNIT-4: **Energy Conservation**	8	20
Introduction, conservation of natural resources, principles of energy conservation and energy audit. Brief description of energy conservation in power plants, electric utilities, electric drives, industries and electric lighting.		
UNIT 5: **Superconductivity**	8	20
Basic characteristics of superconductors. Brief description of applications of superconductivity to electric power systems - superconducting generators, motors, transformers, transmission cables and magnetic storage.		
TOTAL	**36**	**100**

Reference:

1. C L. Wadhwa, Electrical power system. New Age international publishers.

2. B.R. Gupta: Power system Analysis and Design.

Course outcomes:

On successful completion of the course, the student will be able to:

1. Student will be able to analyse voltage stability
2. Understand distribution automation and SCADA
3. Able to apply FACTS devices
4. Able to audit electrical utilities.
5. Understand superconductivity and applications
6. Understand the methods to charge for the transmission line uses and for the power losses in transmission system.

7. Work on the relatively newer components of Power Systems in industry, like SCADA, FACTS and Superconductors.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S
6	S	S	S	S	S	M	M	M	M	M	S
7	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, and self-study cases.

<table>
<tr><th>Method</th><th colspan="2">What</th><th>To whom</th><th>When/where (Frequency in the course)</th><th>Max Marks</th><th>Evidence collected</th><th>Contributing to course outcomes</th></tr>
<tr><td rowspan="5">DIRECT ASSMENT</td><td rowspan="4">CIE</td><td>Mid Term Test</td><td rowspan="5">Student</td><td>Two tests</td><td>20</td><td>Midterm Answer books</td><td>1 to 5</td></tr>
<tr><td>Weekly Test</td><td>Two Weekly Test</td><td>10</td><td>Weekly Test Copies</td><td>1 to 5</td></tr>
<tr><td rowspan="2">Graded Assignments</td><td>Two Assignments</td><td>10</td><td>Log of record</td><td>1 to 5</td></tr>
<tr><td>Total</td><td>40</td><td></td><td></td></tr>
<tr><td>ESE</td><td>End Sem Evaluation</td><td>End of the course</td><td>60</td><td>Answer scripts at BTE</td><td>1 to 5</td></tr>
<tr><td>INDIRECT ASS</td><td colspan="2">Student feedback</td><td>Students</td><td>Middle of the course</td><td>-NA-</td><td>Feedback forms</td><td>1 to 2, delivery of the course</td></tr>
</table>

Suresh Gyan Vihar University HOD Electrical Department JAIPUR

	End of Course survey		End of course		Questionnaire	1 to 5, Effectiveness of delivery of instructions and assessment methods

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Course Title: **POWER SYSTEM PLANNING & RELIABILITY**		Course Code	: **EE 601**
Semester	: **3rd Semester**	Core / Elective	: **Core**
Teaching Scheme in Hrs (L:T:P)	: **3:0:0**	Credits	: **3 Credits**
Type of course	: **Lecture + Assignments**	Total Contact Hours	: **36**
Continuous Internal Evaluation	: **40 Marks**	SEE	: **60 Marks**
Programmes: **M.Tech Power System & Dual Degree (B.Tech Electrical +M.Tech Power System)**			

Pre-requisites:

EE 401 – Power System Analysis, EE 418 – Power System Planning.

Course Objectives:

1. Understand the effect of the load variation on the existing power system and how the increase/decrease in the load in the future will require efficient and reliable planning.
2. Study the importance of Reliability analysis for Power System Development
3. Learn the different aspects of planning of a power system in terms of the different types of generating capacity
4. Analyse systems through Reliability concepts of outage and generation capacity.
5. Make students familiar with the various techniques used to evaluate Reliability of different components of Power System.

Course Content:

Topic and Contents	Hours	Marks
UNIT-1: **Load Forecasting**	8	20

Classification and characteristics of loads. Approaches to load forecasting. Forecasting methodology. Energy forecasting.		
UNITS-2: **Basic Reliability Concepts**	8	20
General reliability function, Markov Chains and processes and their applications, simple series and parallel system models.		
UNITS-3: **Static Generating Capacity Reliability Evaluation**	8	20
Outage definitions, loss of load probability methods, loss of energy probability method. Frequency and duration methods, load forecasting uncertainty.		
UNIT-4: **Spinning Generating Capacity Reliability Evaluation**	6	20
Spinning capacity evaluation, load forecast uncertainty.		
UNIT 5: **Transmission System Reliability Evaluation**	6	20
Average interruption rate method. The frequency and duration method. Stormy and normal weather effects. Inter-connected Systems Generating Capacity Reliability Evaluation: Introduction, The loss of toad approach. Reliability evaluation in two and more than two interconnected systems. Interconnection benefits.		
TOTAL	**36**	**100**

