KL Electrical & Electronics Engineering

KLEF

DEPARTMENT OF ELECTRICAL ENGINEERING

PROGRAM DEVELOPMENT DOCUMENT

M.Tech in POWEER ELECTRONICS & POWER SYSTEMS

2022

Vision of the University

To be a globally renowned university.

Mission of the university:

To impart quality higher education and to undertake research and extension with emphasis on application and innovation that cater to the emerging societal needs through all-round development of students of all sections enabling them to be globally competitive and socially responsible citizens with intrinsic values.

<u>VISION of the Department</u>

To Produce globally renowned leader in education, extension activities and Carrying out research and technology development in frontier areas of electronics and electrical engineering and allied fields

<u>MISSION of the Department</u>

To produce quality electrical and electronics engineers having strong theoretical foundation, innovative, good design experience , exposure to research and development and responsible for social needs.

Program Educational Objectives

Programme Educational Objectives:

1.To produce well trained post graduates in the domain of power electronics and electrical drives, and ensure that at least 50 % of those are employable in the diversified sectors of industry, public sector or multinational corporations.

2. To produce some of these (15-20 %) post graduates will pursue Ph.D.

3. To produce some of these will demonstrate the academic leadership in engineering institutions and serve the education.

4. To inculcate research attitude and lifelong learning among postgraduates

Program Outcomes

a. apply the knowledge of science and mathematics in designing, analyzing and using the power converters and drives for various applications and problem solving
b. design the modern electric machines, drives, power converters, and control circuits for specific application
c. use modern tools, professional software platforms, embedded systems for the diversified applications
d. Function as a member of a multidisciplinary team and correlate the domain knowledge with global problems.
e. sense and demonstrates the communication at different levels effectively
f. explore ideas for inculcating research skills and appreciate, critical and independent thinking and engage in lifelong learning

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MAPPING OF PEOs with MISSION OF THE DEPARTMENT:

S.No.	Program Educational Objectives(PEOs)	M1 Training the leaders of tomorrow	M2 Training the innovators of tomorrow	M3 Training the outstanding career professionals of tomorrow	M4 Conducting fundamental research
1	To produce well trained post graduates in the domain of power electronics drives, and ensure that at least 50 % of those are employable in the diversified sectors of industry, public sector or multinational corporations.	√	√	√	
2	To produce some of these (15-20 %) post graduates will pursue Ph.D.		√	√	√
3	To produce some of these will demonstrate the academic leadership in engineering institutions and serve the education.	√	√	√	
4	To inculcate research attitude and lifelong learning among postgraduates		√	√	√

MAPPING OF POs/PSOs with PEOs:

Mapping of POs to PEOs					
S.No.	Program Objectives(POs)	Program Educational Objectives(PEOs)			
		1	2	3	4
a	apply the knowledge of science and mathematics in designing, analyzing and using the power converters and drives for various applications and problem solving	√	√	√	√
b	.design the modern electric machines, drives, power converters, and control circuits for specific application	√	√		√
c	use modern tools, professional software platforms, embedded systems for the diversified applications	√	√		√
d	Function as a member of a multidisciplinary team and correlate the domain knowledge with global problems.	√	√	√	√
e	sense and demonstrates the communication at different levels effectively	√		√	√
f	.explore ideas for inculcating research skills and appreciate, critical and independent thinking and engage in lifelong learning	√	√		√

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES (POs) and PROGRAM SPECIFIC OUTCOMES (PSOs)

SL	Course Code	Course Title	CO NO	Description of the Course Outcome	PO						PSO	
					1	2	3	4	5	6	1	2
1	22EE5111	ANALYSIS OF POWER CONVERTERS	CO1	Analyze the various high power controller converters and power factor correction.		3					2	
			CO2	Analyze the performance of Switch-Mode PWM and different control techniques for Inverters	3						2	
			CO3	Analyze the operation of multi-level to inverters and Z-source inverter.					3		2	
			CO4	Understand the various applications of power converters with solar systems		3					2	
			CO5	Demonstrate and test basic power electronic converters by hardware realization and MATLAB software.							2	
2	22EE5112	ADVANCED POWER SYSTEM ANALYSIS AND PROTECTION	CO1	Apply mathematical methods for the solution of Power flow problem	3							
			CO2	Analyze of power system with symmetrical and unsymmetrical faults			3					
			CO3	Apply power system protection equipment				3				
			CO4	Apply digital relaying algorithms for protection of power system equipment				3				
3	22EE5113	MODELING AND ANALYSIS OF ELECTRICAL MACHINES	CO1	Apply the basic concepts of Electromagnetic Energy Conversion Principles to DC Machines	3							
			CO2	Understand the performance of electrical machines through mathematical modeling		3						
			CO3	Illustrate the dynamic behaviour of electrical machines under different operating conditions.	3							
			CO4	Analysis of special machines		3						
4	22EE5104	EMBEDDED CONTROLLER S AND APPLICATION S	CO1	Apply Programming of 8051 Microcontroller for general purpose applications			3					
			CO2	Apply programming concepts of 8051 for interfacing peripherals			3					
			CO3	Demonstrate Architecture and Programming of PIC Microcontroller			3					
			CO4	Apply programming concepts of 8051 and PIC Microcontroller for interfacing peripherals			3					
			CO5	Apply programming concepts of the 8051and PIC microcontroller					3			
5	22EE5211	ADVANCED ELECTRICAL DRIVES	CO1	Understand the modeling of AC machines	3	2						
			CO2	Contrast the speed control performance of 3-Phase induction and synchronous motor drive using vector control methods	3	2						

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			CO3	Analyze the dynamic behavior of SRM motor drives under various control methods	3	2						
			CO4	Distinguish the performance of BLDC Motor drive using various control techniques	3	2						
			CO5	Demonstrate and test electric converters by hardware realization and MATLAB software		3						
6	22EE5212	POWER SYSTEM STABILITY& CONTROL	CO1	Analyze Synchronous Machine modeling		3						
			CO2	Analyzing power system stability	3							
			CO3	Analyze Small signal stability		3						
			CO4	Analyze Excitation control and Voltage Stability		3						
7	22EE5213	GRID INTEGRATION OF RENEWABLE ENERGY SYSTEMS	CO1	Understand renewable energy Systems	3							
			CO2	Apply grid integrated techniques for solar PV System.					3			
			CO3	Apply grid integrated techniques for wind energy System.				3				
			CO4	Understand grid operation and control methods and standards.	3							
8	22EE5204	AI AND IOT FOR MODERN ELECTRICAL SYSTEMS	CO1	Demonstrate IoT devices and tools				3				
			CO2	Operate the cloud system Environment				3				
			CO3	Utilize AI and ML Techniques		3						
			CO4	Utilize AI techniques for electrical systems						3		
9	22EE51A1	RELIABILITY ENGINEERING	CO1	Understand the system reliability concepts	3							
			CO2	Apply the frequency and duration techniques for component repairable system.	3							
			CO3	Apply the network reliability concepts to generation system reliability analysis.	3							
			CO4	Apply the network reliability concepts to transmission and distribution system reliability analysis.	3							
10	22EE51A2	APPLICATION OF PYTHON PROGRAMMING IN ELECTRICAL SYSTEMS	CO1	Understand Conditionals, Iterables, Regex, Files, Error Handling, Data Structures, Algorithm design and Object-Oriented Python			3					
			CO2	Apply object-oriented programming, Python Standard Library, SciPy's optimization and Signal Processing and Linear algebra			3			2		
			CO3	Understand Data Analysis using Pandas. Apply supervised Learning and Unsupervised Learning techniques using Scikit-Learn	2		3					
			CO4	Analyse real world electrical engineering problems using pandapower and PyPSA for power system modeling, analysis and optimization.			3					
			CO5	Analyze the applications of Python programming for electrical engineering applications			3					

