ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

SCHOOL OF ELECTRICAL SCIENCES

B. Tech in Electrical Engineering

Curriculum and Syllabus

(2023-24 admitted students)

FINAL COMMON CURRICULUM (COURSE STRUCTURE)
FOR BACHELOR OF TECHNOLOGY IN ELECTRICAL ENGINEERING
COURSES TO BE EFFECTIVE FROM ACADEMIC SESSION 2023– 2024 ADMITTED BATCH
(3rd Semester to 8th Semester)

School/ Department: School of Electrical Sciences

Abbreviation used:

AC	Audit course	LC	Laboratory Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks), (ii) Quiz/ Assignment/Attendance (20 marks)					

THIRD YEAR (*FIFTH SEMESTER*)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	EE3101	Electrical Power Transmission and Distribution	3	0	0	3	40	60	-	100
2	PC	EE3103	Power Electronics	3	0	0	3	40	60	-	100
3	PC	EE3105	Microprocessors and Microcontrollers	3	0	0	3	40	60	-	100
4	PE	EE3201 EE3203 EE3205 EE3207	1. Electromagnetic Field Theory 2. Control Systems-II 3. Energy Conservation and Auditing 4. Special Electrical Machines	3	0	0	3	40	60	-	100
5	HS	BH3401/ BH3403	Business Management / Entrepreneurship Development	3	0	0	2	40	60	-	100
6	MC	IP3401/ IP3403	Environmental Engineering/ Industrial Safety Engineering	3	0	0	2	40	60	-	100
7	LC	EE3501	Power Electronics Lab	0	0	3	1.5	-	-	100	100
8	LC	EE3503	Microprocessors and Microcontrollers Lab	0	0	3	1.5	-	-	100	100
9	ACC	CS3511	OOPs	0	0	3	1.5	-	-	100	100
10	PSI	EE3701	Seminar on SIRE – I*	0	0	3	1.5	-	-	100	100
			Total	**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

***Project / Seminar / Internship**

THIRD YEAR (*SIXTH SEMESTER*)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	EE3102	Power System Analysis and Operation	3	0	0	3	40	60	-	100
2	PC	EE3104	Digital Signal Processing	3	0	0	3	40	60	-	100
3	PE	EE3202 EE3204 EE3206 EE3208	1. Renewable Energy Systems 2. Power Station Engineering 3. Electric Vehicle 4. Electrical Machine Design	3	0	0	3	40	60	-	100
4	PE	EE3212 EE3214 EE3216 EE3218	1. Power System Protection 2. Electric Drives and Control 3. FACTS and HVDC 4. Storage Technology	3	0	0	3	40	60	-	100
5	HS	BH3403/ BH3401	Entrepreneurship Development / Business Management	3	0	0	2	40	60	-	100
6	MC	IP3403/ IP3401	Industrial Safety Engineering/Environmental Engineering	3	0	0	2	40	60	-	100
7	PR	EE3602	Project for Product Development – I	0	0	6	3	-	-	100	100
8	LC	EE3502	Power Systems Lab	0	0	3	1.5	-	-	100	100
9	LC	EE3504	Digital Signal Processing Lab	0	0	3	1.5	-	-	100	100
10	Summer Internship and Research Experience (SIRE -II) *										
			Total	**18**	**0**	**12**	**22**	**240**	**360**	**300**	**1000**

***Minimum 4 weeks of Summer Course / Training / Internship / Skill Course / etc. after 4th Semester**

Abbreviation used:

AC	Audit course	LC	Laboratory Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks), (ii) Quiz/ Assignment/Attendance (20 marks)					

FOURTH YEAR (*SEVENTH SEMESTER*)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PE	EE4201 EE4203 EE4205 EE4207	1. Smart Grid Technology 2. Power Quality 3. High Voltage Engineering 4. Restructured Power System	3	0	0	3	40	60	-	100
2	PE	EE4211 EE4213 EE4215 EE4217	1. Utilization of Electrical Energy 2. Distribution System Engineering 3. Power System Dynamics and Control 4. Electrical Engineering Materials	3	0	0	3	40	60	-	100
3	OE		Open Elective – I	3	0	0	3	40	60	-	100
4	ACC	CS4101	Advanced AI	3	0	0	2	40	60	-	100
5	SE	EE4701	Seminar on SIRE - II	0	0	6	1	-		100	100
6	PR	EE4601/ EE4603	Project for Product Development – II / Internship Project - I	0	0	4	2	-		100	100
			Total	**12**	**0**	**10**	**14**	**160**	**240**	**200**	**600**

FOURTH YEAR (*EIGHTH SEMESTER*)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	OE		Open Elective – II	3	0	0	3	40	60	-	100
2	OE		Open Elective – III	3	0	0	3	40	60	-	100
3	OE		Open Elective – IV	3	0	0	3	40	60	-	100
4	SE	EE4702	Seminar on Project	0	0	6	3	-		100	100
5	PR	EE4602/ EE4604	Project for Product Development – III / Internship Project - II	0	0	8	4	-		100	100
			Total	**9**	**0**	**14**	**16**	**120**	**180**	**200**	**500**

***Project / Seminar / Internship**

GRAND TOTAL CREDITS: 162

Honors Course offered by School of Electrical Sciences

Sl. No.	Course Code	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	SEM-5	EE3171	Machine Learning Applications in Smart Grid Systems	3-0-0	3
2	SEM-6	EE3172	Electricity Markets and Regulatory Frameworks	3-0-0	3
3	SEM-7	EE4171	Load Forecasting and Reliability in Power Systems	3-0-0	3
4	SEM-7	EE4173	Advanced Power Converter	3-0-0	3
5	SEM-8	EE4172	System Identification and Adaptive Control	3-0-0	3
Subject (Sessional)					
6	SEM-6	EE3572	Advanced Power System Lab	0-0-3	1.5
7	SEM-7	EE4571	Advanced Power Electronics Simulation Lab	0-0-3	1.5
			Total	**15-0-6**	**18**

Minor Course offered by School of Electrical Sciences

1. Minor in Smart Grid Management

Sl. No.	Course Code	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	SEM-5	EE3261	Electrical Power Transmission and Distribution	3-0-0	3
2	SEM-6	EE3262	Power Electronics	3-0-0	3
3	SEM-7	EE4261	Smart Grid Technologies and Architectures	3-0-0	3
4	SEM-7	EE4263	Advanced Metering Infrastructure (AMI) and Demand Side Management	3-0-0	3
5	SEM-8	EE4262	Data Analytics and Machine Learning for Smart Grid Applications	3-0-0	3
Subject (Sessional)					
6	SEM-6	EE3562	Power System and Power Electronics Lab	0-0-3	1.5
7	SEM-7	EE4561	Smart Grid Simulation Lab	0-0-3	1.5
			Total	**15-0-6**	**18**

2. Minor in Electric Vehicle and E-mobility

Sl. No.	Course Code	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	SEM-5	EE3263	Basics of Electrical Vehicles	3-0-0	3
2	SEM-6	EE3264	Power Electronics for E-Mobility	3-0-0	3
3	SEM-7	EE4265	Energy Storage Systems and Battery Management	3-0-0	3
4	SEM-7	EE4267	EV Charging Infrastructure and Grid Integration	3-0-0	3
5	SEM-8	EE4264	Motors for E-mobility and their control	3-0-0	3
Subject (Sessional)					
6	SEM-6	EE3564	Power Electronics and Drives Lab	0-0-3	1.5
7	SEM-7	EE3563	Electric Vehicle Lab	0-0-3	1.5
			Total	**15-0-6**	**18**

List of Open Elective Subjects offered by School of Electrical Sciences:

OPEN ELECTIVES I (ODD SEM)

1. EE4301 Renewable Energy Technologies
2. EE4303: Electric and Hybrid Vehicles

OPEN ELECTIVES II, III & IV (EVEN SEM)

1. EE4302: Energy Management and Auditing
2. EE4304: Energy Conversion Devices
3. EE4306: Hybrid Storage Systems

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OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks), (ii) Quiz/ Assignment/Attendance (20 marks)					

THIRD YEAR (*FIFTH SEMESTER*)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	EE3101	Electrical Power Transmission and Distribution	3	0	0	3	40	60	-	100
2	PC	EE3103	Power Electronics	3	0	0	3	40	60	-	100
3	PC	EE3105	Microprocessors and Microcontrollers	3	0	0	3	40	60	-	100
4	PE	EE3201 EE3203 EE3205 EE3207	5. Electromagnetic Field Theory 6. Control Systems-II 7. Energy Conservation and Auditing 8. Special Electrical Machines	3	0	0	3	40	60	-	100
5	HS	BH3401/ BH3403	Business Management / Entrepreneurship Development	3	0	0	2	40	60	-	100
6	MC	IP3401/ IP3403	Environmental Engineering/ Industrial Safety Engineering	3	0	0	2	40	60	-	100
7	LC	EE3501	Power Electronics Lab	0	0	3	1.5	-	-	100	100
8	LC	EE3503	Microprocessors and Microcontrollers Lab	0	0	3	1.5	-	-	100	100
9	ACC	CS3511	OOPs	0	0	3	1.5	-	-	100	100
10	PSI	EE3701	Seminar on SIRE – I*	0	0	3	1.5	-	-	100	100
			Total	**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

***Project / Seminar / Internship**

THIRD YEAR (*SIXTH SEMESTER*)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	EE3102	Power System Analysis and Operation	3	0	0	3	40	60	-	100
2	PC	EE3104	Digital Signal Processing	3	0	0	3	40	60	-	100
3	PE	EE3202 EE3204 EE3206 EE3208	5. Renewable Energy Systems 6. Power Station Engineering 7. Electric Vehicle 8. Electrical Machine Design	3	0	0	3	40	60	-	100
4	PE	EE3212 EE3214 EE3216 EE3218	5. Power System Protection 6. Electric Drives and Control 7. FACTS and HVDC 8. Storage Technology	3	0	0	3	40	60	-	100
5	HS	BH3403/ BH3401	Entrepreneurship Development / Business Management	3	0	0	2	40	60	-	100
6	MC	IP3403/ IP3401	Industrial Safety Engineering/Environmental Engineering	3	0	0	2	40	60	-	100
7	PR	EE3602	Project for Product Development – I	0	0	6	3	-	-	100	100
8	LC	EE3502	Power Systems Lab	0	0	3	1.5	-	-	100	100
9	LC	EE3504	Digital Signal Processing Lab	0	0	3	1.5	-	-	100	100
10	Summer Internship and Research Experience (SIRE -II) *										
			Total	**18**	**0**	**12**	**22**	**240**	**360**	**300**	**1000**

***Minimum 4 weeks of Summer Course / Training / Internship / Skill Course / etc. after 4th Semester**

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Electrical Power Transmission and Distribution	EE3101	3-0-0	3

PREREQUISITES:

1. Basic Electrical Engineering.
2. Electrical Circuit Analysis.

COURSEOUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Understand the basics of various fundamentals of electrical power generation, transmission & distribution.	Understand (L2)
CO2	Analyse transmission line parameters and its effects on transmission lines.	Analyze (L4)
CO3	Apply electrical characteristics of transmission line such as types of transmission lines, various effects on transmission & per unit representation of power system.	Apply (L3)
CO4	Mechanical design with the types of conductors, insulators, underground cable parameters and power system earthing.	Create (L5)

MODULE 1: (8 Hours)

Transmission Line Parameters: Inductance of a Conductor due to Internal Flux, Flux Linkages between Two Points External to an Isolated Conductor, Inductance of a Single Phase Two Wire Line, Flux Linkages of one Conductor in a Group, Inductance of Composite-Conductor Lines. Inductance of a Three Phase Line with symmetrical and Unsymmetrical Spacing. Inductance Calculations for Bundled Conductors, Skin effect and Proximity effect, Corona Effect. Capacitance of a Two Wire Line, Capacitance of a Three Phase Line with symmetrical and Unsymmetrical Spacing, Effect of Earth on the Capacitance of a Three Phase Line, Capacitance Calculations for Bundled Conductors, Parallel- Circuit Three Phase Lines.

MODULE 2: (7 Hours)

Transmission Line Performances: Analysis of Short, medium and long Transmission Line, Equivalent Circuit, Representation of lines and calculation of transmission parameters, Voltage Profile of transmission lines, Ferranti Effect, Power Flow Through Transmission Line, Power Flow capability and Surge Impedance Loading, Reactive Compensation of Transmission Line.

MODULE 3: (7 Hours)

Overhead Line Conductors and Insulators: Types of conductors: ACSR, AAAC, HTLS etc. Insulator Materials, Types of Insulators: Porcelain, Glass, Polymer, Hydrophobicity, Creepage Distance, Voltage Distribution in suspension type insulators, Improvement of String Efficiency, Insulator Failure, Testing of Insulators, Concept of Sag and Tension.

MODULE4: (8 Hours)

Distribution: Classification of Distribution Systems, Primary and secondary distribution network, Voltage Drop in DC Distributors, Voltage Drop in AC Distributors, Kelvin’s Law, Limitations of Kelvin’s Law, Application of Capacitors to Distribution Systems.

Underground Cables: Type and construction, Classification of Cables, Parameters of Single Core

Cables, Grading of Cables, Capacitance of Three Core Cable.

Power System Earthing.