Reference:

1. Roy Billinton and Ronald N. Allan -Reliability Evaluation of power system volume-I
2. Roy Billinton and Ronald N. Allan -Reliability evaluation of power System volume-II
3. J Endreny - Reliability modelling in electric power system.
4. A.S. Pabla - Electric power distribution

Course outcomes:

On successful completion of the course, the student will be able to:

1. Perform reliability analysis on electrical systems.
2. Evaluate possible sources of unreliability in the system and its possible causes.
3. Perform analysis using the Reliability concept for systems under study.
4. Plan an electrical system with proper reliability analysis while taking into consideration the future loads.
5. Evaluate Reliability of different components of Power System in industry, like Static Generating Capacity, Spinning Generating Capacity and Transmission Capacity.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, and self-study cases.

<table>
<tr><th>Method</th><th colspan="2">What</th><th>To whom</th><th>When/where (Frequency in the course)</th><th>Max Marks</th><th>Evidence collected</th><th>Contributing to course outcomes</th></tr>
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<tr><td>Total</td><td>40</td><td></td><td></td></tr>
<tr><td>ESE</td><td>End Sem Evaluation</td><td>End of the course</td><td>60</td><td>Answer scripts at BTE</td><td>1 to 5</td></tr>
<tr><td rowspan="2">INDIRECT ASSESSMENT</td><td colspan="2">Student feedback</td><td rowspan="2">Students</td><td>Middle of the course</td><td rowspan="2">-NA-</td><td>Feedback forms</td><td>1 to 2, delivery of the course</td></tr>
<tr><td colspan="2">End of Course survey</td><td>End of course</td><td>Questionnaire</td><td>1 to 5, Effectiveness of delivery of instructions and assessment methods</td></tr>
</table>

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Course Title: **Restructured Power System**		Course Code	: EE 609
Semester	: III	Core / Elective	: **Core**
Teaching Scheme in Hrs (L:T:P)	: **3:0:0**	Credits	: **3 Credits**
Type of course	: **Lecture + Assignments**	Total Contact Hours	: **36**
Continuous Internal Evaluation	: **40 Marks**	ESE	: **60 Marks**
Programmes: M.Tech **POWER SYSTEM + DUAL DEGREE EE + PS**			

Pre-requisites:

Graduate level Electrical Engineering Course of Indian Universities.

Course Objectives:

1. To understand the restructuring of the power industry.
2. To understand the working of restructured power systems as market model and to manage the congestion of the transmission lines.
3. To understand the working of the restructured systems in which the price of electricity may be different at different nodes.
4. To understand the concepts of ancillary services in restructured power systems.
5. To understand how to charge for the transmission network and for the losses in transmission system.
6. Make the students familiar with the various types of management models used in Restructured Power Systems, like – Transmission Congestion Management, Ancillary Service Management, LMP, FTR, etc.

Course Content:

Topic and Contents	Hours	Marks
UNIT-1: **Introduction**	6	20
Introduction to restructuring of power industry, issues involved in deregulation, objectives of deregulation of various power systems across the world. Fundamentals of Economics. Consumer behaviour, Supplier behaviour, Market equilibrium, Various costs of production, Perfectly competitive market		
UNIT-2: **The Philosophy of Market Models**	6	20

. Comparison of various market models, Electricity vis-à-vis other commodities, Congestion Management, Ancillary Services, Market architecture, **Transmission Congestion Management**. Classification, Calculation of ATC, ATC calculation using PTDF and LODF based on DC model		
UNIT-3: **Locational Marginal Prices (LMP) and Financial Transmission Rights (FTR)**	8	20
Mathematical preliminaries: Convexity, Duality, Perturbation analysis, Sensitivity analysis, KKT necessary conditions for optimality LMP, Lossless DCOPF model for LMP calculation Loss compensated DCOPF model for LMP calculation Accuracy comparison of both the models Introduction to Financial Transmission Rights, Risk Hedging Functionality Of financial Transmission Rights		
UNIT-4: **Ancillary Service Management**	8	20
Types of ancillary services, Load-generation balancing related services Issues in reactive power management, Black start capability service		
UNIT 5: **Pricing of transmission network usage and loss allocation**	8	20
Postage stamp method, Incremental postage stamp method, Contract path method, MW-Mile method, Power flow tracing Proportionate sharing principle, Graph theoretic approach Simultaneous equations approach, Merits and de-merits of different paradigms, Introduction to loss allocation Classification of loss allocation methods, Pro-rata methods Incremental methods, Power flow tracing based allocation Comparison between various methods		
TOTAL	**36**	**100**

Reference:

1 Fundamentals of Power System economics Daniel Kirschen and Goran Strbac, John Wiley & Sons Ltd, 2004.

2 Making competition work in electricity Sally Hunt, John Wiley & Sons, Inc., 2002.

3 Operation of restructured power systems Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Bollen, Kluwer Academic Pub., 2001.