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11	22EE51A3:	ENERGY MANAGEMENT SYSTEMS	CO1	Understand data acquisition components of power system		3						
			CO2	Understand energy data monitoring, reporting and communication		3						
			CO3	Apply supervisory control for energy management					3			
			CO4	Understand Energy management center functions	3							
12	22EE51B1:	OPTIMIZATION TECHNIQUES	CO1	Understand classical optimization techniques, describe clearly the problems with and without constraints, identify its parts and analyze the individual functions, Feasibility study for solving an optimization problem.				3				
			CO2	Apply mathematical translation of the verbal formulation of an optimization problem and design algorithms of linear programming problems, the repetitive use of which will lead reliably to finding an approximate solution.				3				
			CO3	Analyze and measure the performance of an algorithm of different methods to solve non-linear programming problems, study and solve optimization problems.				3				
			CO4	Analyze optimization techniques using algorithms. Investigate study, develop, organize and promote innovative solutions for various applications.				3				
13	22EE51B2	ADVANCED CONTROL THEORY	CO1	Apply the mathematical representation to dynamic systems		3						
			CO2	Apply the techniques to design the controllers	3							
			CO3	Apply the techniques to identify non linear system stability					3			
			CO4	Apply the algorithms for stability analysis		3						
14	22EE51D3	DEREGULATED POWER SYSTEMS	CO1	Understand the market operations in the electricity market under deregulated environment, Open Access Same-time Information System (OASIS) and Available Transfer Capability (ATC).	3							
			CO2	Analyze the concepts of Electricity Pricing.					3			
			CO3	Analyze the Power System Operation in Competitive Environment and Market Power.					3			
			CO4	Analyze the concepts of Transmission Pricing and Congestion pricing.	3							
15	22EE52A1	DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS	CO1	Design of non-isolated and isolated DC-DC converters	3	2						
			CO2	Understand the working of Resonant converters	3	2						
			CO3	Modelling of non-isolated DC -DC converters	3	2						
			CO4	Design of closed loop controls for switched mode power supplies	3	2						

16	22EE52A2	SWITCHED MODE POWER SUPPLIES	CO1	Understand Pspice modelling of power semiconductor devices and passive components behaviour with protection circuits.	3						2	
			CO2	Analyse performance of AC-DC controlled, uncontrolled converters and DC-DC converters using Pspice and MATLAB Simulink model.		3					2	
			CO3	Evaluate DC-AC converters performance using modern simulation tools.	3						2	
			CO4	Analyse AC voltage controller and cyclo-converter performance with programming and simulation tools.		2					2	
17	22EE52C3	FACTS & POWER QUALITY	CO1	Understand the importance of FACTS devices and their applications to the Power Systems.	3						2	
			CO2	Analyse the static shunt and series compensation and operation of devices under this category.		3					2	
			CO3	Apply DSTATCOM for power quality restoration	3						2	
			CO4	Apply combined compensation techniques for power quality restoration and fault ride through.		2					2	
218	22E52D1	SMART GRID TECHNOLOGIES	CO1	Understand the basic concepts of smart grid, terminology, challenges and initiatives.	3							2
			CO2	Identify various smart operations of power system structure, components, and monitoring techniques.		3						2
			CO3	Apply smart metering and advanced metering infrastructure with monitoring, protection and measuring units.		3						2
			CO4	Illustrate various communication protocols and cyber-security importance in smart grid.				3				2
19	22E52D2	ENERGY CONSERVATION & AUDIT	CO1	Understand the concept of Energy Audit and Energy Management		3						
			CO2	Analyze the various characteristics of energy efficient motors			3					
			CO3	Analyze the different energy instruments and importance of power factor improvement			3					
			CO4	Analyze the economic aspects of electrical energy		2						
20	22E52D3	SMART APPLIANCE AND SMART CITIES	CO1	Evaluate the characteristics of smart home appliances.		3						2
			CO2	Understand the essential elements of smart cities		3						2
			CO3	Analyze the Characteristics of a Smart City		3						2
			CO4	Apply the Designing, and Implementing a Smart City		3						2

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Y22 M.TECH POWER ELECTRONICS & POWER SYSTEMS							PO						PSO	
Sl	Course Code	Course Title	L	T	P	Cr	1	2	3	4	5	6	1	2
1.	22EE5111	Analysis of Power Converters	3	1	2	5	3	3			3			2
2.	22EE5112	Advanced Power System Analysis and Protection	3	1	0	4	3		3	3				
3.	22EE5113	Modelling and Analysis of Electrical Machines	3	1	0	4	3	3						
4.	22EE5104	Embedded Controllers and Applications	3	0	2	4			3		3			
5.	22EE5211	Advanced Electrical Drives	3	0	2	4	3	2						
6.	22EE5212	Power System Stability and Control	3	1	2	5	3	3						
7.	22EE5213	Grid Integration of Renewable Energy systems	3	1	0	4	3			3	3			
8.	22EE5204	AI and IOT for Modern Electrical Systems	3	1	0	4		3	3			2		
9.	22EE51A1	Reliability Engineering	3	0	0	3	3							
10.	22EE51A2	Applications of Python Programming for Electrical Systems	2	0	2	3	2	3				2		
11.	22EE51A3	Energy Management Systems	3	0	0	3	3	3			3			
12.	22EE51B1	Optimization Techniques	3	0	0	3				3				
13.	22EE51B2	Advanced Control Theory	3	0	0	3	3	3			3			
14.	22EE51D3	Deregulated Power Systems	3	0	0	3	3				3			
15.	22EE52A1	Digital Simulation of Power Electronic Systems	3	0	0	3	3	2						
16.	22EE52A2	Switched Mode Power Supply and PWM Techniques	3	0	0	3	3	3					2	
17.	22EE52C3	FACTS & Power Quality	3	0	0	3	3	3					2	
18.	22EE52D1	Smart Grid Technologies	3	0	0	3		3		3				2
19.	22EE52D2	Energy Conservation & Audit	3	0	0	3		3	3					
20.	22EE52D3	Smart Appliances and Smart Cities	3	0	0	3		3						2
21.	22IE5149	Seminar	0	0	4	2	3	3	3	3	3		3	3
22.	21IE5250	Term Paper	0	0	4	2	3	3	3	3	3		3	3
23.	21IE6150	Dissertation	0	0	36	18	3	3		3	2	2	3	3
24.	21IE6250	Dissertation	0	0	36	18	3	3	3	3	3	2	3	3

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22EE511: ANALYSIS OF POWER CONVERTERS

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
1	Analyze the various high power controller converters and power factor correction.	PO2/PSO1	4
2	Analyze the performance of Switch-Mode PWM and different control techniques for Inverters	PO1/PSO1	4
3	Analyze the operation of multi-level to inverters and Z-source inverter.	PO-5/PSO1	3
4	Understand the various applications of power converters with solar systems	PO-2/PSO1	2
5	Demonstrate and test basic power electronic converters by hardware realization and MATLAB software.	PO-3/PSO1	3

HIGH POWER ELECTRONIC CONVERTERS: Multi-pulse SCR Rectifiers, Performance parameters - Six-pulse, 12-pulse and 24- pulse SCR rectifier, Effect of line and leakage inductances, Power factor control. Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform PWM, single phase.and three-phase converter systems.