TEXT BOOKS:

1. J. Grainger and W. D. Stevenson," Power System Analysis", McGraw Hill Education,1994.
2. D.P.KothariandI.J.Nagrath,"ModernPowerSystemAnalysis",McGrawHillEducation,2003
3. C.L. Wadhwa – Electrical Power Systems, Fifth Edition, New Age International,2009.

REFERENCE BOOKS:

1. J. B. Gupta," A course in power systems", S K KATARIA & SONSpublications.
2. V.K Mehta and Rohit Mehta", "Principles of Power Systems", Third Edison, S. Chand & Company Ltd, New Delhi,2004.
3. M.V. Deshpande –Elements of Electrical Power Station Design, Third Edition, Wheeler Pub.

CO-PO MAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	3	2	2	-	-	-	-	2	3	-
CO2	3	3	3	3	3	2	-	-	-	-	-	2	3	-
CO3	3	3	3	3	3	2	-	-	-	-	-	2	3	2
CO4	3	3	3	3	3	2	-	-	-	-	-	2	3	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power Electronics	EE3103	3-0-0	3

PREREQUISITES:

1. Basic Electronics

COURSEOUTCOMES:

At the end of this course students will able to:

CO	Course Outcome	Bloom's Level
CO1	Explain the structure, characteristics, and operation of high-power semiconductor devices including IGBT, MOSFET, SCR, and wide band gap devices like SiC and GaN.	Understand (Level 2)
CO2	Analyze different controlled rectifier circuits and computing their performances	Analyze (Level 4)
CO3	Evaluate the performance of non-isolated and isolated DC-DC converters under steady-state continuous and discontinuous current conditions.	Evaluate (Level 5)
CO4	Design and compare various inverter topologies including PWM and multilevel inverters, and explain the working of cycloconverters.	Apply/Create (Level 3/6)

MODULE 1: (8 Hours)

Introduction to High-Power Semiconductor Devices - Insulated Gate Bipolar Transistors (IGBTs): Design and operation principles, Power MOSFETs: Structure, operation, and characteristics, Comparison with other high-power devices Thyristors and Related Devices: Structure and types (e.g., SCR, GTO), Switching characteristics and applications Advanced Materials for High-Power Devices: Wide band gap materials (e.g., SiC, GaN), Advantages and challenges. Integration and Application of High-Power Devices: Power modules and converters

MODULE 2: (7 Hours)

Phase Controlled rectifiers: full/half-controlled converters for R, RL ,RLE load with source inductance and without source inductance, dual converters, sequence control. Phase controlled rectifiers: Single-phase full wave fully controlled rectifier with R-L and R-L-E load; Three-phase full wave fully controlled rectifier with R-L and R-L-E load; Input current wave shape and power factor. Single phase semi converter with R-L and R-L-E load, 3 phase semi-converter with R-L and R-L-E load. Effect of source inductance on the performance of full converter

MODULE 3: (7 Hours)

DC-DC converter: Buck converter: analysis and waveforms at steady state for continuous and discontinuous load current operations, duty ratio control of output voltage. Boost converter: analysis and waveforms at steady state, relation between duty ratio and average output voltage, continuous and discontinuous load current operations, Buck-Boost regulators, Cuk regulators.

Isolated Types: Fly Back Converters, Forward converters, Push Pull Converters, Bridge Converter.

MODULE4: (8 Hours)

Voltage source inverter: Single-phase bridge inverter, three-phase inverter: 180^0& 120^0conduction. Voltage and frequency control of inverter; single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation (Sine PWM), Space Vector PWM of 3-phaseinverter. Current source inverter: 1-phase & 3-phase. Introduction to multilevel inverter. Operation principle of cycloconverter.

TEXT BOOKS:

1. M. H. Rashid," Power electronics: circuits, devices, and applications", Pearson Education India, 2009.

2. N. Mohan and T. M. Undeland," Power Electronics: Converters, Applications and Design", John Wiley & Sons,2007.

REFERENCE BOOKS:

1. R. W. Erickson and D. Maksimovic," Fundamentals of Power Electronics", SpringerScience & Business Media,2007.
2. L. Umanand," Power Electronics: Essentials and Applications", Wiley India,2009.

CO-PO MAPPING

(*1-Weak Correlation; 2-Medium correlation;3-Strong Correlation)*

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	–	–	2	–	2	–	–	–	–	1	3	2
CO2	3	3	2	2	2	–	2	–	–	–	–	2	3	2
CO3	3	3	2	2	3	–	2	–	–	–	–	2	3	3
CO4	3	3	3	2	3	–	2	–	–	1	2	3	3	3

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Power Electronics Laboratory	EE3501	0-0-3	1.5

COURSEOUTCOMES:

At the end of this course, students will able to

CO	Course Outcome
CO1	Acquire knowledge of V-I characteristics of various Power Semiconductor devices and able to design and simulate their base/gate drive circuits and understand the design of cosine controlled triggering circuit of SCR.
CO2	Validate the output performances of different controlled rectifier circuits with various loading conditions
CO3	Understand the design of different DC-DC converter circuits (isolated and non-isolated type) and verifying through experimentation
CO4	Understand the design and operation of single phase Voltage Source Inverter circuit topology with Sin PWM control and simulation of the same circuit in MATLAB-SIMULINK platform

Experiment List:

1. Study of the V-I characteristics of SCR, TRIAC and MOSFET.
2. Study of the cosine controlled triggering circuit.
3. Study of the single phase half wave controlled rectifier and semi converter circuit with R and R-L Load.
4. Study of single phase full wave controlled rectifier circuits (mid-point and Bridge type) with R and R-L Load.
5. Study of three phase full wave controlled rectifier circuits (Full and Semi converter) with R and R- L Load.
6. Study of the Buck converter and boost converter.
7. Study of the single phase PWM voltage source inverter.
8. Study of the forward converter and fly back converter.
9. Study of ac voltage regulator and single phase cyclo converter.
10. Study of three phase inverter in 120 and 180 degree mode of operation.

TEXT BOOKS:

1. M. H. Rashid," Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland," Power Electronics: Converters, Applications and Design", John Wiley & Sons,2007.

REFERENCE BOOKS:

1. R. W. Erickson and D. Maksimovic," Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
2. L. Umanand," Power Electronics: Essentials and Applications", Wiley India, 2009.

CO-PO MAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	3	1	3	-	-	-	-	-	-	-	3	2
CO2	2	3	2	3	2	-	-	-	-	-	-	-	3	2
CO3	2	2	3	3	3	-	-	-	-	-	-	-	3	3
CO4	2	2	2	2	3	-	-	-	-	-	-	-	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Microprocessors and Microcontrollers	EE3105	3-0-0	3

Prerequisites:

1. Programming for problem solving

Course Outcomes:

At the end of the course, students will be able to:

CO Code	Course Outcome	Bloom's Level
CO1	Explain the architecture, instruction set, and addressing modes of 8085 microprocessor and perform assembly language programming.	Understand (L2), Apply (L3)
CO2	Design and interface peripheral devices like memory, ADC, DAC, and I/O devices with the 8085 microprocessor for real-world applications.	Design (L6), Apply (L3)
CO3	Understand the architecture, memory organization, and instruction set of the 8086 microprocessor and implement simple assembly programs.	Understand (L2), Apply (L3)
CO4	Design and implement programs using the 8051 microcontroller, including interfacing with external devices such as LCDs and generating delay and square wave signals.	Apply (L3), Design (L6)

Module 1: (10 Hours)

Introduction to 8085 Microprocessor & Architecture, Pins & Signal - Instruction set of 8085, Memory & I/O Addressing, Assembly language programming using 8085 Instruction Set, Timing diagram, Use of Stack & Subroutines, Data transfer techniques, 8085interrupts.

Module 2: (8 Hours)

Interfacing & support chips: Interfacing EPROM & RAM Memories, 2716, 2764, 6116 & 6264 Microprocessor Based System Development Aids, Programmable Peripheral Interface: 8255, Programmable DMA Controller: 8257, Programmable Interrupt Controller: 8259. Application: Delay calculation, square wave generation, Interfacing of ADC & DAC, Data Acquisition System.

Module 3: (10 Hours)

Advanced Microprocessor: Basic features of Advance Microprocessors, Intel 8086 (16 bit processors): - 8086 Architecture, Register organization, signal descriptions, Physical Memory Organization, Addressing Modes, Instruction Formats, Instructions Sets & Simple Assembly language program.

Module 4: (07 Hours)

8051 Microcontrollers: MCS-51 Architecture, Registers, Stack Pointer & Program Counter. 8051 Pin Description, Connections, Parallel I/O ports, Memory Organization, 8051 Addressing Modes & Instructions, 8051 Assembly Language Programming Tools. Simple application: Delay calculation, square wave generation and Interfacing of LCD unit.

Text Books:

1. K. Roy & K. M. Bhurchandi," Advanced Microprocessor and Peripherals (Architecture, Programming & Interfacing)", TMH Publications.
2. D. V. Hall and S. S. S. P. Rao," Microprocessor & its Interfacing"- 3rd Edition, TMH Publication
3. M. A. Mazidi & J. G. Majidi," Microcontroller and Embedded Systems", 2nd Edition, Prentice Hall Publication

Reference Books:

1. Ramesh, Gaonkar," Microprocessor Architecture Programming and Application with the 8085", 5th Edition CBS Publication.

CO-PO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	1	1	-	-	-	-	-	-	-	3	1
CO2	3	3	3	2	1	-	-	-	-	-	-	-	3	1
CO3	3	2	3	1	1	-	-	-	-	-	-	-	3	2
CO4	3	3	2	2	2	-	-	-	-	-	-	-	3	2

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Microprocessors and Microcontrollers Lab	EE3503	0-0-3	1.5

Prerequisites:

1. Programming for problem solving

Course Outcomes:

CO Code	Course Outcome	Bloom's Level
CO1	Develop programs for performing arithmetic operations (addition, subtraction, multiplication, and division) and sorting of data in ascending and descending order.	Apply (L3)
CO2	Implement and interface ADC and DAC systems, and use them in practical applications such as signal generation and measurement.	Apply (L3)
CO3	Interface and control different types of motors (stepper motor, DC motor, servo motor) and display devices like seven-segment display and graphical LCD.	Apply (L3), Implement (L4)
CO4	Develop programs for data transmission through serial and parallel ports and interface sensors for data measurement (temperature, pressure).	Apply (L3), Implement (L4)

List of Experiments

(At least 08 experiments to be performed)

1. Write program for addition, subtraction, multiplication and division operation.
2. Sorting of data in ascending and descending order.
3. Square root of a given data.
4. To generate a square wave of frequency 10kHz (similar).
5. Interfacing with ADC and DAC.
6. Implementation and Interfacing of Seven segment display.
7. Implementation and Interfacing of different motors like stepper motor, DC motor and servo motor.
8. To measure and display data from temperature and pressure sensor.
9. To interface a graphical LCD.
10. To study programming and transmission of data through serial and parallel port.

Text Books:

1. K. Roy & K. M. Bhurchandi," Advanced Microprocessor and Peripherals (Architecture, Programming & Interfacing)", TMH Publications.
2. D. V. Hall and S. S. S. P. Rao," Microprocessor & its Interfacing"- 3rd Edition, TMH Publication
3. M. A. Mazidi & J. G. Majidi," Microcontroller and Embedded Systems", 2nd Edition, Prentice Hall Publication

Reference Books:

1. Ramesh, Gaonkar," Microprocessor Architecture Programming and Application with the 8085", 5th Edition CBS Publication.

CO-POMAPPING

(1-Weak Correlation; 2-Medium correlation; 3-Strong Correlation)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	3	2	3	2	3	-	-	-	-	-	-	2	3	2
CO 2	3	2	3	2	3	-	-	-	-	-	-	2	3	3
CO 3	3	2	3	2	3	-	-	-	-	2	2	3	3	2
CO 4	3	2	3	2	3	-	-	-	-	2	2	3	3	3

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
OOPS	CS3511	0-0-3	1.5

Prerequisites:

1. Programming in C

Course Outcomes:

CO1	Understand the fundamentals of object-oriented programming and implement basic C++/Java programs.
CO2	Apply object-oriented concepts like classes, inheritance, and polymorphism in solving electrical engineering-related problems.
CO3	Demonstrate the use of file handling, templates, and exception handling for data-driven electrical applications.
CO4	Develop mini-projects or simulations modeling real-time electrical systems using OOP principles.

Detailed Syllabus

1. **Introduction to Object-Oriented Programming** Basic input/output operations Classes and Objects in C++/Java
2. **Constructors and Destructors** Default, parameterized, and copy constructors Object lifecycle concepts
3. Function Overloading and Operator Overloading: Arithmetic operator overloading Function overloading for different data types
4. Inheritance and Its Types Single, Multilevel, and Multiple Inheritance Use case: Hierarchy of Electrical Devices (e.g., resistor → variable resistor → potentiometer)
5. Polymorphism Compile-time and runtime polymorphism Virtual functions and abstract classes
6. File Handling Creating and reading files Writing electrical equipment logs into files
7. Templates and Exception Handling Use of function and class templates Try-catch blocks for fault tolerance in simulations
8. Standard Template Library (STL) [for C++] or Collections [for Java] Vectors, Lists, Maps Application in storing sensor values or circuit elements
9. Mini Project (Any one) Electric Circuit Analyzer using classes for components like resistors, capacitors Billing System for power consumption (Objects: Customer, Meter, Bill) Simulation of a DC Motor with class-based modeling

Text Books:

1. **E. Balagurusamy**, *Object-Oriented Programming with C++*, Tata McGraw Hill.
2. **Herbert Schildt**, *Java: The Complete Reference*, McGraw-Hill Education.