Course outcomes:

On successful completion of the course, the student will be able to:

1. Understand the need of restructuring of the power industry and the behaviour of affected parties.
2. Understand how the electricity is different from other commodities and how the mathematical tools be used to manage the congestion of the transmission lines using PTDF and LODF.
3. Understand the basics of the methods to determine the electricity price at different nodes.
4. Understand the concept of ancillary services in restructured power systems which are required to run the power system in a smooth manner.
5. Understand the methods to charge for the transmission line uses and for the power losses in transmission system.

6. Understand and use different types of Management models used in the Restructured Power Systems used nowadays in the industry.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	Program outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S
6	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, and self-study cases.

Method	What		To whom	When/where (Frequency in the course)	Max Marks	Evidence collected	Contributing to course outcomes
DIRECT ASSMENT	CIE	Mid Term Test	Student	Two tests	20	Midterm Answer books	1 to 5
		Weekly Test		Two Weekly Test	10	Weekly Test Copies	1 to 5
		Graded Assignments		Two Assignments	10	Log of record	1 to 5
				Total	**40**		
	ESE	End Sem Evaluation		End of the course	60	Answer scripts at BTE	1 to 5
INDIRECT ASS	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 2, delivery of the course

	End of Course survey		End of course		Questionnaire	1 to 5, Effectiveness of delivery of instructions and assessment methods

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40

Model Question Paper:

M.TECH (PS) – III Semester / DUAL DEGREE (EE + PS) – IX Semester
Restructured Power System (EE-608)

Time: 3 Hours **Maximum Marks: 60**

Instructions to candidates: ▪ Attempt over all 5 questions selecting one question from each unit.

▪ All questions carry equal marks.

UNIT-I

Que.1 What were the factors responsible for the restructuring of power industry.In what respect the consumers be benefitted with restructuring of power industry, when compared with the vertically integrated power system?

OR

Que.2 Differentiate between the marginal and the average cost of the production? In deciding the production level which cost is more beneficial,explain with a suitable example. How the marginal concept is applicable to consumers?

UNIT-II

Que.3. What are the possible ways in which buyers and sellers can trade electrical energy? On this basis discuss various market models for trading of electrical energy, with their merits and the demerits in reference to competition in the electricity market.

OR

Que.4. A system is having three buses. The line reactance in between bus 1 and bus 2 is 0.2 ohms, between bus 2 and bus 3 is .3 ohms and between bus 3 and 1 is .4 ohms. Net generation at bus 1 and bus 2 is 500 MW and 200 MW respectively. The net load on bus 3 is 700 MW. Using DC model, determine power flow on various lines. Under this operating condition what capacity is available for transaction of power from bus 1 to bus 3, if the power flow limit for line 1-2, 2-3, 3-1 is 700 MW, 600 MW and 500 MW respectively.

UNIT-III

Que.5 (a). Write short notes on any two of the following:

(i) Risk Hedging, (ii) Perturbation analysis, (iii) Duality.

Que.5 (b). Discuss the accuracy in Lossless and loss compensated DCOPF methods of LMP calculation.

OR

Que.6. Consider a three bus power system having bus L, M and N. Bus L and N are generator buses and the bus M and N are load buses. All the three buses are connected by transmission lines having same impedances. Generator G1 at bus L is having capacity 500 MW with a price bid of Rs. 1400/= per MWh. The capacity of generator G2 at bus N is 400 MW with a price bid of Rs. 1800/= per MWh. Load at bus M is 50 MW and load at bus N is 200 MW. The capacity of line LM is 300 MW, capacity of line MN is 400 MW and the capacity of line LN is 100 MW. Assuming lossless lines determine the LMP on each bus.

UNIT-IV

Que.7. What do you understand by the ancillary services? Why these services has got importance in restructured systems.Which functions fall in the category of ancillary services? How these ancillary services were managed in vertically integrated systems?

OR

Que.8. Compare various sources of reactive power on the basis of their ability to provide voltage support, speed of response, cost. What are various issues in these services and how the system operator can procure these services?

UNIT-V

Que.9. Explain power flow tracing proportionate sharing principle for pricing of transmission network usage. How it is advantageous to other methods?