SWITCH-MODE DC-AC INVERTERS: Basic Concepts- PWM Principles- Sinusoidal Pulse Width Modulation in Single Phase Inverters-Choice of carrier frequency in SPWM- Bipolar and Unipolar Switching - Blanking Time -Maximum Attainable DC Voltage - Switch Utilization. Six step inverters, voltage control & PWM strategies, and implementation aspects, Modification of power circuit for Four quadrant operation,Pulse width modulation techniques (hysteresis, SVM), Selective Harmonic Reduction Techniques. **MULTILEVEL INVERTERS AND IMPEDANCE SOURCE INVERTERS:** Multilevel concept – Classification of multilevel inverters – Diode clamped multilevel inverter –improved diode Clamped inverter –Flying capacitors multilevel inverter - Cascaded multilevel inverter -Multilevel inverter -features of multilevel inverters – comparisons of multilevel converters. – PWM techniques for MLI.- Quasi –Z source Inverters, control methods **POWER CONVERTERS APPLICATIONS:** Lighting, pumping and refrigeration Systems: Electronic ballast, LED power drivers for indoor and outdoor applications. PFC based grid fed LED drivers, PV / battery fed LED drivers. PV fed power supplies for pumping and refrigeration Applications.

Text books:

1. M.H. Rashid : Power Electronics Handbook, Butterworth-Heinemann, 4th edition, 2017.
2. N. Mohan, T.M. Undeland, W.P. Robbins: Power Electronics: Converters, Applications, John Wiley & Sons, 3rd edition, 2003.

Reference Books:

1. Umanand, L.: Power Electronics: Essentials and Applications, John Wiley India, 1st Edition, 2009.
2. Jayant Baliga B: Fundamentals of Power Semiconductor Devices, Springer, 1st Edition 2008.

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22EE5112: ADVANCED POWER SYSTEM ANALYSIS AND PROTECTION

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	CO	PO/PSO	BTL
1	Understand the modeling aspects of power system components and form the network matrices	PO1	3
2	Apply mathematical methods for the solution of Power flow problem	PO3	4
3	Analyze of power system with symmetrical and unsymmetrical faults	PO4	3
4	Apply digital relaying algorithms for protection of power system	PO-4	3

Network Modeling- Conditioning of Y Matrix, Method of successive elimination, Triangular factorization. **Load flow analysis**- AC-DC load flow-Single and three phase methods-Sequential solution techniques and extension to multiple and multi-terminal DC systems, Load flow with FACTS devices, Distribution load flow

Fault studies- 3-ϕ analysis of balanced and unbalanced faults-fault calculations-Short circuit faults-open circuit faults. **System Contingency Analysis** – Z_{bus} Method in Contingency Analysis, Adding and Removing Multiple Lines, PiecewiseSolution of Interconnected Systems, Analysis of Single Contingencies, Analysis of Multiple Contingencies,

Protection of Power System Equipment - summation transformer, phase-sequence current segregating network.Load shedding and frequency relays; Out of step relaying; Re-closing and synchronizing - adaptive protection – integrated protection and control.

Digital Protection: Developments in computer relaying – mathematical basis for protective relaying algorithms, Fourier Transforms – Discrete Fourier transforms –Walsh - Hadamard, Haar - wavelet transforms, digital relaying algorithms,Working principles of numerical relays

TEXT BOOKS:

1. Grainger, J. J. and Stevenson, W. D. 'Power System Analysis' Tata McGraw Hill, New Delhi, 2003.
2. Badri Ram & DN Viswakarma, "Power System Protection & Switch Gear", Tata McGraw Hill Publishing Company Limited, New Delhi (1995).

REFERENCE BOOKS:

1. Grainger, J. J. and Stevenson, W. D. 'Power System Analysis' Tata McGraw Hill, New Delhi, 2003.
2. Pai, M. A., 'Computer Techniques in Power System Analysis', Tata McGraw Hill, New Delhi, 2006.
3. P. Venkatesh,B V Manikandan,S Charles Raja and A Srinivasa Rao, "Electric Power System Analysis, Security & Deregulation", PHI, 2012.
4. Digital Protection for Power Systems A.T.Johns and S.K.Salman, 1995.

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22EE5113: MODELING AND ANALYSIS OF ELECTRICAL MACHINES

L-T-P-S: 3-1-0-0 Credits: 4 Pre-Requisite: NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the basic concepts of Electromagnetic Energy Conversion Principles to DC Machines	PO1	3
CO2	Understand the performance of electrical machines through mathematical modeling	PO2	2
CO3	Illustrate the dynamic behaviour of electrical machines under different operating conditions	PO2	3
CO4	Analysis of special machines	PO2	4

Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system. The Primitive Machine Equations. Mathematical model of a separately excited DC motor, DC series motor and DC Shunt motor- Voltage and torque equation of dc machine.

Calculation of air gap mmf and per phase machine inductance using physical machine data; Induction machine: Three phase symmetrical induction machine in phase variable form; Application of reference frame theory to three phase symmetrical induction Machine. Dynamic direct and quadrature axis model in arbitrarily rotating reference frames.

Three phase salient pole synchronous machines in phase variable form. Voltage and torque equation of salient pole synchronous machine including damper winding in stator reference frame.Voltage and torque equation of salient pole synchronous machine including damper winding in rotor reference frame. Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters.

Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self-controlled operation; Analysis of Switch Reluctance Motors. Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

Text Books:

1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D.Umans, 'Electric Machinery', Tata McgrawHill, 5th Edition, 1992.

2. Generalized Theory of Electrical Machines – P.S.Bimbra- Khanna publications-5th edition 1995

Reference Books:

1. R. Krishnan, 'Electric Motor & Drives: Modeling, Analysis and Control', Prentice Hall of India, 2nd Edition, 2001.

2. Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, 1st Edition, 1989

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22EE5104: Embedded Controllers and Applications

L-T-P-S: 3-0-2-0 Credits: 4 Pre-Requisite: NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply Programming of 8051 Microcontroller for general purpose applications	3	3
CO2	Apply programming concepts of 8051 for interfacing peripherals	3	3
CO3	Demonstrate Architecture and Programming of PIC Microcontoller	3	3
CO4	Apply programming concepts of 8051 and PIC Microcontroller for interfacing peripherals	3	3
CO5	Apply programming concepts of the 8051and PIC microcontroller	3,5	3

SYLLABUS:

8051 Microcontroller functional aspects: Microcontroller families, 8051 Architecture- Signal Description, Register organization, Internal RAM, Special Function Registers, Addressing modes, Instruction set, Interrupts, Timer/Counter module, Serial Data Communication module, and RS-232C Standard.