Reference Books:

1. **Robert Lafore**, *Object-Oriented Programming in C++*, Sams Publishing.
2. **Bjarne Stroustrup**, *The C++ Programming Language*, Addison-Wesley.

CO-PO Mapping: ***(1:Low, 2:Medium, 3:High)***

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	1	-	-	-	-	1	-	-
CO2	3	3	2	2	2	-	-	-	-	2	-	-
CO3	2	2	2	1	3	-	-	-	-	2	-	-
CO4	2	3	3	3	3	-	-	-	2	2	1	1

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Electromagnetic Field Theory	EE3201	3-0-0	3

Prerequisites:

1. Mathematics-I
2. Mathematics-II

Course Outcomes

At the end of the course, students will be able to:

Course code	Course Outcome	Bloom's Level
CO1	Understand and apply vector calculus to analyze static electric and magnetic fields in different coordinate systems.	Understand/Apply Level-2/3
CO2	Explain the fundamental laws of electromagnetism (Coulomb's law, Gauss's law, Ampere's law, Faraday's law) and apply them to solve field problems.	Understand Level-2
CO3	Analyze time-varying fields and Maxwell's equations to understand wave propagation in various media.	Analyze Level-4
CO4	Evaluate the behavior of electromagnetic waves in different media using boundary conditions and wave equations.	Evaluate Level-5

Module 1: (08 Hours)

Co-ordinate systems & Transformation: Cartesian co-ordinates, circular cylindrical co-ordinates, spherical co-ordinates. Vector Calculus: Differential length, Area & volume, Line, surface and volume Integrals, Del operator, Gradient of a scalar, Divergence of a vector & Divergence theorem, Curl of a vector & Stoke's theorem, Laplacian of a scalar.

Module 2: (10 Hours)

Electrostatic Fields: Coulomb's Law, Electric Field Intensity, Electric Fields due to point, line, surface and volume charge, Electric Flux Density, Gauss's Law- Maxwell's Equation, Applications of Gauss's Law, Electric Potential, Relationship between E and V- Maxwell's Equation an Electric Dipole & Flux Lines, Energy Density in Electrostatic Fields., Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions. Electro- static boundary-value problems: Poisson's and Laplace's Equations, Uniqueness Theorem, General procedures for solving Poisson's and Laplace's equations, Capacitance

Module 3: (06 Hours)

Magneto static Fields: Magnetic Field Intensity, Biot-Savart's Law, Ampere's circuit Law-Maxwell Equation, applications of Ampere's law, Magnetic Flux Density-Maxwell's equations. Maxwell's equation for static fields, Magnetic Scalar and Vector potentials. Magnetic Boundary Conditions.

Module 4: (12 Hours)

Electromagnetic Field and Wave propagation: Faraday's Law, Trans- former & Motional Electromagnetic Forces, Displacement Current, Maxwell's Equation in Final forms, Time-Harmonic Field. Electromagnetic Wave Propagation: Wave Propagation in lossy Dielectrics, Plane Waves in loss less Di- electrics, Free space, Good conductors Power & Poynting vector. Antennas: Introduction, Hertzian dipole, Half wave dipole antenna, Quaterwave monopole antenna, small loop antenna, Antenna characteristics.

Text Books:

1. Matthew N. O. Sadiku, Principles of Electromagnetics, 6th Ed., Oxford Intl. Student Edition, 2014.
2. W. Hayt, J A. Buck " Engineering Electromagnetics", McGraw Hill Education, Special Indian Edition, 2012.

Reference Books:

1. C. R. Paul, K. W. Whites, S. A. Nasor, Introduction to Electromagnetic Fields, 3rd Ed, TMH.
2. W.H. Hyat, Electromagnetic Field Theory, 7th Ed, TMH.
3. A. Pramanik," Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi, 2009.
4. A. Pramanik," Electromagnetism-Problems with solution", Prentice Hall India, 2012.
5. G.W. Carter," The electromagnetic field in its engineering aspects", Long- mans, 1954.
6. W.J. Duffin," Electricity and Magnetism", McGraw Hill Publication,1980.
7. W.J. Duffin," Advanced Electricity and Magnetism", McGraw Hill,1968.
8. E.G. Cullwick," The Fundamentals of Electromagnetism", Cambridge University Press,1966.
9. B. D. Popovic," Introductory Engineering Electromagnetics", Addison- Wesley Educational Publishers, International Edition, 1971.

CO-PO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	2	1	1	-	-	-	-	-	-	2	1	1
CO2	2	1	2	2	-	-	-	-	-	-	-	2	2	2
CO3	3	3	3	3	-	-	-	-	-	-	-	3	3	2
CO4	3	3	3	3	-	-	-	-	-	-	-	3	2	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Control Systems-II	EE3203	3-0-0	3

Prerequisites:

1. Control System-I.

Course Outcomes:

CO Code	Course Outcome	Bloom's Level
CO1	Obtain discrete representation of LTI systems.	Understand (Level-2)
CO2	Evaluate stability of discrete-time control systems using Z-domain techniques.	Evaluate (Level-5)
CO3	Analyze discrete-time systems using the state-space approach	Analyze (Level-4)
CO4	Model and analyze discrete and nonlinear systems.	Analyze (Level-4)

At the end of this course, students will demonstrate the ability to:

Module 1: (06 Hours)

Discrete-Time Control Systems: Introduction: Discrete Time Control Systems and Continuous Time Control Systems, Sampling Process. Sample and Hold, The Z-transform: Discrete-Time Signals, The Ztransform, Z-transform of Elementary functions, Important properties and Theorems of the Z-transform. The inverse Z transform, Z Transform method for solving Difference Equations.

Module 2: (6 Hours)

Z-Plane Analysis of Discrete Time Control Systems: Impulse sampling & Data Hold, Reconstruction of Original signals from sampled signals: Sampling theorem, folding, aliasing. Pulse Transfer function: Starred Laplace Transform of the signal involving Both ordinary and starred Laplace Transforms; General procedures for obtaining pulse Transfer functions, Pulse Transfer function of open loop and closed loop systems. Mapping between the s-plane and the z-plane, Stability analysis of closed loop systems in the z-plane: Stability analysis by use of the Bilinear Transformation and Routh stability criterion, Jury stability Test

Module 3: (08 Hours)

State Space Approach for discrete time systems: State space models of discrete systems, State space analysis. Lyapunov Stability, Controllability, observability analysis. Effect of pole zero cancellation on the controllability & observability.

Module 4: (14 Hours)

Non-linear Systems: Introduction, Common Physical Non-linearities, The Phase-plane Method: Basic Concepts, Singular Points, Stability of Nonlinear System, Construction of Phase-trajectories, The Describing Function Method: Basic Concepts, Derivation of Describing Functions, Stability analysis by Describing Function Method, Jump Resonance.

Lyapunov's Stability Analysis: Introduction, Lyapunov's Stability Criterion, The Direct Method of Lyapunov and the Linear System, Methods of Constructing Lyapunov Functions for Non-linear Systems.

Text Books:

1. K. Ogata, "Digital Control Engineering", 2nd edition,Prentice Hall, Englewood Cliffs, 2012.

2. I. J. Nagarath, M. Gopal, “Control Systems Engineering”, 8TH EDITION, New Age International Pvt Ltd, 2024.
3. H. K. Khallil, “Non Linear Systems”, 3rd edition (2001), Pearson Education

Reference Books:

1. G. F. Franklin, J. D. Powell and M. L. Workman, “Digital Control of Dynamic Systems”, AddisonWesley, 1998.
2. B. C. Kuo, “Digital Control System”, 2nd Edition, Oxford University Press, 2007.
3. B. Friedland, “Control System Design - An Introduction to State-Space Methods”, McGraw-Hill, 2007.
4. A NagoorKani, “Advanced Control Theory”, CBS; 3rd edition, 2020
5. S. H. Zak, “Systems and Control”, Oxford Univ. Press, 2003
6. M. Gopal, “Digital Control Engineering”, 2nd editionWiley Eastern, 2014.

CO-PO MAPPING

(1-Weak Correlation; 2-Medium correlation; 3-Strong Correlation)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	3	1	2	2	3	-	-	-	-	-	-	-	2	-
CO 2	3	1	2	2	1	-	-	-	-	-	-	-	3	-
CO 3	1	1	1	1	1	-	-	-	-	-	-	-	3	-
CO 4	3	1	3	3	1	-	-	-	-	-	-	-	2	1

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Energy Conservation and Auditing	EE3205	3-0-0	3

Prerequisites:

1. Basic Electrical Engineering

Course Outcomes

At the end of the course, students will be able to:

Course code	Course Outcome	Bloom's Level
CO1	Understand the importance of energy conservation from both financial and environmental perspectives.	Understand Level-2
CO2	Analyze the different energy efficient technologies in electrical system	Analyze Level-4
CO3	Evaluate a detailed energy audit and evaluation of energy-saving opportunities in electrical systems.	Evaluate Level-5
CO4	Apply the concepts of energy efficiency in electrical, lighting, and industrial Systems.	Apply Level-3

Module 1 **(10 Hours)**

Energy Scenario and Economics:

Energy Scenario -An overview of Indian Energy Scenario, Energy Conservation and its importance, Energy Conservation Act and related policies, Bureau of Energy Efficiency (BEE) Regulations, Star Rating, Carbon Credit, PAT Scheme.Classification of energy conservation measures, plantenergy performance, benchmarking, and energy performance.

Energy Economics -Cash flow diagram, discount rate, payback period, internal rate of return, net present value, and life cycle cost., understanding energy costs.

Module 2 **(10 Hours)**

Energy Conservation in Electrical Systems

Energy conservation opportunities inEnergy generation, energydistribution, energy usage by processes, Electricity billing, Efficient operations of transformers, Electric motors (motor efficiencycomputation, energy efficient motors), pumps, fans, blowers, cooling towers, power factor improvement, and harmonics.

Module 3 **(08 Hours)**

Electrical Energy Audit:

Energy audit concepts, Energy auditing: Need, types, methodology and approaches; Preliminary energy auditmethodology, Detail energy audit methodology, detailed energy audit activities, Evaluation of saving opportunities, Energy audit reporting and Energy audit instruments. Case study of energy audit in different industrial organisations / electrical utilities

Module 4 **(08 Hours)**

Energy Efficient Building: Understanding the Building Envelope, HAVC systems, Introduction to Smart Buildings, Introduction to Renewable Energy Use in building, Illumination, luminous flux, lumen, luminous intensity, candela power, brightness, glare, types of lighting (incandescent, CFL, and LED), Energy Efficient Lighting Systems, Cost Effectiveness of Efficient Lightning Technologies, Energy Saving Calculations.

TextBooks:

1. Kumar, O. Prakash, P. S. Chauhan, and S. Gautam, *Energy Management: Conservation and Audits*, 1st ed. Boca Raton, FL: CRC Press, 2020.
2. U. Desideri and F. Asdrubali, Eds., *Handbook of Energy Efficiency in Buildings: A Life Cycle Approach*, 1st ed. Oxford, UK: Butterworth-Heinemann, 2018.

Reference Books:

1. Callaghn, P. W." Design and Management for Energy Conservation", Pergamon Press, Oxford, 1981.
2. Dryden. I. G. C.," The Efficient Use of Energy", Butterworths, London, 1982.
3. I. G. C. Dryden, Ed., *The Efficient Use of Energy*, 2nd ed. London, U.K.: Butterworth Scientific, 1982
4. D. R. Patrick, S. W. Fardo, R. E. Richardson, B. W. Fardo, and M. Barron, *Energy Conservation Guidebook*, 4th ed. River Publishers, 2023.
5. A. V. Desai, Ed., *Energy Economics*. New Delhi, India: Wiley Eastern Ltd., 1990.
6. A. Thumann, W. J. Younger, and T. Niehus, *Handbook of Energy Audits*, 8th ed. Boca Raton, FL: CRC Press, 2009.
7. D. Y. Goswami and F. Kreith, Eds., *Handbook of Energy Efficiency and Renewable Energy*, 2nd ed. Boca Raton, FL: CRC Press, 2015.
8. Handbook on Energy Audit and Environment Management, Y P Abbi and Shashank Jain, TERI, 2006.
9. Howard E. Jordan, Energy-Efficient Electric Motors and TheirApplications, Plenum Pub Corp., 2nd edition, 1994.
10. CPRI Training Manual on Energy Conservation and Auditing/ Website of CPRI and BEE

CO-PO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	-	-	-	-	-	-	-	3	1
CO2	3	2	3	2	2	-	-	-	-	-	-	-	3	1
CO3	3	2	2	2	1	-	-	-	-	-	-	-	3	2
CO4	3	2	2	1	2	-	-	-	-	-	-	-	3	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Special Electrical Machines	EE3207	3-0-0	3

Prerequisites:

2. Electrical Machine-I
3. Electrical Machine-II

Course Outcomes

At the end of the course, students will be able to:

CO Code	Course Outcome	Bloom's Level
CO1	Explain the construction, working principle, and performance of Switched Reluctance Motors (SRM) and Synchronous Reluctance Motors (SynRM).	Understand
CO2	Analyze the EMF/torque equations, phasor diagrams, and control strategies of Permanent Magnet Synchronous Motors (PMSM) and Brushless DC Motors (BLDC).	Analyze
CO3	Illustrate the construction, excitation methods, and closed-loop control of Stepping Motors using microprocessors and drive circuits.	Apply
CO4	Describe the construction, principle of operation, and applications of Linear Induction Motors and Linear Synchronous Motors.	Understand

Module 1 **(10 Hours)**

SWITCHED RELUCTANCE MOTORS: Constructional features– Rotary and Linear SRMs-Principle of operation– Torque production– Steady state performance prediction- Analytical method- Power Converters and their controllers – Methods of Rotor position sensing – Sensorless operation – Closed loop control of SRM - Characteristics.