OR

Que.10. Loss allocation was never a problem in vertically integrated power system. Explain. What are various methods of loss allocation in restructured power system? Describe.

Guidelines for Question Paper Setting:

1. The question paper must be prepared based on the blue print without changing the weigh age of model fixed for each unit.
2. The question paper pattern provided should be adhered to
3. The paper should have 10 questions in all, wherein it will have 2 questions from each unit.
4. Student shall be asked to attempt in all 5 questions, 1 Question from each unit.
5. Student shall be given Internal choice in every Unit.

Suresh Gyan Vihar University HOD Electrical Department JAIPUR

6. Questions should not be set from the recapitulation topics.

Course Title: **SOLAR RADIATION AND ENERGY CONVERSION**		Course Code	: EE 611
Semester	: III	Core / Elective	: Elective
Teaching Scheme in Hrs (L:T:P)	: **3:0:1**	Credits	: **3 Credits**
Type of course	: **Lecture + Assignments**	Total Contact Hours	: **48**
Continuous Internal Evaluation	: **40 Marks**	SEE	: **60 Marks**
Programmes: **M.Tech Electrical Engineering**			

Outcomes

- To familiarize students with the characteristics of solar radiation, its global distribution, and conversion methods of solar energy to heat and power.

Objectives

- The characteristics and world distribution of solar radiation.
- The solar radiation and measurement techniques.
- The methods of calculation of solar radiation availability at a given location.
- The fundamentals of thermal and direct conversion of solar energy to power.

Topic and Contents	Hours	Marks
UNIT I - ENERGY RESOURCES AND SOLAR SPECTRUM	6	20
World energy resources - Indian energy scenario - Environmental aspects of energy utilization. Renewable energy resources and their importance - Global solar resources. Solar spectrum – Electromagnetic spectrum, basic laws of radiation. Physics of the Sun - Energy balance of the earth, energy flux, solar constant for earth, green house effect.		
UNIT II - SOLAR RADIATION AND MEASUREMENT	6	20
Solar radiation on the earth surface - Extraterrestrial radiation characteristics, Terrestrial radiation, solar insolation, spectral energy distribution of solar radiation. Depletion of solar radiation - Absorption, scattering. Beam radiation, diffuse and Global radiation. Measurement of solar radiation – Pyranometer, Pyrheliometer, Sunshine recorder. Solar time - Local apparent time (LAT), equation of time (E).		

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UNIT III - SOLAR RADIATION GEOMETRY AND CALCULATIONS	8	20
Solar radiation geometry - Earth-Sun angles – Solar angles. Calculation of angle of incidence - Surface facing due south, horizontal, inclined surface and vertical surface. Solar day length – Sun path diagram – Shadow determination. Estimation of Sunshine hours at different places in India. Calculation of total solar radiation on horizontal and tilted surfaces. Prediction of solar radiation availability.		
UNIT IV - SOLAR THERMAL ENERGY CONVERSION	8	20
Thermodynamic cycles – Carnot – Organic, reheat, regeneration and supercritical Rankine cycles - Brayton cycle – Stirling cycle – Binary cycles – Combined cycles. Solar thermal power plants - Parabolic trough system, distributed collector, hybrid solar-gas power plants, solar pond based electric-power plant, central tower receiver power plant.		
UNIT V - SOLAR ELECTRICAL ENERGY CONVERSION	8	20
Solar photovoltaic energy conversion - Principles - Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I-V characteristics, effect of variation of solar insolation and temperature, losses. Solar PV power plants.		
TOTAL	**36**	**100**

REFERENCES

1. Foster .R, Ghassemi M., Cota A., "*Solar Energy*", CRC Press, 2010.
2. Duffie .J.A, Beckman W.A. "*Solar Engineering of Thermal Processes*", 3rd ed., Wiley, 2006.
3. De Vos .A, "*Thermodynamics of Solar Energy Conversion*", Wiley-VCH, 2008.
4. Garg .H.P, Prakash .J, "*Solar Energy Fundamentals and Applications*", Tata McGraw-Hill, 2005.
5. Kalogirou .S, "*Solar Energy Engineering*", Processes and Systems, Elsevier, 2009.
6. Petela .R, "*Engineering Thermodynamics of Thermal Radiation for Solar Power*", McGraw-Hill Co., 2010.
7. Yogi Goswami .D, Frank Kreith, Jan F. Kreider, "*Principles of Solar Engineering*", Second Edition, Taylor & Francis, 2003.
8. Andrews .J, Jelley .N, "*Energy Science*", Oxford University Press, 2010.