8051 Programming & Interfacing:, Simple Programs involving Arithmetic and Logical Instructions, Timers/Counters, Serial Communication & Interrupts. Matrix Key Board interface, Stepper Motor interface, LCD interface

PIC Microcontroller functional aspects: Introduction, Architectural overview, Memory organization, interrupts and reset, I/O ports, Timers, C Programming PIC microcontroller

PIC microcontrollers Interface Applications: DAC Interfacing, ADC Interfacing, Digital relaying, Closed loop control of dc motor, speed encoder interface using CCP module

TEXT BOOKS:

1.Mazidi&McKinley "The 8051 Micro controller and Embedded systems: using assembles and C, 2nd edition,2007.

2. Mazidi &McKinley, "PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18", 1st edition, 2008

REFERENCE BOOKS:

1. Rajkamal, "Microcontrollers - Architecture, Programming, Interfacing & System Design", 2nd edition, Pearson Education,2009.
2. Ted Van Sickle, "Programming Microcontrollers in C", 2nd edition, 2001.

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22EE5211: ADVANCED ELECTRICAL DRIVES

L-T-P-S: 3-0-2-0 Credits: 4 Pre-Requisite: NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
1.	Understand the modeling of AC machines	PO1,PO2	2
2.	Contrast the speed control performance of 3-Phase induction and synchronous motor drive using vector control methods	PO1,PO2	4
3.	Analyze the dynamic behavior of SRM motor drives under various control methods	PO1,PO2	4
4.	Distinguish the performance of BLDC Motor drive using various control techniques	PO1,PO2	4
5	Analyze the applications of Python programming for electrical engineering applications	PO2	4

Syllabus:

FIELD ORIENTED CONTROL OF INDUCTION MOTOR DRIVES - Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy. **SENSORLESS VECTOR CONTROL OF INDUCTION MOTOR**: Slip and Speed Estimation at Low performance, Rotor Angle and Flux-linkage Estimation at high performance -rotor Speed Estimation Scheme- estimators using rotor slot harmonics, Model Reference adaptive systems, Extended Kalman Filter. **CONTROL OF SYNCHRONOUS MOTOR DRIVES**: Self control-margin angle control-torque control-power factor control-Brushless excitation systems - SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers. **CONTROL OF BLDC MOTOR DRIVES**: principle of operation of BLDC Machine, Sensing and logic switching scheme, BLDM as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor - current controlled Brushless dc motor Servo drive.

TEXT BOOKS

1. Electric Motor Drives Modeling, Analysis & control -R. Krishnan- Pearson Education
2. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications
3. Sensorless Vector Direct Torque control –Peter Vas, Oxford University Press

REFERENCES BOOKS

1. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications-
2. Power Electronics control of AC motors – MD Murphy & FG Turn Bull Pergman Press -1st edition-1998
3. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992
4. VedamSubramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2002

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22EE5212: POWER SYSTEM STABILITY& CONTROL

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
1	Analyze Synchronous Machine modeling	PO-1	4
2	Analyzing power system stability	PO-2	4
3	Analyze Small signal stability	PO2	4
4	Analyze Excitation control and Voltage Stability	PO-2	4

SYLLABUS:

POWER SYSTEM STABILITY: Basic Concepts and Definitions, Classifications,Review of Steady state and Transient state stability, Numerical method to determine transient stability, classical model of a multi machines systems. Introduction to Frequency Stability.

SMALL SIGNAL STABILITY: Small signal stability of a single machine infinite bus system, Effects of excitation systems, Power system stabilizers, Sub Synchronous Resonance.

EXCITATION CONTROL: Typical Excitations configurations and Automatic Voltage regulators, Effect of excitation on (a) Power limits, (b) Transient stability, (c) Dynamic stability, Basic Concepts Related to Voltage Stability – Voltage Collapse – Voltage Stability Analysis – Prevention of Voltage Collapse.

Security control- Security analysis and monitoring, generator and line outages by linear sensitivity factors, **State estimation**- Power system state estimation, Weighted least square state estimation, state estimation of AC network, Treatment of bad data – network observability and pseudo measurements.

TEXT BOOKS:

1. Power System Stability and Control – Prabha Kundur, TATA McGRAW – HILL, 2006.
2. Power System Stability by Kimbark, Vol- I, II & III – 1968, Dover Publication Inc, Newyork-1968.

REFERENCE BOOKS:

1. Power System Dynamics Stability & Control – K.R.Padiyar, 2nd Edition, B.S. Publication 2002.
2. Power System Control and Stability – P. M. Anderson & A.A. Fouad, 2nd Edition, Wiley IEEE press-2002.

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22EE5213: GRID INTEGRATION OF RENEWABLE ENERGY SYSTEMS

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand renewable energy Systems	PO5	2
CO2	Apply grid integrated techniques for solar PV System.	PSO1	3
CO3	Apply grid integrated techniques for wind energy System.	PSO1	3
CO4	Understand grid operation and control methods and standards.	PO7	2

Syllabus:

Introduction to renewable energy systems, environmental aspects of electric energy conversion, impacts of renewable energy generation on environment, need of integrating large renewable energy sources, issues related to integration of large renewable energy sources.Need of power electronic equipment's in grid integration, converter, inverter, chopper, ac regulator and cycloconverters for AC/DC conversion. **Solar-Photovoltaic (PV)** cells-characteristics, variability, energy conversion principles, electrical modelling, optimal power extraction, shading effect, Stand-alone PV system, Grid connected PV system, Design of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing. **Wind energy systems:** variability, principles of wind energy extraction, electromechanical energy conversion, characteristics of wind turbines, voltage regulation. Control of standalone system and Grid connected system (Voltage and frequency control). Islanding, and reconnecting. Primary frequency control in large systems, Fault ride through.

Grid operation and Control: Scheduling and dispatch, Forecasting, reactive power and voltage control, frequency control, operating reserve, storage systems, electric vehicles, CERC and CEA orders (technical and safety standards)

Text Books:

1. Integration of Alternative sources of Energy, Felix A. Farret and M. Godoy Simoes, IEEE Press – Wiley-Interscience publication, 2006.
2. Grid integration of solar photovoltaic systems, Majid Jamil, M. Rizwan, D.P.Kothari, CRC Press (Taylor & Francis group), 2017

Reference Books:

1. Renewable Energy Grid Integration, Marco H. Balderas, Nova Science Publishers, New York, 2009.
2. Wind Power Integration connection and system operational aspects, B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, IET Power and Energy Series 50 (IET digital library), 2007
3. Power Generation, Operation, and Control, Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, John Wiley & Sons, New York, 2013 (3rd edition)

22EE5204: AI and IoT for Modern Electrical Systems

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Demonstrate IoT devices and tools	PO4	2
CO2	Operate the cloud system Environment	PO4	3
CO3	Utilize AI and ML Techniques	PO2	3
CO4	Utilize AI techniques for electrical systems	PO6	3

Syllabus:

IoT Devices and Enabling Technologies: IoT Architecture, IoT Infrastructures -Sensor Devices, Actuators, IoT protocols and software's- MQTT, UDP, MQTT-brokers, publish subscribe modes, HTTP, COAP, XMPP and gateway protocols, IoT point to point communication technologies, Selection of Wireless technologies - 6LoWPAN, Zigbee, WIFI, BT, BLE,SIG,NFC, LORA, Lifi and Widi.