SYNCHRONOUS RELUCTANCE MOTORS: Constructional features– Types– Axial and Radial flux motors– Operating principles– Variable Reluctance and Hybrid Motors–Voltage and Torque Equations- Phasor diagram - Characteristics.

Module 2 **(10 Hours)**

PERMANENT MAGNET SYNCHRONOUS MOTORS: Principle of operation– Ideal PMSM – EMF and Torque equations– Armature reaction MMF– Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics- Power controllers-Converter Volt-ampere requirements. Magnetic Equivalent Circuit

PERMANENT MAGNET BRUSHLESS DC MOTORS: Permanent Magnet materials– Magnetic Characteristics – Permeance coefficient- Principle of operation– Types– Magnetic circuit analysis– EMF and torque equations – Commutation Power controllers– Motor characteristics and control.

Module 3 **(10 Hours)**

STEPPING MOTORS: Constructional features– Principle of operation– Variable reluctance motor –Hybrid motor– Single and multi stack configurations– Torque equations– Modes of excitations– Characteristics– Drive circuits– Microprocessor control of stepping motors– Closed loop control.

Module 4 **(06 Hours)**

Linear induction motor: Construction– principle of operation– applications. Linear synchronous motor: Construction – principle of operation– applications.

TextBooks:

1. T. J. E. Miller, Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford , 1989
2. E. G. Janardanan, Special Electrical Machines, PHI, New Delhi, 2014

Reference Books:

1. T. Kenjo, Stepping Motors and Their Microprocessor Controls, Clarendon Press, London , 1984
2. R. Krishnan, Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and application, CRC Press, New York , 2001
3. K. Venkataratnam, Special Electrical Machines, Universities Press (India) Pvt. Ltd. 2008

CO-PO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	1	-	-	3	2
CO2	3	3	3	2	2	-	-	-	-	1	-	-	3	3
CO3	2	2	2	1	2	-	-	-	-	1	-	-	2	2
CO4	2	1	2	1	1	-	-	-	-	1	-	-	2	1

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Business Management	BH-3401	3-0-0	3

Course Outcomes:

i. Comparing and contrasting efficient functional models of business management by integrating the three core areas such as Finance, Human Resource and Marketing Management.

ii. Executing the Management principles in all the functional areas of business.

iii. Correlating the interrelations and interdependence of the areas of Management in a business organisation.

iv. Assessing the functional and managerial practices in business organisations.

MODULE-1: Management Principles - 8 hours

Management Concepts, Nature and Functions, Management Process and Roles of Managers, Levels of Management and Managerial Skills, Theories of Management – Contributions of F.W.Taylor, Henry Fayol, Elton Mayo, Line and Staff Relationship, Centralisation and Decentralisation, Delegation of Authority , Management thoughts in Modern Trend –Systems Approach

MODULE-2: Financial Management – 8 hours

Concept, Financial function and Role of Financial Managers, Instruments of raising short-term and long-term funds, Capital Structure, Techniques of Project Appraisal, Components of Working Capital, Operating Cycle, Factors affecting requirement of Working Capital.

MODULE-3: Human Resource Management - 7 hours

Nature and Scope of Human Resource Management, Manpower Planning, Recruitment and Selection Methods, Performance Appraisal, Need, Objectives, Modern methods of Appraisals: 720 degree, MBO, Assessment Centre Method, Talent Acquisition, Training Need Analysis, Career Planning, Organisational Citizenship Behaviour.

MODULE- 4: Marketing Management - 7 hours

Concept, Nature, Scope and Importance, Marketing Mix and 7P's of Marketing, Segmentation, Targeting, Positioning, Factors influencing consumer decision-making, e-marketing and Green Marketing

Reference Books:

1- *Modern Business Organisation and Management*, S.A. Sherlekar, Himalaya Publishing House, 2016.
2- *Essentials of Management*, Stephen P. Robbins, 6th Edition, Pearson, 2010.
3- *Financial Management*, Sheeba Kapil, 1st Edition,Pearson, 2013.
4- *Human Resource Management Text and Cases*, K. Aswathappa, 10th Edition,TMH, 2023
5- *Marketing Management*, Rajan Saxena, 6th Edition, TMH publishing house, 2022.
6- *Principles of Management*, Dipak Kumar Bhattacharyya, 1st Edition, Pearson, 2011
7- *Mgmt (Principles of Management)*, Willium& Tripathy, 1st Edition, Cengage Learning, 2016

CO-PO Mapping

CO/PO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2	2	2		2	2	3	3	3	3	3
CO2						1	3	3	3	3	3	3
CO3					2	2	1	3	3	3	3	3
CO4						1	1	3	3	3	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Entrepreneurship Development	BH-3403	3-0-0	3

Course Outcomes:

1. Exemplifying the business opportunities, social responsibilities and the support system for setting up an enterprise.
2. Determining stages of Entrepreneurial Process starting from idea generation, developing a business plan and operational aspects of an Enterprise.
3. Appraising the different funding options and Financial Management of an enterprise.
4. Assessing the Start-up management practices like incubation, mentorship and Government initiatives.

MODULE-1: Introduction to Entrepreneurship - 8 hours

Concept, Functions of an Entrepreneur, Entrepreneurial Process, Entrepreneurial Motivation and Barriers, Traits to be a successful Entrepreneur, Creativity and scope of Entrepreneurship in India: Types of new age business (FinTech, EdTech, Healthcare, Agripreneurship, Defence, Drone, Space, IT, Robotics, Digital Transformation, Women-Entrepreneurship, Social Entrepreneurship, Corporate Social Responsibility, Business Ethics – Role of Values in Management.

MODULE-2: Entrepreneurial Idea into Action - 8 hours

Developing a Business Idea; Opportunity, Methods and Creativity, Deciding to set up a start-up, Forms of business organisations (Sole tradership/propreitorship, Partnership, Joint-Stock Company) and MSMEs (Micro, Small and Medium enterprises), Size and Location of the enterprise, Feasibility Study: Market Survey, Techno-economic feasibility and preparing a Project Report.

MODULE-3: Entrepreneurial Finance and Funding - 7 hours

Sources of funding(Bootstrapping, Angel Investors, Venture Capital, Crowdfunding etc.) Project Investment Analysis, Break-Even Analysis, ROI Analysis, Basics of Income Statement and Balance Sheet.

MODULE- 4: Managing an Enterprise – 7 hours

The Start-up ecosystem, Business Incubators, Start-up Accelerators, Mentorship and Networking, Failure and Resilience, Risk Management, Ethical dilemmas and Exit Strategies, Start-up Policy and Initiatives of the Government.

Reference Books:

1. *Entrepreneurship: Successfully Launching New Ventures*, B.R. Barringer, 6th, Pearson, 2020
2. *Fundamentals of Entrepreneurship and Project planning*, Madhurima Lall, 1st, Sultan Chand & Sons, 2021
3. *Entrepreneurial Development,*S.S. Khanka, 1st Edition, S Chand and Company, 1999
4. *Entrepreneurship Development and Small business enterprises,* P.M. Charantimath, 3rd Edition, Pearson, 2019
5. *Entrepreneurship: Theory, Process and Practice,* Donald F Kuratco, 11th, Cengage, 2023
6. *Entrepreneurship*, Robert. D. Hisrich & Sabyasachi Sinha, 11th Edition, TMH, 2020

CO-PO Mapping

CO/PO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					2	3	3	3	3	3	3	3
CO2		2	2	2	2	3	3	3	3	3	3	3
CO3					2	3	3	3	3	3	3	3
CO4					2	3	3	3	3	3	3	3

IP 3401 - ENVIRONMENTAL ENGINEERING

CREDIT	2		L-3	T-0	P-0

PREREQUISITES: Basic Physics, Basic Chemistry

COURSE OUTCOMES
At the end of the course a student will be able to

CO1	Understand the multidisciplinary nature of environmental science and ecosystem structure and functions
CO2	Analyze various forms of environmental pollution and assess their impact using scientific parameters
CO3	Demonstrate knowledge of water and wastewater treatment processes and air pollution control technologies
CO4	Evaluate the role of environmental policies, EIA, and sustainable practices in pollution control and resource conservation

CONTENT

Module 1 (10 hours)	**Fundamentals of Environment and Ecosystem:** Multidisciplinary nature of environmental Engineering. **Study of Ecosystem:** Definition, Properties, Structure and Function of an ecosystem. Food chains, food webs, Flow of Energy, Ecological Pyramids, Biogeochemical cycles, Types of ecosystems, Bioaccumulation, Bio magnification, ecosystem value, Degradation of Ecosystem. **Concept of Environment and pollution:** Atmospheric chemistry, soil chemistry, water quality characteristics, DO, BOD and COD, water pollution, Marine Pollution, soil pollution, thermal pollution, nuclear hazard, Air Pollution: Air Quality, cause and effects of air pollution, Water and air quality standards, and Index, Noisepollution: Introduction, Noise standards, measurement, Ln Concept and control
Module 2 (8 hours)	**Water treatment process**: Pre-treatment of water, conventional process, advanced water treatment process. **Waste water treatment process**: Natural Treatment, Engineering Treatment -Pre-treatment, primary and secondary waste water treatment process **Air Pollution Control**: The natural self-cleansing properties of Environment, Air pollution meteorology, Atmospheric dispersion, Diffusion equation, ground level emission, plume rise, Effective stack height, Air Pollution control from stationarysources by installing Engineering devices, Flue gas desulphurisation, NOX removal.
Module 3 (8 hours)	**Solid waste management:** Source, classification, separation, storage and transportation of solid wastes, Waste minimization techniques, Benefits of waste minimization, reuse, recycle, thermal and biological treatment, secure land fill technique. **Impact of Environmental pollution and related issues:** Global climate change, global warming and greenhouse gases, Acid rain, ozone layer depletion, healthissues.
Module4 (4 hours)	**Environmental Impact Assessment:** EIA procedure, Preparation of an EIS From unsustainable to sustainable development, circular economy, Environmental Protection Act, Air (Prevention and Control of Pollution) Act, Water (Preventionand Control of Pollution) Act, Wildlife Protection Act.

TEXTBOOKS

1.	Fundamentals of Ecology, M.C.Dash, Tata McGraw Hill, 2006.

2.	Environmental Pollution Control Engineering, C.S. Rao, New Age International Publishers, 2018
3.	Environmental Engineering, G. Kiely, TMH, 2007
REFERENCES	
1.	Environmental Engineering, H.S. Peavy, D.R. Rowe and G. Tchobanoglous, McGraw Hill.
2.	Introduction to Environmental Engineering and Science, G.M. Masters, Pearson, 2015
3.	Integrated Solid Waste Management, G. Tchobanoglous, McGraw Hill, 2014
4.	Water Supply Engineering, S.K. Garg; Khanna Publishers, 37th Edition

CO-PO-PSO MAPPING

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	1	1	2	3	1	1	2	1	2	2	2
CO2	3	3	2	2	2	2	3	1	1	2	1	2	2	2
CO3	3	3	3	2	2	2	3	1	2	2	2	3	3	3
CO4	2	2	2	2	1	3	3	2	2	2	2	3	3	3

Correlation Level 1: Slight 2: Moderate 3: High

<table>
<tr><th colspan="6">IP3403 - INDUSTRIAL SAFETY ENGINEERING</th></tr>
<tr><td>CREDIT</td><td>3</td><td></td><td>L-3</td><td>T-0</td><td>P-0</td></tr>
<tr><td colspan="6">PREREQUISITES: NA</td></tr>
<tr><td colspan="6">COURSE OUTCOMES
At the end of the course a student will be able to</td></tr>
<tr><td>CO1</td><td colspan="5">Apply safety principles in various work environments, especially in construction and machine operations.</td></tr>
<tr><td>CO2</td><td colspan="5">Identify safety hazards, implement safety measures,</td></tr>
<tr><td>CO3</td><td colspan="5">Analyse risks to prevent accidents and injuries.</td></tr>
<tr><td>CO4</td><td colspan="5">Understand of safety protocols, policies, and the responsibilities of individuals and organizations in ensuring a safe working environment.</td></tr>
<tr><td colspan="6">CONTENT</td></tr>
<tr><td>Module 1
(6 hours)</td><td colspan="5">Safety Introduction: Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization-objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.</td></tr>
<tr><td>Module 2
(7 hours)</td><td colspan="5">Personal Protection in work environment:Personal protection in the work environment, Types of PPEs, Personal protective equipment- respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.</td></tr>
<tr><td>Module 3
(7 hours)</td><td colspan="5">Safety issues in Construction: Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.</td></tr>
<tr><td>Module4
(12 hours)</td><td colspan="5">SafetyHazardsinMachines and Hazardidentificationandanalysis: Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices.Safetyinturning,andgrinding.WeldingandCutting-SafetyPrecautionsofGas welding and Arc Welding. Material Handling-Classification-safety consideration- manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance.
Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identificationofhazards:Inventoryanalysis,Fireandexplosionhazardratingofproc essplants
- The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operabilitystudy(HAZOP))–methodology,criticalityanalysis,correctiveactionandfollow-up. Control of</td></tr>
</table>

	Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).
TEXTBOOKS	
1.	R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
2.	Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.
3.	Krishnan, N.V. (1997).Safety management in Industry. Jaico Publishing House, New Delhi.
REFERENCES	
1.	John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All India Traveller Book Seller, Delhi.
2.	Ronald P. Blake. (1973). Industrial safety. Prentice Hall, New Delhi.
3.	Alan Waring. (1996). Safety management system. Chapman & Hall, England.
4.	Vaid, K.N., (1988). Construction safety management. National Institute of Construction Management and Research, Mumbai

CO-PO-PSO MAPPING

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	3	2	2	2		3					3	2
CO2	3	3	3	2				3	2				3	2
CO3	3	3	3	2				3					3	2
CO4	2	2	1	2		3		3	2	2			2	2

Correlation Level 1: Slight 2: Moderate 3: High

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power System Analysis and Operation	EE3102	3-0-0	3

PREREQUISITES:

1. Electrical CircuitAnalysis.
2. Electrical Power Transmission and Distribution.

COURSEOUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Analyze power flow in power systems using numerical methods such as Gauss-Seidel, Newton-Raphson, and Decoupled Load Flow Method.	Analyze (L4)
CO2	Evaluate power system economics including economic dispatch, unit commitment, and transmission loss coefficients.	Evaluate (L5)
CO3	Analyze and control frequency and voltage in power systems using concepts like droop control, automatic generation control, and excitation system control.	Analyze (L4), Apply (L3)
CO4	Analyze power system stability, including loss of synchronism and voltage collapse phenomena, using techniques like swing equations and the Equal Area Criterion.	Analyze (L4)

MODULE 1: (12 Hours)

Representation of Power System: Single line diagram, per unit quantities and its advantage, Power Flow Analysis: Review of the structure of a Power System and its components. Analysis of Power Flows: Formation of Bus Admittance Matrix. Real and reactive power balance equations at a node. Load and Generator Specifications. Application of numerical methods for solution of non-linear algebraic equations - Gauss Seidel, Newton-Raphson methods and Decoupled load flow method for the solution of the power flow equations.

MODULE 2: (6 Hours)

Power System Economics: Basic Pricing Principles: Generator Cost Curves, Utility Functions, Economic Operation with and without Transmission losses, Transmission loss coefficient, Economic Dispatch, Unit Commitment.

MODULE 3: (10 Hours)

Power System Control: MW-frequency control, models of single area & multi area MW frequency control, Reactive Power-Voltage control. Droop Control and Power Sharing. Automatic Generation Control. Reactive Power Management, Excitation System, Automatic Voltage Regulators.

Z bus building algorithm,Symmetrical components and Fault Analysis.

MODULE 4: (8 Hours)

Power System Stability: Swing Equations of a synchronous machine connected to an infinite bus. Power angle curve, equal area criterion and its application, critical clearing angle, fault clearing time, step-by-step solution of swing curve, factors influencing transient stability, methods of improving stability.

TEXT BOOKS:

1. J. Grainger and W. D. Stevenson," Power System Analysis", McGraw Hill Education.
2. J. Grainger, W. D. Stevenson and G. W. Chang," Power System Analysis", McGraw Hill Education.
3. O. I. Elgerd," Electric Energy Systems Theory", McGraw Hill Education.

REFERENCE BOOKS:

1. A. R. Bergen and V. Vittal," Power System Analysis", Pearson Education Inc.
2. D.P.Kothari and I.J.Nagrath,"Modern Power System Analysis",McGrawHillEducation.
3. B.M.Weedy, B.J.Cory, N.Jenkins, J.Ekanayake and G.Strbac,"Electric Power Systems", Wiley.
4. Prabha Kundur," Power System Stability and Control", McGraw Hill Inc., IndianEdition

CO-PO-PSOMAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	-	-	-	-	-	-	-	3	2
CO2	3	3	2	3	2	-	-	-	-	-	-	-	2	2
CO3	3	3	3	3	3	-	-	-	-	1	1	-	3	3
CO4	3	3	3	3	2	-	-	-	-	-	-	1	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power Systems Lab	EE3502	0-0-3	1.5

PREREQUISITES:

1. Electrical Machines Lab
2. Electrical Power Transmission and Distribution
3. Power System Analysis and Operation
4. MATLAB

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Analyze the operating characteristics and fault behavior of alternators, including the determination of fault currents and reactance parameters.	Analyze (L4)
CO2	Investigate the performance of protective relays, such as over-current relays, biased differential relays, distance relays, and over/under voltage relays and plot their characteristics.	Investigate (L5)
CO3	Conduct steady-state and fault analysis of power systems, including short-circuit, load flow, and fault location analysis.	Apply (L3)
CO4	Design and simulate power system components, such as transmission lines and power system fault analysis, power flow analysis, using MATLAB.	Design (L6)

List of Experiments

Any 10 to be performed

1. To determine sub-transient direct axis and sub-transient quadrature axis synchronous reactance of a 3-ph salient pole alternator.
2. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation.
3. To study the Electromechanical type IDMT over-current relay and with different plug setting and time setting multipliers and plot its time - current characteristics.
4. To study the microcontroller type IDMT over-current relay and with different plug setting and time setting multipliers and plot its time - current characteristics.
5. To determine the operating characteristics of biased different relay with different bias settings.
6. To determine A, B, C, D parameters of an artificial transmission line.
7. To study the directional over current relay and determine the operating time.
8. To study the reverse power relay and its operating characteristics.
9. To determine location of fault in a cable using cable fault locator.
10. To study the Ferranti Effect and voltage distribution in HV long transmission line using transmission line model.
11. To study the Overvoltage and Under voltage relay and operating characteristics.

Experiments beyond syllabus:

1. To formulate the Y-Bus matrix and perform load flow analysis.

2. To compute voltage, current, power factor, regulation and efficiency at the receiving end of a three phase Transmission line when the voltage and power at the sending end are given. Use Π model.
3. To perform symmetrical fault analysis in a power system.
4. Write a program to solve economic dispatch problem of a power system with only thermal units. Take production cost function as quadratic and neglect transmission loss.
5. Write a program to solve the Load Flow problem of a given network using Gauss-Seidel Method.
6. Write a program to solve the Load Flow problem of a given network using Newton-Raphson Method.
7. Write a program to solve the Load Flow problem of a given network using Decoupled Load Flow Method.

TEXT BOOKS:

4. J. Grainger and W. D. Stevenson," Power System Analysis", McGraw Hill Education.
5. J. Grainger, W. D. Stevenson and G. W. Chang," Power System Analysis", McGraw Hill Education.
6. O. I. Elgerd," Electric Energy Systems Theory", McGraw Hill Education.

REFERENCE BOOKS:

5. A. R. Bergen and V. Vittal," Power System Analysis", Pearson Education Inc.
6. D.P.KothariandI.J.Nagrath,"ModernPowerSystemAnalysis",McGrawHillEducation.
7. B.M.Weedy,B.J.Cory,N.Jenkins,J.EkanayakeandG.Strbac,"ElectricPowerSystems",Wiley.
8. PrabhaKundur," Power System Stability and Control", McGraw Hill Inc., IndianEdition

CO-PO-PSO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	3	3	2	3	2	-	-	-	2	1	-	3	3	3
CO 2	3	3	3	2	3	-	-	-	2	1	2	3	3	2
CO 3	3	3	2	3	3	-	-	-	2	1	-	3	3	2
CO 4	3	3	3	2	3	-	-	-	2	1	2	3	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Digital Signal Processing	EE3104	3-0-0	3

Prerequisites:

1. Mathematics.
2. Signals and Systems.

Course Outcomes

At the end of this course, students will demonstrate the ability to:

CO Code	Course Outcome	Bloom's Level
CO1	Describe discrete-time signals and systems, explain sampling and reconstruction, and apply z-transform for LSI system analysis.	Understand (L2)
CO2	Apply Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT) algorithms to analyze signals in the frequency domain and implement discrete-time systems.	Apply (L3)
CO3	Analyze specifications and design digital filters (FIR and IIR) using various techniques to meet desired frequency characteristics.	Analyze (L4)
CO4	Evaluate the impact of finite word length effects, spectral estimation techniques, and multi-rate processing in practical DSP systems.	Evaluate (L5)

Module 1: (10 Hours)

Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals - aliasing; Sampling theorem, Hold circuit and Nyquist rate. z-Transform, Region of Convergence, Analysis of Linear Shift In- variant systems using z-transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z transforms.

Module 2: (10Hours)

DiscreteFourierTransform:FrequencyDomainAnalysis,DiscreteFourierTransform(DFT),Properties of DFT, Convolution of signals, Fast Fourier Transform Algorithm, Parseval's Identity, Implementation of Discrete Time Systems.

Module 3: (10 Hours)

Design of Digital filters: Design of FIR Digital filters: Window method, Park Mc Clellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Low-pass, Band-pass, Band- stop and High pass filters.

Module 4: (06Hours)

Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multi-rate signal processing.

Text Books:

1. Salivahanan, S. 2019. *Digital Signal Processing*. 4th ed. New Delhi: McGraw Hill Education.
2. J. G. Proakis and D. G. Manolakis," Digital Signal Processing: Principles, Algorithms and Applications", 5th ed.: Prentice Hall,2021.

Reference Books:

1. V. Oppenheim and R. W. Schafer," Discrete Time Signal Processing", 3rd ed.: Prentice Hall, 2009.

2. S. K. Mitra," Digital Signal Processing: A computer-based approach", 4th ed. New Delhi: McGraw Hill, 2011.

CO-PO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	2	-	-	-	-	-	-	-	3	2
CO2	3	3	-	-	3	-	-	-	-	-	-	-	3	2
CO3	3	2	3	-	2	-	-	-	-	-	-	-	3	3
CO4	3	2	-	3	3	-	-	-	-	-	-	-	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Digital Signal Processing Lab	EE3504	0-0-3	1.5

Prerequisites:
1. MATLAB
2. Signals and Systems Lab

Course Outcomes

Upon successful completion of the laboratory, the students will be able to

CO Code	Course Outcome	Bloom's Level
CO1	Demonstrate the generation and implementation of basic discrete-time signals and systems, including sine and square waves, and system behavior in the time domain.	Understand (L2)
CO2	Apply convolution techniques (linear and circular) and analyze the frequency response of systems using DFT/IDFT and FFT algorithms.	Apply (L3)
CO3	Analyze and interpret the characteristics and properties of the Discrete Fourier Transform and evaluate spectral behavior of digital systems.	Analyze (L4)
CO4	Design and implement digital filters (FIR and IIR) using appropriate techniques such as windowing and Butterworth/Chebyshev approximations to meet frequency specifications.	Evaluate (L5)

List of Experiments

(Any 10 experiments to be performed)

1. Generation of Sine wave & Square wave.
2. Implementation of discrete time systems in time domain.
3. Linear convolution & Circular convolution of two sequences.
4. Frequency response of a system described by a difference equation.
5. DFT & IDFT of the given sequences.
6. Properties of DFT.
7. Fast Fourier Transform.
8. Design of FIR Low Pass filters using window technique.
9. Design of FIR High Pass filter using window technique.
10. Design of IIR Low Pass filter using Butter worth and Chebyshev approximations.
11. Design of IIR High Pass filter using Butter worth and Chebyshev approximations.
12. Design of Optimal/ Equi ripple IIR High/ Low Pass filter.

Text Books:

1. Salivahanan, S. 2019. *Digital Signal Processing*. 4th ed. New Delhi: McGraw Hill Education.
2. J. G. Proakis and D. G. Manolakis," Digital Signal Processing: Principles, Algorithms and Applications",5th ed. : Prentice Hall,2021.

Reference Books:

1. V. Oppenheim and R. W. Schafer," Discrete Time Signal Processing", 3rd ed.: Prentice Hall, 2009.
2. S. K. Mitra, "Digital Signal Processing: A computer-based approach", 4th ed. New Delhi: McGraw Hill, 2011.

CO-PO MAPPING

(1-Weak Correlation; 2-Medium correlation; 3-Strong Correlation)

PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	2	-	-	-	-	-	-	-	3	2
CO2	3	2	-	-	3	-	-	-	-	-	-	-	3	2
CO3	3	3	-	2	3	-	-	-	-	-	-	-	3	2
CO4	3	2	3	-	3	-	-	-	-	-	-	-	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Renewable Energy Systems	EE3202	3-0-0	3

Prerequisites:

1. Power Electronics.

Course Outcomes

At the end of this course, the students will able to,

Course code	Course Outcome	Bloom's Level
CO1	Analyze the energy scenario and the consequent growth of the power generation from renewable energy sources.	Analyze Level-4
CO2	Explain the basic physics of wind and solar power generation**.**	Understand Level-2
CO3	Synthesize the power electronic interfaces for wind and solar generation.	Analyze Level-4
CO4	Resolve the issues related to the grid-integration of solar and wind energy systems**.**	Evaluate Level-5

Module 1: (08 Hours)

Wind Energy: Wind power statistics of India and world, Wind Turbine Types (HAWT and VAWT) and their construction, Wind power curve-Betz's Law-Power from a wind turbine (Numerical Problems).