Course Title: **Operation and Control of Power System**		Course Code	: EE 603
Semester	: III	Core / Elective	: **Core**
Teaching Scheme in Hrs (L:T:P)	: **3:0:0**	Credits	: **3 Credits**

Suresh Gyan Vihar University HOD Electrical Department JAIPUR

Type of course	: **Lecture + Assignments**	Total Contact Hours	: **36**
Continuous Internal Evaluation	: **40 Marks**	ESE	: **60 Marks**
Programmes: M.Tech **POWER SYSTEM + DUAL DEGREE EE + PS**			

Pre-requisites:

Power System Analysis, Control System.

Course Objectives:

1. Help the learner to understand optimal power system constraints
2. Understand the optimal unit commitment problem and solution
3. Learn about optimal generation scheduling
4. Learn about load frequency control
5. Learn power system security and AGC
6. Make students familiar with various techniques used for Optimal Power System operation, like Optimal Generation Scheduling, Optimal Unit Commitment, etc.

Course Content:

Topic and Contents	Hours	Marks
UNIT-1: **Optimal Power System Operation**	7	20
System constraints. Generator operating cost. Input-Output and incremental fuel characteristics of a generating unit. Optimal operation of generators on a bus bar, algorithm and flow chart. Optimal unit commitment, constraints in unit commitment, spinning reserve, thermal and hydro constraints.		
UNIT-2: **Unit Commitment Solution methods**	7	20
Priority list method and dynamic programming method. Reliability consideration, Patton's security function, security constrained optional unit commitment, start-up considerations.		
UNIT-3: **Optimal Generation Scheduling**	6	20
Development of transmission loss and incremental loss equations. Optimal generation scheduling including transmission losses, algorithm and flow chart. Optimal load flow solution. Hydrothermal coordination.		
UNIT-4: **Load Frequency Control**	9	20
Control of real and reactive power of generator. Turbine speed governing system, Modelling of speed governing system. Methods of frequency control: flat frequency, flat tie line and tie line load bias control. Block diagram representation of load frequency control of an isolated system, steady state analysis, dynamic response. Introduction to Two – area load frequency control.		
UNIT 5: **Power System Security & Automatic Generation Control**	7	20
Introduction to power system security, System monitoring, contingency analysis, System state classification, security control, Speed governing		

characteristic of a generating unit. Load sharing between parallel operating generators. Introduction to automatic generation control of an area by computer (description of block diagram).		
TOTAL	**36**	**100**

Reference:

1. C.L. Wadhwa, Electrical power system. New Age international publishers.
2. B.R. Gupta: Power system Analysis and Design
3. P.S. Murthy, Operation Control of Power System.

Course outcomes:

On successful completion of the course, the student will be able to:

1. Student will be able to analyse various constraints of optimal power system operation
2. Solve the unit commitment problem
3. Solve the optimal generation scheduling
4. Understand the speed governing system of steam turbine and analyse steady state and dynamic response.
5. Understand power system security and AGC
6. Suggest and implement methods for various aspects of Optimal Power System operation in the Power System industry.

Mapping Course Outcomes with Program Outcomes:

Course outcomes	**Program outcomes**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	S	S	S	S	S	M	M	M	M	M	S
2	S	S	S	S	S	M	M	M	M	M	S
3	S	S	S	S	S	M	M	M	M	M	S
4	S	S	S	S	S	M	M	M	M	M	S
5	S	S	S	S	S	M	M	M	M	M	S
6	S	S	S	S	S	M	M	M	M	M	S

S: Strong relationship M: Moderate relationship

Course Assessment and Evaluation:

The Course will be delivered through lectures, class room interaction, and self-study cases.

Method	**What**		**To whom**	**When/where (Frequency in the course)**	**Max Marks**	**Evidence collected**	**Contributing to course outcomes**
DIR ECT ASS ME	CIE	Mid Term Test	Student	Two tests	20	Midterm Answer books	1 to 5

		Weekly Test		Two Weekly Test	10	Weekly Test Copies	1 to 5
		Graded Assignments		Two Assignments	10	Log of record	1 to 5
				Total	**40**		
	ESE	End Sem Evaluation		End of the course	60	Answer scripts at BTE	1 to 5
INDIRECT ASSESSMENT	Student feedback		Students	Middle of the course	-NA-	Feedback forms	1 to 2, delivery of the course
	End of Course survey			End of course		Questionnaire	1 to 5, Effectiveness of delivery of instructions and assessment methods

CIE – Continuous Internal Evaluation **ESE** –End Semester Examination

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering and Understanding	35
2	Applying the knowledge acquired from the course	25
3	Analysis and Evaluation	40