Cloud Computing: Basics-Cloud systems, Cloud computing protocols, Role of Web services, Deployment Models- Public, Community, Hybrid, Private Clouds, Cloud Analytics over Thingspeak, Google Firebase, AWS-console, Functions. Database Services-Relational DBMS, RDS Services.

AI and ML on Cloud: Data Pre-processing techniques in Machine Learning, Data-handling, importing libraries, Data pre-processing using python, Missing data, Categorical Data. Regression and Classification algorithms in ML. Cloud based Real- time Monitoring systems, M2M communications, Case Studies **AI for Electrical Systems:** AI and Machine learning algorithms for Renewable technologies-PV MPP techniques, RMSE and MAPE analysis for short term irradiance, solar energy and load forecasting, temperature forecasting. Wind speed forecasting, Intelligent Energy Management System of Hybrid Solar/Wind/Battery Power Sources, Electric vehicle-BMS, case studies- smart cities, smart grid, smart building, electrical vehicles

Text Books:

1. AI and IoT in Renewable Energy, **Shaw**, R.N., **Mendis**, N., **Mekhilef**, S., **Ghosh**, A,Springer, 2011
2. Sensors and Actuators – D. Patranabis – 2nd Ed., PHI, 2013
3. Applications of AI and IoT in Renewable Energy, R.N., **Mendis**, N., **Mekhilef**, S., **Ghosh**, A, Elsevier, 2021

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22EE51A1: RELIABILITY ENGINEERING

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO 1	Understand the system reliability concepts	PO-8	2
CO 2	Apply the frequency and duration techniques for component repairable system.	PO-9	3
CO 3	Apply the network reliability concepts to generation system reliability analysis.	PO-8	3
CO 4	Apply the network reliability concepts to transmission and distribution system reliability analysis.	PSO-2	3

Network Modelling and Reliability Analysis: Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV process – recursive technique - Bath tub curve - reliability measures MTTF, MTTR, MTBF.**Frequency & Duration Techniques:**Frequency and duration concept – Evaluation of frequency of encountering state, mean cycle time, for one , two component repairable models – evaluation of cumulative probability and cumulative frequency of encountering of merged states. **Generation System Reliability Analysis:** Reliability model of a generation system– recursive relation for unit addition and removal – load modeling - Merging of generation load model – evaluation of transition rates for merged state model – cumulative Probability, cumulative frequency of failure evaluation – LOLP, LOLE. **Transmission System Reliability Analysis:** System and load point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model.: **Distribution System Reliability Analysis:** Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices - Load point and system reliability indices – Customer oriented, loss and energy oriented indices – Examples. Parallel Configuration: Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects –Evaluation of various indices – Examples.

Text Books:

1. R. Billinton, R.N.Allan, "Reliability Evaluation of Power systems" second edition, Springer.
2. Charles E. Ebeling, "An Introduction to Reliability and Maintainability Engineering", TATA Mc Graw- Hill – Edition.

Reference Books:

1. R. Billinton, R.N.Allan, "Reliability Evaluation of Engineering System", Plenum Press, New York.
2. Eodrenyi, J., "Reliability modelling in Electric Power System", John Wiley, 1980

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22EE51A1: RELIABILITY ENGINEERING

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO 1	Understand the system reliability concepts	PO-1	2
CO 2	Apply the frequency and duration techniques for component repairable system.	PO-1	3
CO 3	Apply the network reliability concepts to generation system reliability analysis.	PO-1	3
CO 4	Apply the network reliability concepts to transmission and distribution system reliability analysis.	PO-1	3

Network Modelling and Reliability Analysis: Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV process – recursive technique - Bath tub curve - reliability measures MTTF, MTTR, MTBF.**Frequency & Duration Techniques:**Frequency and duration concept – Evaluation of frequency of encountering state, mean cycle time, for one , two component repairable models – evaluation of cumulative probability and cumulative frequency of encountering of merged states. **Generation System Reliability Analysis:** Reliability model of a generation system– recursive relation for unit addition and removal – load modeling - Merging of generation load model – evaluation of transition rates for merged state model – cumulative Probability, cumulative frequency of failure evaluation – LOLP, LOLE. **Transmission System Reliability Analysis:** System and load point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model.: **Distribution System Reliability Analysis:** Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices - Load point and system reliability indiçes – Customer oriented, loss and energy oriented indices – Examples. Parallel Configuration: Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects –Evaluation of various indices – Examples.

Text Books:

3. R. Billinton, R.N.Allan, "Reliability Evaluation of Power systems" second edition, Springer.
4. Charles E. Ebeling, "An Introduction to Reliability and Maintainability Engineering", TATA Mc Graw- Hill – Edition.

Reference Books:

3. R. Billinton, R.N.Allan, "Reliability Evaluation of Engineering System", Plenum Press, New York.
4. Eodrenyi, J., "Reliability modelling in Electric Power System", John Wiley, 1980

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22EE51A2: Application of Python Programming in Electrical Systems

L-T-P-S: 2-0-2-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand Conditionals, Iterables, Regex, Files, Error Handling, Data Structures, Algorithm design and Object-Oriented Python	3	2
CO2	Apply object-oriented programming, Python Standard Library, SciPy's optimization and Signal Processing and Linear algebra	3,6	3
CO3	Understand Data Analysis using Pandas. Apply supervised Learning and Unsupervised Learning techniques using Scikit-Learn	1,3	3
CO4	Analyse real world electrical engineering problems using pandapower and PyPSA for power system modeling, analysis and optimization.	3	4
CO5	Analyze the applications of Python programming for electrical engineering applications	3	4

SYLLABUS:

Algorithm Design and Recursion, Searching, Recursive Problem Solving, Conditionals, Iterables & Regex in Python, Python Objects I: Strings, Python Objects II: Lists, Tuples and Loops, File Input/Output, Errors and Exceptions, Python Objects III: Dictionaries and Sets, An Introduction to Object-Oriented Programming, Stacks, queues, Linked Lists. Bubble, Quick, and Merge Sort.

Object oriented programming and classes, constructor, Inheritance – Implementing a subclass, Classes and polymorphism, Recursive calls to methods, Class variables, class methods, Class for Vectors in the Plane, Class for Complex Numbers, Classes for Numerical Differentiation, Classes for Numerical Integration, Python Standard Library, SciPy's optimization and Signal Processing. Linear Algebra: solve systems of linear equations, eigenvalues, and eigenvectors. Case study: analysis of vibrating strings or atoms Scikit-learn, Manipulating Tabular Data Using Pandas, Supervised Learning: Classification and Regression. Unsupervised Learning: Clustering, **Predictive Modelling / Machine Learning**: predictive algorithms, regression analysis, and clustering analysis from large databases.