Wind energy conversion system (WECS): Fixed–speed drive scheme-Variable speed drive scheme, Challenges in Grid integration of WECS. Wind physics, Betz limit, tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions.

Review of modern Wind Generator topology: fixed and variable speed Wind turbines, induction generators, doubly fed induction generators and their characteristics, permanent-magnet synchronous generators.

Module 2: (10 Hours)

Solar Photovoltaic Power Generation: Solar photovoltaic: Technologies-Amorphous, mono-crystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, power electronic converters for solar systems, maximum power point tracking (MPPT) algorithms, control of converters.Inverter Specifications for Solar Applications (From MNRE, SECI, and other sources), Rooftop Solar PV, Net Metering,Grid integration issues in Solar PV

Solar thermal systems: Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems), Pyranometer and Pyrheliometer, Solar Thermal Collectors, Solar concentrators (Parabolic trough, Parabolic dish, Central Tower Collector).

Module 3: (06 Hours)

Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection.ENERGY FROM OCEAN: Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP), Classification of Tidal Power Plants, Advantages and Limitations of TPP. Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system.

Module 4: (06 Hours)

Biomass Power: Principles of biomass conversion, Combustion and fermentation, Anaerobic digestion, Types of biogas digester, Wood gasifier, Pyrolysis, Bio gas, Wood stoves, Bio diesel, Combustion engine. Brief idea on Fuel cells and Battery Storage Technology. Applications.

Text Books:

1. T. Ackermann," Wind Power in Power Systems", John Wiley and Sons Ltd.,2005.
2. G. M. Masters," Renewable and Efficient Electric Power Systems", John Wiley and Sons,2004.
3. H. Siegfried and R. Waddington," Grid integration of wind energy con- version systems", John Wiley and Sons Ltd.,2006.
4. C. S. Solanki," Solar Photovoltaics Fundamentals, Technologies and Applications", PHI Learning Private limited, third edition April2015.

Reference Books:

1. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
2. D.P.Kothari, K.C.Singal, RakeshRanjan, Renewable Energy Sources and Emerging Technologies, Prentice Hall of India, New Delhi, 2009.
3. A. K. Tripathy. Multiple Choice Questions on Renewable Energy. ISBN: 9788179931288
4. Seema Behera, Bishnupriya Dash, Renewable Energy System, Engineer's Mind Publications, 2012 (first edition).
5. S. N. Bhadra, D. Kastha, S. Banerjee - Wind Electrical Systems-Oxford University Press (2013).

CO-PO-PSO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

CO s	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	3	3	0	0	0	0	0	3	3
CO2	3	3	2	3	2	3	3	0	0	0	0	0	3	3
CO3	3	3	3	3	2	3	3	0	0	0	0	0	3	3
CO4	3	3	2	2	2	3	3	0	0	0	0	0	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power Station Engineering	EE3204	3-0-0	3

Course Outcomes:
At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Identify various conventional and non-conventional energy sources and explain their applications in the Indian power generation scenario.	Remember, Understand
CO2	Analyze load characteristics and apply economic factors to determine cost-effective generation and tariff structures.	Analyze, Apply
CO3	Explain the construction, operation, and control of nuclear, hydroelectric, and thermal power stations.	Understand, Apply
CO4	Evaluate environmental impacts of different power plants and summarize pollution control techniques and renewable energy technologies.	Evaluate, Understand

MODULE 1 **(8 Hours)**

Introduction: Introduction to different sources of energy and general discussion on their application to generation, Indian Energy Scenario, Recent trends in Power Generation

Prediction of Load: Connected Load, Maximum Load, Demand Factor, Average load, Load Factor, Load duration curves,Diversity Factor, Choice of Type of Generation, Capacity Factor, Reserve Factor, Plant Use Factor, Base Load, Intermediate Load and Peak Load Plants.

Economics of power generation: Cost of Electrical Energy, Construction costs, Fixed cost, Costs for Energy, Depreciation of Plant, Fuel cost, Economic scheduling principle, Annual Operating Costs, Effect of Load Factor on cost per kWh, Tariff or Charge to Consumer

MODULE 2 **(10 Hours)**

Nuclear power station: Introduction to fission & fusion, Principle of Nuclear Energy, Reactor Construction, Controlled Chain Reaction, Brief study of various Types of Power Reactor – Pressurized water reactor, boiling water reactor, Fast breeder reactor, Operational Control of Reactors, Location and layout of nuclear power plant,Economics of Nuclear Power Station, Radiation Hazards and Shielding, Radioactive waste disposal

Hydro Electric power station:

Schematic Diagram of Hydro Power Plant and functional details of components: Estimation of amount stored by a dam across the river,Selection of site for hydro-electric power plant, Arrangement of Hydroelectric Station:Catchment area, Reservoir, Dam, Head Gate, Spillways, Pen stock, Surge Tanks, Scroll case, Draft tubes and Tail Race, Power House, Classification of Hydroelectric Power Plants. Governors, Operational principle of Kaplan and Francis Turbine and Pelton wheel, Speed and Pressure Regulation, Work done and Efficiency

MODULE 3 **(8 Hours)**

Thermal power station:

Selection of site for thermal power plant. Main Parts and Working of a Steam Station:Overall Block Diagram indicating the air circuit, coal and ash circuit, water and steam circuit, various types of steam turbines, ash and coal handling system, High Pressure and High-capacity water tube boilers, Economizer, Superheaters, De-Superheater, Re-heater, Air Pre-heater**.** Draft System: Natural, Induced Forced and Balance Draft,Condensers, Feed water heaters, Evaporators, Make-up water, bleeding of steam, cooling water system. Electrostatic Precipitator. Basic working Principle and constructional details of Governors.

MODULE 4 **(5 Hours)**

Effluents from power plants and impact on environment: Pollutants and pollution standards, methods of pollution control, safety regulation

Renewable Energy Power Plants: Basics of Solar thermal energy, wind energy, geothermal energyand ocean energy.

Various Power Storage Devices: Battery Storage, Pumped Storage Plant, Hydrogen Storage

TEXT BOOKS:

1. P. K. Nag, "Power Plant Engineering", 3rd Edition, Tata McGraw Hill Publication.
2. M. V. Deshpande, "Elements of Electrical Power Station Design", PHI .

REFERENCES:

1. Arora &Domkundwar, "A Course in Power Plant Engineering", Dhanpat Rai and sons.
2. R. K. Rajput, "A Text Book of Power Plant Engineering", 3rd Edition, Laxmi Publishing.
3. Bernhardt G. A. Skrotzki, William A. Vopat, "Power Station Engineering and Economy", 2nd Edition, Tata McGraw Hill Publication.

CO-PO-PSO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

CO\PO/PSO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO1	1	1	–	–	–	1	2	–	–	–	–	1	2	–
CO2	3	3	2	3	–	–	–	–	–	–	1	2	3	–
CO3	1	1	2	–	–	–	1	–	–	–	–	-	3	2
CO4	1	-	3	–	–	2	3	1	–	–	1	2	2	1

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Electric Vehicle	EE3206	3-0-0	3

COURSE OUTCOMES:
After successfully completing this course a student will able to:

CO	Course Outcome Statement	Bloom's Taxonomy Level
CO1	Describe the architecture, classifications, and components of electric vehicles, and explain their operation.	Understand (Level 2)
CO2	Analyze power flow, vehicle dynamics, and control strategies for electric propulsion systems using fundamental engineering principles.	Analyze (Level 4)
CO3	Apply the principles of power electronics and electric drives to evaluate the performance of EV propulsion systems and regenerative braking techniques.	Apply (Level 3)
CO4	Evaluate energy storage technologies, grid integration techniques for EVs, including V2G and smart charging concepts.	Evaluate (Level 5)

Module-I **(08 Hours)**
Introduction to Hybrid Electric Vehicles(EVs):
Overview of Electric Vehicles: Past, Present & Future of EV, Current market trends and major challenges, Comparison of EVs with Internal Combustion Engine (ICE) vehicles
Fundamentals of EVs & Hybridization: Classification of BEV, HEV, PHEV, FCEV. Series, Parallel & Series-Parallel Hybrid Systems. Power flow control & fuel efficiency analysis. In-wheel drives and multiple motor configurations.
Vehicle Dynamics Fundamentals: Vehicle kinematics and resistances (rolling, aerodynamic, grading). Dynamic equations for EVs. Maximum tractive effort and powertrain considerations.

Module-II **(09 Hours)**
Power Electronics & Electric Drives in EVs:
Power Electronics in EVs: DC/DC converters for EV applications, non-isolated bidirectional DC-DC converter. Voltage source inverters and PWM techniques. Regenerative braking systems. Onboard & offboard EV battery chargers
Electric Machines and Drives: Overview of Induction Motor (IM), Permanent Magnet Synchronous Motor (PMSM), Brushless DC Motor (BLDC), Switched Reluctance Motor (SRM) for EV application.
Fundamental of Motor control strategies.

Module-III **(06 Hours)**
EV Charging & Grid Integration:
EV Charging Infrastructure & Technologies: Types of EV charging (Slow, Fast, DC Fast Charging), Charging station components & requirements, Wireless charging & ultra-fast charging trends.
Grid Integration & Vehicle-to-Grid (V2G) Technology: Grid-to-Vehicle (G2V) & Vehicle-to-Grid (V2G) concepts, Impact of EVs on the power grid, smart charging & energy management.

Module-IV **(07 Hours)**
Energy Storage Systems & Battery Management
Battery Technologies for EVs: Battery chemistry, characteristics & performance analysisof Lead-acid, NiMH, Li-ion. Supercapacitors & Basics of Hydrogen Fuel Cells.

Battery Management System (BMS): Functions & need for BMS in EVs. State-of-charge (SoC) and state-of-health (SoH) estimation. Thermal management & safety concerns.

Future Trends & Developments in EVs: Solid-state batteries & alternative energy sources, Autonomous & connected EV technologies**,** Sustainable mobility & policy trends.

Text Book:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2021
2. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2012.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2005.
3. hrisMi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011
4. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001

Course Articulation Matrix:

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	2	2	-	-	-	-	2	2	1
CO2	3	3	3	3	2	1	2	-	-	-	-	2	3	2
CO3	3	3	3	2	3	0	1	-	-	-	-	2	3	3
CO4	3	3	3	3	2	2	3	-	-	-	-	2	3	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Electrical Machine Design	EE3208	3-0-0	3

Prerequisites:

1. Electrical Machines – I,
2. Electrical Machines – II

Course Outcomes:

Upon successful completion of the course, the student will be able to

CO	Course Outcome Statement	Bloom's Level
CO1	Understand the fundamental concepts of electrical machine design, including magnetic and thermal considerations.	Understand (Level 2)
CO2	Analyze and design the core and windings of single-phase and three-phase transformers using standard design equations.	Analyze (Level 4)
CO3	Design the main components of AC machines such as induction and synchronous machines considering performance parameters.	Apply (Level 3)
CO4	Design DC machines and explore the use of Computer-Aided Design (CAD) tools in electrical machine design.	Apply & Evaluate (Level 3/5)

Module-I: Fundamentals of Electrical Machine Design (8 Hours)

Introduction to Machine Design: Importance of electrical machine design, Design process and considerations, Factors affecting machine performance. limitation in design

Basic Concepts of Magnetic Circuits and Materials: Magnetic circuits and their analysis, Core materials and their properties, Calculation of magnetic flux and mmf

Thermal Considerations & Cooling of Machines: Heat dissipation and cooling methods, Rating and insulation classification, Calculation of temperature rise

Module-II: Design of DC Machines (8 Hours)

Output equation –selection of specific magnetic and electric loadings - separation of D and L – estimation of number of conductors, armature slots and conduct dimensions – choice of number of poles and calculation of length of airgap – design of field systems, interpoles and brushes.

Module-III: Design of AC Machines (Induction & Synchronous) (10 Hours)

Induction Motor Design: output equation -main dimensions – choice of average flux density and ampere conduction for meter — design of stator slots and rotor slots- design of rotor bars end rings– design of wound rotor – design of no-load current.

Synchronous Machine Design: Types of construction – output equation - main dimensions – short circuit ratio and its effects on the performance – design of rotor –Design of field winding – Design of turbo alternators – Rotor design temperature rise and its effects.

Module-IV: Design of Transformers (10 Hours)

Transformer Design: Transformer windings – output equation – design of main dimensions-— design of core - choice of flux density – determination of number of turns and length of mean term - resistance and leakage reactance – no load current calculation –cooling of transformers-calculation of number of tubes.

Computer-Aided Design (CAD) for Electrical Machines: Role of CAD in electrical machine design, Introduction to software tools for machine design

Text Book

1. A course in Electrical Machine design A.K.Sawhney DhanpatRai 6th Edition, 2013

Reference Books

1. AE Clayton and NN Hancock, “The Performance and Design of Direct Current Machines”, CBS Publishers, 3rd edition, 2004.
2. M.G. Say, “Performance and Design of A.C. Machines”, ELBS and Pitman & Sons, 4th edition, 2013.
3. S. K. Sen, “Principles of Electrical Machine Design with computer programmes”, Oxford and IBH Company Pvt. Ltd. New Delhi, 2nd edition,2006.
4. K. M. Vishnu Murthy, “Computer Aided Design of Electrical Machines”, B.S. Publications, 1st edition 2008.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2
CO1	3	2	1	1	1	-	-	-	-	-	-	1	3	1
CO2	3	3	2	2	2	-	-	-	-	-	-	2	3	2
CO3	3	2	3	1	2	-	-	-	-	-	-	2	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3	3	3

CS4101: Advanced AI (L-T-P:Credits)(3-0-0:3)

Prerequisites	Artificial Intelligence

Course Outcomes:

CO1 Understand and differentiate between various probabilistic graphical models including Bayesian Networks, Markov Networks, and their structural

CO2 Apply exact and approximate inference techniques such as variable elimination, belief propagation, and sampling methods for reasoning under uncertainty.