Circuit analysis for series and parallel RLC circuits using PySpice, Power System stability and Analysis.Generating Graphical User Interface (GUI). Data Acquisition and Instrumentation Control: using a Raspberry Pi / Arduino and python code

Textbooks:

1. Object-Oriented Programming in Python —https://pythontextbok.readthedocs.io/en/1.0/
2. Christian Hill - Learning Scientific Programming with Python-Cambridge University Press (2020)
3. Robert Johansson, Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib, Apress (2019)

22EE51A3: ENERGY MANAGEMENT SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand data acquisition components of power system	PO-2	2
CO2	Understand energy data monitoring, reporting and communication	PO-2	2
CO3	Apply supervisory control for energy management	PO-5	3
CO4	Understand Energy management center functions	PO-1	2

General Theory: Purpose and necessity, general structure, data acquisition, transmission and monitoring, general powersystem hierarchical structure, overview of the methods of data acquisition systems, commonly acquired data, transducers, RTUs, data concentrators, various communication channels, cables, telephone lines, power line carrier, microwaves, fiber- optical channels and satellites.**Supervisory and Control Functions:** Data acquisitions, status indications, measured values, energy values, monitoring alarm and event application processing. Control function: ON/OFF control of lines, transformers, capacitors and applications in process industry, valve, opening, closing etc. Regulatory functions: set points and feed-back loops, time tagged data, disturbance data collection and analysis, calculation and report preparation. **MAN- Machine Communication:** Operator consoles and VDUs, displays, operator dialogues, alarm and event loggers, mimic diagrams, report and printing facilities. **Data bases - SCADA, EMS and network data bases:** SCADA system structure - local system, communication system and central system, Configuration- non-redundant single processor, redundant dual processor, multi control centers, system configuration. Performance considerations: real time operation system requirements, modularization of software programming languages.**Energy Management Center** Functions performed at a centralized management center, production control and load management, economic dispatch, distributed centers and power pool management.

Textbooks:

1. TorstenCegrell, Power System Control Technology, Prentice Hall International, 1986

2. Stuart A. Boyer, SCADA: Supervisory Control And Data Acquisition, The Instrumentation, Systems and Automation Society, 4th edition, 2009.

3. Krishna Kant, Computer-Based Industrial Control, PHI Learning,2nd edition, 2013.

4. Bela G. Liptak, Instrument Engineers Handbook, Volume 3: Process Software and Digital Networks, CRC Press, 4th edition, 2011.

5. Behrouz Forouzan, Data Communications and Networking, McGraw-Hill,**5th**edition, 2012.

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22EE51B1: OPTIMIZATION TECHNIQUES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand classical optimization techniques, describe clearly the problems with and without constraints, identify its parts and analyze the individual functions, Feasibility study for solving an optimization problem.	4	2
CO2	Apply mathematical translation of the verbal formulation of an optimization problem and design algorithms of linear programming problems, the repetitive use of which will lead reliably to finding an approximate solution.	4	3
CO3	Analyze and measure the performance of an algorithm of different methods to solve non-linear programming problems, study and solve optimization problems.	4	4
CO4	Analyze optimization techniques using algorithms. Investigate study, develop, organize and promote innovative solutions for various applications.	4	4

Syllabus:

Classical Optimization Techniques: Single variable optimization, multi-variable optimization with no constraints, with equality and inequality constraints, Karush- Kuhn- Tucker constraints.

Linear Programming (LP): Geometry of LP problem, graphical solution, simplex algorithm, two-phases of simplex algorithm, duality, dual simplex method, quadratic programming.

Non-Linear Programming: One-dimensional optimization – Fibonacci method, golden section method, quadratic and cubic interpolation methods, Newton's method.Unconstrained optimization - Steepest descent method, conjugate gradient method, Davidon-Fletcher-Powell method. Constrained Optimization - Augmented Legrangian multiplier method, Branch and bound method

Non-traditional Optimization Methods and Applications: Genetic algorithms (G A), G A Operators, G A for constrained optimization. Particle swarm optimization (PSO).

Text Books:

1. S.S. Rao, 'Engineering Optimization : Theory andPractice.III Edition, New Age International (p) Limited Publications

2. Kalyanmoy Deb, 'Optimization for Engineering Design', PHI Learning Private Limited.

Reference Books:

1. PurnachandraBiswal, ' Optimization in Engineering', Scitech Publications (India) PVT Ltd.

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22EE51B2: Advanced Control Theory

L-T-P-S: 3-0-0-0 Credits: 3 Pre-Requisite: NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
1	Apply the mathematical representation to dynamic systems	PO2	3
2	Apply the techniques to design the controllers	PO1	3
3	Apply the techniques to identify non linear system stability	PO-5	3
4	Apply the algorithms for stability analysis	PO-2	3

Mathematical Preliminaries and State Variable Analysis:Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear systems – The concept of state – State space model of Dynamic systems – Time invariance and Linearity – Non uniqueness of state model – State diagrams for Continuous-Time State models – Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties. Complete solution of state space model due to zero input and due to zero state.

Controllability and Observability: General concept of controllability – Controllability tests, different state transformations such as diagonalization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems – General concept of Observability – Observability tests for Continuous-Time Invariant Systems – Observability of different State transformation forms. State Feedback Controllers and Observers: State feedback controller design through Pole Assignment, using Ackkermans formula– State observers: Full order and Reduced order observers.

Non-Linear Systems: Introduction – Non Linear Systems – Types of Non-Linearities – Saturation – Dead-Zone – Backlash – Jump Phenomenon etc; Linearization of nonlinear systems, Singular Points and its types– Describing function–describing function of different types of nonlinear elements, – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability, and Lypanov's instability theorems – Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

TEXT BOOKS:

1. M. Gopal, Modern Control System Theory by – New Age International – 1984
2. Ogata. K, Modern Control Engineering by– Prentice Hall – 1997
3. N K Sinha, Control Systems– New Age International – 3rd edition.

REFERENCE BOOKS:

1. Donald E. Kirk, Optimal Control Theory an Introduction, Prentice – Hall Network series – First edition.

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22EE51D3: DEREGULATED POWER SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
1	Understand the market operations in the electricity market under deregulated environment, Open Access Same-time Information System (OASIS) and Available Transfer Capability (ATC).	PO-1	2
2	Analyze the concepts of Electricity Pricing.	PO-5	4
3	Analyze the Power System Operation in Competitive Environment and Market Power.	PO-5	4
4	Analyze the concepts of Transmission Pricing and Congestion pricing.	PSO-1	4

SYLLABUS

Key Issues in Electric Utilities Introduction – Restructuring models – Independent System Operator (ISO) – Power Exchange - Market operations – Market Power – Standard cost – Transmission Pricing – Classification of congestion management methods, Calculation of ATC, Non-market methods, Market based methods, Nodal pricing– Management of Inter zonal/Intra zonal Congestion. Open Access Same-time Information System (OASIS)Structure of OASIS - Posting of Information – Transfer capability on OASIS. **Available Transfer Capability (ATC)** Transfer Capability Issues – ATC – TTC – TRM – CBM Calculations – Calculation of ATC based on power flow. **Electricity Pricing** Introduction – Rolled-in transmission pricing methods- Marginal transmission pricing paradigm, , Composite pricing paradigm, Merits and de-merits of different paradigms,-Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-time Price Forecasting. **Power System Operation in Competitive Environment** Introduction – Operational Planning Activities of ISO- The ISO in Pool Markets – The ISO in Bilateral MarketsOperationalPlanning Activities of a GENCO. **Market Power :**Introduction - Different types of market Power– **Exercising Market Power** - Examples,**Transmission Cost Allocation Methods :**Introduction - Postage Stamp Rate Method - Contract Path Method - MW-Mile Method – Unused Transmission Capacity Method - MVA-Mile method – Comparison of cost allocation methods.

TEXT BOOKS:

1. Loi Lei Lai, "Power System Restructuring and Deregulation", John Wiley & Sons Ltd., England, 2001.
2. Kankar Bhattacharya, "Operation of Restructured Power System", Math H.J. Boller and JaapE.DaalderKulwer Academic Publishers, 2001.

REFERENCE BOOKS:

1. Mohammad Shahidehpour and Muwaffaqalomoush, "Restructured Electrical Power Systems", Marcel Dekker, Inc., 2001.
2. P. Venkatesh,B V Manikandan,S Charles Raja and A SrinivasaRao, "Electric Power System Analysis, Security & Deregulation", PHI, 2012

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22EE52A1: Digital Simulation of Power Electronic Converters

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Design of non-isolated and isolated DC-DC converters	PO1,PO2	4
CO2	Understand the working of Resonant converters	PO1,PO2	2
CO3	Modelling of non-isolated DC -DC converters	PO1,PO2	3
CO4	Design of closed loop controls for switched mode power supplies	PO1,PO2	4

SYLLABUS :

Non isolated dc-dc converters: Introduction to dc-dc power supplies-Analysis and design of Buck, Boost, Cuk and SEPIC converters in continuous and discontinuous conduction modes-verification of theoretical analysis of converters using simulation tools

Isolated dc-dc converters: Introduction to dc-dc power supplies with isolation- Analysis and design of Forward and fly-back, Push-Pull, Half bridge and full-bridge converters in continuous and discontinuous conduction modes-verification of theoretical analysis of converters using simulation tools

Resonant converters: Introduction to soft switching techniques, analysis and design of load resonant converters-Series load resonant converter-parallel load resonant converter and hybrid resonant converter - Resonant switch converter- Zero current switching, Zero voltage switching and Zero voltage switching with clamped voltage, comparison of Resonant converter topologies.

Modeling of Non isolated dc-dc converters:

Introduction to small signal Analysis- small signal Analysis of Buck, Boost , Buck-Boost converters in continuous and discontinuous conduction modes using averaged switch models, stability analysis of converters using transfer functions (open loop) derived from small signal Analysis

Closed loop control of converters: Introduction to control of switch mode dc power supplies, voltage feedback, voltage feed forward, current mode PWM control of DC-DC converters, power supply protection and electrical isolation in feedback loop

Text books:

1. Power Electronics Converters, applications & devices- Mohan, Undeland Robbins, Wiley Publications, 2003
2. Power Electronics by Daniel W.Hart , Tata McGraw-Hill publication.2011

Reference Books:

1. Power – Switching Converters; Second Edition by Simon Ang & Alejandro Oliva, CRC Publications,2005
2. Fundamentals of Power Electronics-R.W.Erickson and D.Maksimovic-second edition –kluwer publishers,sixth printing-2004.
3. Power Electronics and applications by L. Umananand Wiley India publications.2009

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22EE52A2: Switched Mode Power Supply and PWM Techniques

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

=CO No	Course Outcome (CO)	PO	Blooms Taxonomy Level (BTL)
CO1	Understand Pspice modelling of power semiconductor devices and passive components behaviour with protection circuits.	PO1,PO2/ PSO1	2
CO2	Analyse performance of AC-DC controlled, uncontrolled converters and DC-DC converters using Pspice and MATLAB Simulink model.	PO1,PO2/ PSO1	4
CO3	Evaluate DC-AC converters performance using modern simulation tools.	PO1,PO2/ PSO1	4
CO4	Analyse AC voltage controller and cyclo-converter performance with programming and simulation tools.	PO1,PO2/ PSO1	4

SYLLABUS:

MODELLING OF POWER ELECTRONIC DEVICES: General purpose circuit analysis software – Methods of analysis of power electronic systems - Transients and the time domain analysis with Pspice – Fourier series and harmonic components – Pspice modelling of diode, BJT,MOSFET,IGBT, SCR,TRIAC in simulation. Diode with R, R-L, R-C and R-L-C load with ac supply. Modelling of SCR, TRIAC and IGBT, simulation of driver and snubber circuits. **SIMULATION OF AC-DC CONVETERS USING PSPICE AND MATLAB SIMULINK**: Modelling of single phase and three-phase uncontrolled and controlled (SCR) rectifiers- simulation of converter fed DC drives-computation of performance parameters: harmonics, power factor, angle of overlap. **SIMULATION OF DC-DC CONVERTERS USING PSPICE AND MATLAB SIMULINK:**Modelling of Chopper circuits- Simulation of thyristor choppers with voltage, current and load commutation schemes- Simulation of chopper fed dc motor- computation of performance parameters. **SIMULATION OF DC-AC CONVERTERS USING PSPICE AND MATLAB SIMULINK:**Modelling of single and three phase inverters circuits – Space vector representation- Pulse-width modulation methods for voltage control- Simulation of inverter fed induction motor drives. **SIMULATION OF AC-AC CONVERTERS USING PSPICE AND MATLAB SIMULINK:**Modelling of AC voltage controllers, and Cyclo-converters- Simulation of AC voltage controllers and Cyclo-converters feeding different loads- Computation of performance parameters.

TEXT BOOKS:

1. Rashid, M., "Simulation of Power Electronic Circuits using PSPICE", Prentice Hall Inc., 2006
2. M. B. Patil, V. Ramnarayanan and V. T. Ranganathan., "Simulation of Power Electronic Converters", 1st Edition, Narosa Publishers, 2010.
3. John Keown., "Microsim, Pspice and circuit analysis"-Prentice Hall Inc., third edition, 1998.

REFERENCE BOOKS:

1. Robert Ericson, 'Fundamentals of Power Electronics', Chapman & Hall, 1997.
2. IssaBatarseh, 'Power Electronic Circuits', John Wiley, 2004Simulink Reference Manual, Math works, USA.
3. Rashid, M., "Power Electronic Circuits, Devices and Applications", Pearson Education Inc.,2004.