CO3 Develop and evaluate learning algorithms for graphical models, including parameter estimation, structure learning, and handling partially observed data.

CO4 Analyze advanced concepts in graphical models such as EM algorithm, hidden variables, causal inference, and decision-theoretic reasoning using utility and value of information.

Detailed Syllabus

Module-I (7 Hours)

Overview of Probability Theory, Bayes Networks, Independence, I-Maps, Undirected Graphical Models, Bayes Networks and Markov Networks, Local Models, Template Based Representations,

Module-II (8 Hours)

Exact Inference: Variable Elimination;Clique Trees, Belief Propagation, Tree Construction, Intro to Optimization, Approximate Inference: Sampling, Markov Chains, MAP Inference, Inference in Temporal Models

Module-III (8 Hours)

Learning Graphical Models : Introduction, Parameter Estimation, Bayesian Networks and Shared Parameters, Structure Learning, Structure Search, Partially Observed Data, Gradient Descent

Module-IV (7 Hours)

EM, Hidden Variables, Undirected Models, Undirected Structure Learning, Causality, Utility Functions, Decision Problems, Expected Utility, Value of Information

Text Books:

1. "Probabilistic Graphical Models: Principles and Techniques", Daphne Koller and Nir Friedman,MIT Press
2. "Pattern Recognition and Machine Learning", Christopher M. Bishop,Springer

References Books:

1. "Bayesian Reasoning and Machine Learning", David Barber, Cambridge University Press
2. "Machine Learning: A Probabilistic Perspective" Kevin P. Murphy, MIT Press

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1								
CO2	3	3	1	1								
CO3	3	3	3	2		2						
CO4	3	3	3	2		2						

(1:Low, 2:Medium, 3:High)

Abbreviation used:

AC	Audit course	LC	Laboratory Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks), (ii) Quiz/ Assignment/Attendance (20 marks)					

FOURTH YEAR (*SEVENTH SEMESTER*)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PE	EE4201 EE4203 EE4205 EE4207	5. Smart Grid Technology 6. Power Quality 7. High Voltage Engineering 8. Restructured Power System	3	0	0	3	40	60	-	100
2	PE	EE4211 EE4213 EE4215 EE4217	5. Utilization of Electrical Energy 6. Distribution System Engineering 7. Power System Dynamics and Control 8. Electrical Engineering Materials	3	0	0	3	40	60	-	100
3	OE		Open Elective – I	3	0	0	3	40	60	-	100
4	ACC	CS4101	Advanced AI	3	0	0	2	40	60	-	100
5	SE	EE4701	Seminar on SIRE - II	0	0	6	1	-		100	100
6	PR	EE4601/ EE4603	Project for Product Development – II / Internship Project - I	0	0	4	2	-		100	100
			Total	**12**	**0**	**10**	**14**	**160**	**240**	**200**	**600**

FOURTH YEAR (*EIGHTH SEMESTER*)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	OE		Open Elective – II	3	0	0	3	40	60	-	100
2	OE		Open Elective – III	3	0	0	3	40	60	-	100
3	OE		Open Elective – IV	3	0	0	3	40	60	-	100
4	SE	EE4702	Seminar on Project	0	0	6	3	-		100	100
5	PR	EE4602/ EE4604	Project for Product Development – III / Internship Project - II	0	0	8	4	-		100	100
			Total	**9**	**0**	**14**	**16**	**120**	**180**	**200**	**500**

***Project / Seminar / Internship**

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power System Protection	EE3212	3-0-0	3

Prerequisites:

1. Electrical Power Transmission and Distribution
2. Power System Analysis and Operation

Course Outcomes

At the end of this course, students will demonstrate the ability to:

Course code	Course Outcome	Bloom's Level
CO1	Analyze the principles and components of power system protection and evaluate the effectiveness of protection schemes.	Analyze (L4)
CO2	Design fault protection schemes and coordinate overcurrent relay settings for power systems.	Design (L6)
CO3	Design and implement protection schemes for electrical equipment such as transformers, generators, and busbars.	Design (L6)
CO4	Apply system protection schemes, digital protection tools, and switchgear technologies to ensure system reliability.	Apply (L3)

Module 1: (10 Hours)

Introduction and Components of a Protection System: Faults in Power System, Element and Features of Protection Schemes, Instrument Transformers, Capacitor Voltage Transformer, Sequence Component, Fault Analysis Review, Symmetrical and unsymmetrical faults.

Module 2: (06 Hours)

Switchgears: Auto reclosing, Theory of Circuit interruption, Circuit constants in relation to Circuit breaking, Re-striking voltage transient, characteristics of Re-striking Voltage, Current chopping, capacitance current breaking, resistance switching.

Circuit Breakers: Types of circuit breakers (air blast, air break, oil, vacuum, SF6, DC circuit breaker), advantages, and testing of the circuit breaker.

Module 3: (10 Hours)

Equipment Protection Schemes: Over Current, directional, distance protection, Differential protection. Transformer,Impact of Power System on Distance Relay, blocking and out of step ,Generator protection, and transmission line protection.Bus Bar arrangement schemes, Bus bar Protection.

System Protection: Effect of Power Swings on Distance Relaying. System Protection Schemes. Under-frequency, Under voltage, and df/dt relays

Module 4: (10 Hours)

Numerical Relaying Concept, Sampling, aliasing issues, Discrete Fourier Transform, Recursive and Half Cycle DFT and Cosine Filter, Least Square Technique, Frequency Response of Phasor Estimation techniques, in the Presence of Decaying DC.

Text books:

1. Electrical Power System by CL Wadhwa, New Age International; 2022, 8th edition..
2. *Power System Protection Static Relays (Second Edition), McGraw Hill, Author: T S Madhava Rao*

Reference Books:

1. Computer Relaying for Power Systems, Second Edition, Arun G. Phadke, James S. Thorp, John Wiley and Sons, Ltd.,Publication
2. *Power System Protection, P. M. Anderson, Power Math Associates, Inc., IEEE Press Power Engineering Series, P M. Anderson, SeriesEditor.*
3. Power System Relaying, Third Edition, Stanley H. Horowitz, Arun G. Phadke, John Wiley & Sons, ltd.

CO-PO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO 2	3	3	3	3	3	-	-	-	2	-	2	-	3	3
CO 3	3	3	3	3	3	-	-	-	-	-	2	-	3	3
CO 4	3	3	3	3	3	3	-	-	-	-	2	3	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Electric Drives and Control	EE3214	3-0-0	3

Prerequisites:

1. Power Electronics.
2. Control Systems.
3. Electrical Machines.

Course Outcome:
At the end of the course the student will be able to:

COs	Course Outcome statement	Bloom's Level
CO1	Understand and analyze drive characteristics, stability and selection of motor type and rating for different application	Understand/Analyze Level-2/4
CO2	Analyze and design the converter fed dc drive performance involving speed control and braking	Analyze Level-4
CO3	Understand the formulation of transfer function of DC motors with closed loop operation	Understand Level-2
CO4	Analyze and apply various drive control techniques for induction motor Synchronous motor, BLDC motor and SR Motor drive	Analyze/Apply Level-4/3

Module 1 (10 Hours)

Introduction: Concepts and classification of Electric drives, Advantages of Electric drives, Selection of motors. Dynamics of Electric drives: Types of loads, Components of Load Torques, Multi quadrant operations, Motor dynamics , Equivalent Values of Drive Parameters, Steady state stability and transient stability. Rating and Heating of motors: Thermal Model of Motor for Heating and Cooling, Heating and cooling curves, Classes of motor duty, Determination of motor rating, Load equalization

Module 2 (10 Hours)

DC motor drives: Basic characteristics, Single phase and three phase controlled rectifier fed DC drives, Dual converters drives, Chopper drives, Rheostatic and regenerative braking, Effects of changes in supply voltage and load torque

Closed-loop control of DC Drive: Control structure of DC drive, Inner current loop and outer speed loop, Dynamic model of separately excited DC motor and transfer functions, Modeling of chopper as gain with switching delay, Plant transfer function

Module 3 (10 Hours)

AC motor drives: Induction motor drives, Stator voltage control, Rotor voltage control – Slip power recovery, Concepts of Static Kramer drives and Static Scherbius drive, V/f control, Current control method, closed loop control

Synchronous motor drives: Speed torque characteristics and torque angle characteristics. Fixed and variable frequency operation modes, Self-control modes.

Module 4 (6 Hours)

Brushless DC motor drive characteristics and control, Traction motor control.

Text Books:

1. G. K. Dubey," Fundamentals of Electrical Drives", CRC Press,2002.
2. R. Krishnan," Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall2001.
3. W. Leonhard," Control of Electric Drives", Springer Science & Business Media, 2001.

Reference Books:

1. Fundamental of Electric Drives by S. K Pilai
2. "Electrical Drives: Concept and applications" by Vedam Subrahmanyam

CO-POMAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	-	-	-	-	-	1	1	2	2
CO2	3	2	2	3	1	-	-	-	-	-	2	2	2	2
CO3	3	3	3	3	2	-	-	-	-	-	2	2	3	3
CO4	3	3	3	3	2	-	-	-	-	-	2	2	3	3

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
FACTS and HVDC	EE3216	3-0-0	3

Prerequisites:
1. Power System Analysis and Operation.
2. Power Electronics.

COURSE OUTCOMES:
At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Understand the basic concepts, advantages, and components of FACTS and HVDC systems in modern power transmission networks.	Understand (L2)
CO2	Analyze the operation and characteristics of various FACTS devices (e.g., SVC, STATCOM, TCSC, UPFC) for voltage regulation, power flow control, and stability improvement.	Analyze (L4)
CO3	Examine different types of HVDC transmission systems and their control strategies, including rectifier and inverter operation.	Analyze (L4)
CO4	Evaluate the impact of FACTS and HVDC systems on power system performance through system modeling and simulation techniques.	Evaluate (L5)

Module 1: (10 Hours)

HVDC Transmission: HVDC Transmission system: Introduction, comparison of AC and DC systems, applications of DC transmission, types of DC links, Layout of HVDC Converter station and various equipment. HVDC Converters, analysis.

Module 2: (10 Hours)

FACTs Concepts: Reactive power control in electrical power transmission, principles of conventional reactive power compensators, flow of power in AC parallel paths, meshed systems, Controllable parameters for Active & Reactive Power Control, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTs controllers.

Module 3: (8 Hours)

Static Shunt Compensators: Shunt compensation - objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators - SVC, STATCOM, SVC and STATCOM comparison.

Module 4: (8 Hours)

Static Series Compensators: Series compensation - objectives of series compensation, Thyristor switched series capacitors (TCSC), static series synchronous compensator (SSSC), power angle characteristics, and basic operating control schemes.

Text Books:

1. S. Kamakshaiah& V. Kamaraju," HVDC Transmission", TMH Education Private Ltd., 2011, New Delhi.
2. Narain G. Hingorani and L. Gyugyi, 'Understanding FACTS', IEEE Press.

Reference Books:

1. K. R. Padiyar, HVDC Power Transmissions Systems: Technology & Systems Interaction, New Age Publication, 2005
2. J. Arrillaga, Peter Pregrinu, High Voltage Direct Current Transmission.

3. Edward Wilson Kimbark,” Direct Current Transmission”, Vol. I, Wiley interscience, New York, London, Sydney, 1971.
4. Colin Adamson and Hingorani N. G.,” High Voltage Direct Current Power Transmission”, Garraway Limited, London, 1960.

CO-PO-PSOMAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	3	3	3	2	2	-	-	-	-	-	-	-	3	2
CO 2	3	3	2	3	2	-	-	-	-	-	-	-	2	2
CO 3	3	3	3	3	3	-	-	-	-	1	1	-	3	3
CO 4	3	3	3	3	2	-	-	-	-	-	-	1	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Storage Technology	EE3218	3-0-0	3

Prerequisites:

1. Chemistry

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome Statement	Bloom's Level
CO1	Explain the need for energy storage systems and differentiate between various conventional and modern storage technologies.	Understand (L2)
CO2	Analyze the characteristics and configurations of battery packs and evaluate their suitability for electric vehicle applications.	Analyze/Evaluate (L4/L5)
CO3	Design an optimized energy storage solution for integration with renewable energy systems and smart grid applications.	Create (L6)
CO4	Assess the safety, efficiency, and lifecycle issues in battery systems, and propose solutions for effective thermal and health management.	Evaluate/Create (L5/L6)

Module 1 (8 hours)

Introduction to Energy Storage: Relevance and scenario, Perspective on development of Energy Storage systems, Energy storage criteria, General concepts and Conventional batteries: their fundamentals andapplications. Grid connected and Off grid energy storage systems and requirements.

Module 2 (10 hours)

Introduction to energy storage for power systems: Role of energy storage systems, applications.