22EE52C3: FACTS & Power Quality

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

Co.No:	Course Outcomes	PO/PSO	BTL
CO 1	Understand the importance of FACTS devices and their applications to the Power Systems.	PO1,PO2/ PSO1	2
CO 2	Analyse the static shunt and series compensation and operation of devices under this category.	PO1,PO2/ PSO1	4
CO3	Apply DSTATCOM for power quality restoration	PO1,PO2/ PSO1	3
CO4	Apply combined compensation techniques for power quality restoration and fault ride through.	PO1,PO2/ PSO1	4

FACTS CONCEPT AND GENERAL SYSTEM CONSIDERATIONS: Introduction to Facts devices, Basic types of FACTS Controllers, benefits from FACTS controllers. **STATIC SHUNT COMPENSATION:** Objectives of shunt compensation, Methods of controllable VAR generation, variable impedance type static VAR generators (SVC): TCR, TSR, TSC, FC-TCR, TSC-TCR, STATCOM, Comparison between SVC and STATCOM, STATCOM.**STATIC SERIES COMPENSATION: Objectives** of series compensation, variable impedance type static series controllers: GCSC, TSSC, TCSC, TCVR and TCPAR.

LOAD COMPENSATION USING DSTATCOM - Compensating single phase loads – Ideal three phase shunt compensator structure –Generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode. **SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM**-Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified Power Quality Conditioner- Wind power interconnection requirement - Fault ride through techniques.

TEXT BOOKS:

1. FACTS: Modelling and Simulation in Power Networks, By Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, César Angeles-Camacho WILEY
2. K.R.Padiyar "FACTS Controller in power Transmission and Distribution" New Age Int Publisher,2007
3. ArindamGhosh "Power Quality Enhancement Using Custom Power Devices", KluwerAcademic Publishers, 2002
4. R.C. Duggan, Mark.F.McGranaghan,SuryaSantoas and H.WayneBeaty, "Electrical Power System Quality", McGraw-Hill, 2004.

REFERENCES

1. Ned Mohan et.al "Power Electronics" John wiley& Sons,2 nd edition ,2002
2. T.J.E Miller, "Reactive power control in electric Systems" John willey& sons,1982.
3. Derek A. Paice , "Power Electronics Converter Harmonics :Multipulse Methods for CleanPower",Wiley,1999.
4. Ewald Fuchs, Mohammad A. S. Masoum Power Quality in Power Systems and Electrical.

27/4/23

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22EE52D1: SMART GRID TECHNOLOGIES

L-T-P-S: 3-0-0-0 Credits: 3 Pre-Requisite: NIL

Mapping of Course Outcomes with PO/PSO

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the basic concepts of smart grid, terminology, challenges and initiatives.	PO1/PSO2	2
CO2	Identify various smart operations of power system structure, components, and monitoring techniques.	PO2/PSO2	3
CO3	Apply smart metering and advanced metering infrastructure with monitoring, protection and measuring units.	PO2/PSO2	3
CO4	Illustrate various communication protocols and cyber-security importance in smart grid.	PO4/PSO2	2

INTRODUCTION TO SMART GRID: Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

SMART GRID TECHNOLOGIES: Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation - service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

SMART METERS AND ADVANCED METERING INFRASTRUCTURE: Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection. High Performance Computing for Smart Grid Applications

COMMUNICATION SYSTEMS: Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TEXT BOOKS

1. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2017.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.

REFERENCES BOOKS

1. Control and Optimization Methods for Electric Smart Grids, Aranya Chakraborthy, Marija D Ilic Editor, Springer Publications.
2. Smart Grid Fundamentals of Design and Analysis, James Momoh, Wiley IEEE Press, Ed 2012.

22EE52D2: ENERGY CONSERVATION & AUDIT

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the concept of Energy Audit and Energy Management	PO-2	2
CO2	Analyze the various characteristics of energy efficient motors	PO-3	4
CO3	Analyze the different energy instruments and importance of power factor improvement	PO-3	4
CO4	Analyze the economic aspects of electrical energy	PO-2	4

BASIC PRINCIPLES OF ENERGY AUDIT: Energy audit- definitions, concept, types of audit, energy index, cost index, pie-charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit. **ENERGY MANAGEMENT:**

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting - Energy manger, Qualities and functions, language, Questionnaire - check list for top management. Demand side management. **ENERGY EFFICIENT MOTORS:** Energy efficient motors,.factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage van at ion-voltage unbalance- over motoring- motor energy audit. **POWER FACTOR IMPROVEMENT, LIGHTING AND ENERGY INSTRUMENTS:** Power factor - methods of improvement, location of capacitors, PF with non linear loads, effect of harmonics on PF , PF motor controllers - Good lighting system design and practice, lighting control, lighting energy audit - Energy Instruments- watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's. **ECONOMIC ASPECTS AND ANALYSIS:** Economics Analysis - Depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, life cycle costing analysis - Energy efficient measures- calculation of simple payback method, net present worth method - Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

TEXT BOOKS:

1. W.C.Turner, "Energy management hand book", John wiley and sons Energy management and good lighting practice: fuel efficiency- book let 12-EEO
2. W.K. Murphy, G- MckayButier worth, "Energy management", Heine mann publications, 2007.

REFERENCE BOOKS:

1. Paulo Callaghan, "Energy management", Mc-graw Hill Book company, 1st edition, 1998
2. Giovanni and Petrecca, "Industrial Energy Management: Principles and Applications", The Kluwer international series-207 (1999)
3. Howard E.Jordan, "Energy-Efficient Electric Motors and their applications", Plenum pub corp; 2nd ed. (1994)

KL | Electrical & Electronics Engineering

22EE52D3: Smart Appliance and Smart Cities

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO

CO#	Course Outcome	PO/PSO	BTL
CO1	Evaluate the characteristics of smart home appliances.	5/2	4
CO2	Understand the essential elements of smart cities	2/2	2
CO3	Analyze the Characteristics of a Smart City	2/1	4
CO4	Apply the Designing, and Implementing a Smart City	5/2	3

Syllabus:

Modern Domestic Appliances Solid State Lamps: Introduction - Review of Light sources - white light generation techniques, Characterization of LEDs for illumination application. Power LEDs- High brightness LEDs- Electrical and optical properties. LED driver considerations-Power management topologies - colour issues of white LEDs- Dimming of LED sources, BLDC motors for pumping and domestic fan appliances, inverter technology-based home appliances, Smart devices and equipment.

Smart-cities Smart city pilot projects, essential elements of smart cities, active distribution networks, microgrids, distribution system automation, Reliability and resiliency studies, decentralized operation of power network.

Characteristics of a Smart City- Public Administration and Services: Health and Public Safety , Culture and Education,
Smart Grids, Street Lighting, Energy and Efficiency, Mobility and Transportation,
Water and Environmental, Buildings and Homes

Planning, Designing, and Implementing a Smart City-Resident-Centric Solutions,Robust Communication,Partnerships , Funding.
Smart City Standards and Initiatives,Smart City Examples, Smart City Challenges and Success Factors

Text Books:

1. Vinod Kumar Khanna, "Fundamentals of Solid State Lighting", CRC press, 1st Edition, 2014.
2. S. Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 1st Edition, 2013.
3. Smart Grids Advanced Technologies and Solutions, Second Edition by Stuart Borlase, CRC Press Tyalor and Francis

Reference Books:

1. Craig Di Louie, "Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications", Fairmont Press, Inc., 1st Edition, 2006.
2. Robert S Simpson, "Lighting Control: Technology and Applications", Focal Press, 1st Edition, 2003
3. Chang-liang Xia, "Permanent Magnet Brushless DC Motor Drives and Controls", John Wiley & Sons Singapor