Overview of energy storage technologies: Thermal, Mechanical, Chemical, And Electrochemical, Electrical energy storage: Batteries, Super capacitors, Superconducting Magnetic Energy Storage (SMES), Hydrogen production and storage, introduction to fuel cell technology.

Module 3 (10 Hours)

Classification of batteries and their characteristics,Battery design for transportation, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced BatteryAssisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation, Recycling of Batteries from Electric Vehicles.

Module 4 (8 hours)

Storage for renewable energy systems: Solar energy, Wind energy, pumped hydro energy, fuel cells, energy storage in micro-grid and smart grid, and energy management with storage systems.Hybrid Energy storage systems: configurations and applications.

Text/Reference Book

1. Robert Huggins, Energy Storage, Springer, 2014th Edition.

2. Andrei G. Ter-Gazarian, Energy Storage for Power Systems (3rd Edition), IET, ISBN: 978-1-78561-867-3, 2020.

Reference Book

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
2. Yuping Wu, Lithium-Ion Batteries: Fundamentals and Applications (Electrochemical Energy Storage and Conversion), CRC Press, 2015.
3. Patrick T. Moseley, Jürgen Garche, Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Elsevier, 2015.

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	–	–	2	1	3	–	–	–	–	1	3	2
CO2	3	3	3	2	3	–	2	–	–	1	1	2	3	3
CO3	3	3	3	2	3	–	3	–	–	2	2	3	3	3
CO4	2	3	3	2	3	–	3	–	–	1	2	3	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Smart Grid Technology	EE4201	3-0-0	3

PREREQUISITES:

1. Power Systems
2. Renewable Energy System
3. Power Electronics
4. Control Systems.

COURSEOUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Understand the basics of various features and fundamentals of smart grid.	Understand (L2)
CO2	Analyze the role of automation and digitization for designing smart transmission and distribution system.	Analyze (L4)
CO3	Apply various advanced technology like communication, IoT, artificial intelligence and optimization in designing Smart grid.	Apply (L3)
CO4	Create and design the standards for smart electrical system with integration of renewable energy, emerging devices and technologies.	Create (L5)

MODULE-1 **(8 Hours)**

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, Concept of Resilient &Self-Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives. Smart Grids in India and World.

MODULE-2 **(8 Hours)**

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, smart sensors, Phasor Measurement Unit (PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: Energy Management System (EMS), FACTS and HVDC,

MODULE-3 **(10 Hours)**

Wide area monitoring, Protection and control, Distribution systems: distribution management system (DMS), Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

MODULE-4 **(10 Hours)**

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.

Computational Techniques: Static and Dynamic Optimization Techniques for power applications such as Economic load dispatch, Artificial Intelligent Techniques and Evolutionary Algorithm Applications in power system,

Text Books:

1. S.Borlase,“SmartGrids,Infrastructure,TechnologyandSolutions”,CRCPress,1stEdition, 2013.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.

References Books:

1. A. G. Phadke and J. S. Thorp, “Synchronized Phasor Measurements and their Applications”, Springer, 2nd Edition, 2017.
2. T. Ackermann,“Wind Power in Power Systems”, Hoboken, N J, USA, John Wiley, 2ndEdition, 2012.
3. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014.
4. G.Masters,“RenewableandEfficientElectricPowerSystem”,Wiley–IEEEPress,2nd Edition, 2013.
5. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015.

CO-PO MAPPING

(1- Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	2	2	2	-	-	-	-	-	-	1	3	2
CO3	3	3	2	3	2	-	-	-	-	-	-	1	3	3
CO4	2	3	2	2	-	1	-	-	-	-	-	2	2	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power Quality	EE4203	3-0-0	3

Prerequisites:

1. Power System Analysis and Operation
2. Power Electronics.

CO Code	Course Outcome	Bloom's Level
CO1	Identifying and Analyzing Power Quality Issues	Analyze (L4) and Remembering (L1)
CO2	Understanding and Applying Mitigation Techniques	Understand (L2)/ Apply (L3)
CO3	Comprehending the Impact of Power Quality	Understand (L2)
CO4	Evaluating Power Quality Monitoring and Control Devices	Evaluating (L5)

Module I: (8 Hours)

Electric Power Quality Phenomena: Impacts of power quality problems on end users, Power quality standards, power quality monitoring.
Overview of Power Quality Disturbances: Transients, short duration voltage variations, long duration voltage variations, voltage imbalance, wave-form distortions, voltage fluctuations, power frequency variations, power acceptability curves,

Module II: (8 Hours)
Power Quality Reactive Power issues, Poor load power factor, loads containing harmonics, notching in load voltage, dc offset in loads, unbalanced loads.
Transients: Origin and classification- capacitor switching transient-lighting-load switching-impact on users, Protection and mitigation of transients.

Module III: (10 Hours)

Harmonics: Harmonic distortion standards, power system quantities under non sinusoidal conditions-harmonic indices-source of harmonics-system response characteristics-effects of harmonic distortion on power system apparatus –principles for controlling harmonics, reducing harmonic currents in loads, filtering, modifying the system frequency response- Devices for controlling harmonic distortion, inline reactors or chokes, zigzag transformers, passive filters, active filters.

Module IV: (10 Hours)

Power Quality Conditioners: Shunt and series compensators, Distribution STATCOMS (DSTATCOMS) and Dynamic Voltage Restorers (DVRs), Rectifier supported DVR, DC Capacitor supported DVR, DVR Structure, Voltage Restoration – Series Active Filter- Shunt Active Filter – Unified power quality conditioners.

TEXT BOOKS:

1. Ghosh Arindam and Ledwich Gerard, 'Power quality enhancement using custom power devices' Springer.
2. Arrillaga J., Watson N. R. and Chen S., 'Power System Quality Assessment' Wiley.

REFERENCE BOOKS:

1. Angelo Baggini 'Handbook of Power Quality' – Wiley.
2. R.C. Duggan, 'Power Quality', TMH Publication, 2002

CO-POMAPPING

(1-Weak Correlation; 2-Medium correlation; 3-Strong Correlation)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	3	3	3	2	2	-	-	-	-	-	-	-	3	2
CO 2	3	3	2	3	2	-	-	-	-	-	-	-	2	2
CO 3	3	3	3	3	3	-	-	-	-	1	1	-	3	3
CO 4	3	3	3	3	2	-	-	-	-	-	-	1	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
High Voltage Engineering	EE4205	3-0-0	3

PREREQUISITES:

1. Electrical Measurements
2. Electrical Machines.

COURSEOUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	To understand the basic concepts of insulating materials (gaseous, liquids, solids, vacuum, composites) and their applications in high-voltage equipment.	Understand (L2)
CO2	To understand the breakdown phenomenon in air, solid and liquid insulation	Analyze (L4)
CO3	To apply knowledge on applying techniques for generation of high voltage and high current.	Apply (L3)
CO4	To design high voltage electrical equipments with various testing devices	Create (L5)

MODULE 1: (9Hours)

Conduction and breakdown in gases: Ionization processes. Townsend current growth equation. Current growth in the presence of secondary processes. Townsend's criterion for breakdown. Experimental determination of ionization coefficients. Breakdown in electronegative gases, time lags for break down, streamer theory of breakdown in gases, Paschen's law, Breakdown in non-uniform field and corona discharges, Penning effect, Vacuum breakdown.

MODULE-II (7HOURS) (9 Hours)

Conduction and breakdown in liquid dielectrics: Pure liquids and commercial liquids, conduction and breakdown in liquids.

Breakdown in solid dielectrics: Introduction, Intrinsic breakdown. Electromechanical breakdown, Thermal breakdown. Solid dielectrics in practice. Applications of nano filled materials for outdoor and indoor insulation

MODULE-III (9 HOURS)

Generation of high voltages and currents: Generation of high D.C, voltages, Generation of high alternating voltages, Generation of Impulse voltages. Tripping and control of impulse generators. Generation of Impulse currents. Measurements of high voltages and currents: Measurement of high D.C. voltages. Measurement of high D.C. and impulse voltages. Introduction. Measurement of high D.C. A.C. and impulse currents, cathode ray oscillographs for impulse voltages and currents measurements.

MODULE-IV (9 HOURS)

High voltage testing of electrical power apparatus: Testing of insulators and bushings. Testing of isolators and circuit breakers, cables. Testing of transformers, surge diverter

Nondestructive testing of materials and electrical apparatus: Introduction. Measurement of D.C. resistivity. Measurement of dielectric constant and loss factor. Partial discharge measurements. Radio Interference measurements.

TEXT BOOKS:

1. M.S. Naidu and V. Kamaraju, High Voltage Engineering, Tata McGraw-Hill, 5th Edition, 2018.
2. C.L.Wadhwa, “High Voltage Engineering”, Third Edition, New Age International Publishers,2012.
3. M. Abdel-Salam, H. Anis, A. El-Morshedy, R. Radwan, High-Voltage Engineering – Theory and Practice, 2nd edition, Marcel Dekker, Inc,(Special Indian Edition) 2010

REFERENCE BOOKS:

1. E.Kuffel, W.S. Zaengl, and J.Kuffel “High Voltage Engineering Fundamentals”, Second edition2000, published by Butterworth-Heinemann
2. E.W. Kimbark, Direct Current Transmission-vol.1, Wiley Inter science, New York , 1971
3. Hugh M.Ryan,(ed) “High Voltage Engineering & Testing”, 3rd Edition, The Institution of Engineering and Technology, IET series. 2001

CO-POMAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	3	2	2	-	-	-	-	2	3	-
CO2	3	3	3	3	3	2	-	-	-	-	-	2	3	-
CO3	3	3	3	3	3	2	-	-	-	-	-	2	3	2
CO4	3	3	3	3	3	2	-	-	-	-	-	2	3	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Restructured Power System	EE4207	3-0-0	3

PREREQUISITES:

1. Electrical Power Transmission and Distribution.
2. Power Systems Analysis and Operation.

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Explain the fundamentals of power market restructuring, consumer/supplier behaviour, and economic principles.	Understand (L2)
CO2	Analyze different electricity market models and generator bidding strategies under deregulated conditions.	Analyze (L4)
CO3	Apply concepts of congestion management, transmission pricing, and loss allocation techniques.	Apply (L3)
CO4	Evaluate ancillary service management and the implications of reforms in the Indian power sector.	Evaluate (L5)

MODULE 1: (10 Hours)

Introduction to Restructuring of Power Industry and Fundamentals of Economics: Introduction, reasons for restructuring / deregulation of power industry, understanding the restructuring process, Introduction to issues involved in deregulation, Reasons and objectives of deregulation of various power systems across the world, Consumer behavior, Supplier behavior, Market equilibrium, Short-run and long-run costs, Various costs of production, Relationship between short-run and long-run average costs, Perfectly competitive market.

MODULE 2: (10 Hours)

The Philosophy of Market Models and Market Power and Generators Bidding: Introduction, Market models based on contractual arrangements, Comparison of various market models, Electricity vis-à-vis other commodities, Market architecture, Attributes of a perfectly competitive market, the firm's supply decision under perfect competition, Imperfect competition, Financial markets associated with electricity markets, Introduction to optimal bidding by a generator company, Optimal bidding methods, Different entities in deregulated electricity markets, Benefits from a competitive electricity market.

MODULE 3: (8 Hours)

Transmission Congestion Management: Introduction, Classification of congestion management methods, Calculation of Available Transfer Capability (ATC), Non-market methods, Market based method, Nodal pricing, Intra-zonal congestion management, Price area congestion management, Capacity alleviation method, Comparison and conclusion, Mathematical preliminaries,

Financial Transmission Rights (FTR): Introduction to Financial Transmission Rights, Risk Hedging Functionality of Financial Transmission Rights, Simultaneous feasibility test and revenue adequacy, FTR issuance process, Treatment of revenue shortfall, Secondary trading of FTRs, Flow Gate rights, FTR and market power, FTR and merchant transmission investment

Pricing of Transmission Network Usage and Loss Allocation: Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing methods, Introduction to loss allocation, Classification of loss allocation methods.

MODULE 4: (8 Hours)

Ancillary Service Management: Introduction to ancillary services, Types of ancillary services, Classification of ancillary services, Load-generation balancing related services, Voltage control and reactive power support services

Reforms in Indian Power Sector: Introduction, Framework of Indian power sector, Reform initiatives during 1990-1995, the availability-based tariff (ABT), The Electricity Act 2003.

TEXT BOOKS:

1. Loi Lei Lai, "Power System Restructuring and Deregulation", John Wiley & Sons Ltd, England
2. Mohammad Shahidehpour, Muwaffaq Alomoush, "Restructured Electric Power Systems: Operation, Trading and Volatility", Marcel Dekker, Inc.
3. D. S. Kirschen and G. Strbac, "Fundamentals of power system economics", John Wiley & Sons.

REFERENCE BOOKS:

1. Geoffrey Rothwell, Tomas Gomez (Eds.), "Electricity Economics Regulation and Deregulation", IEEE Press Power Engineering Series, John Wiley & Sons.
2. Steven Stoft, "Power System Economics: designing markets for electricity", Wiley Inter science.
3. Barrie Murray, "Electricity Market – Investment, Performance and Analysis" John Wiley and Sons Publications.

CO-PO-PSO MAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

CO \ PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	2	2	2	-	-	-	-	-	-	1	3	2
CO3	3	3	2	3	2	-	-	-	-	-	-	1	3	3
CO4	2	3	2	2	-	1	-	-	-	-	-	2	2	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Utilization of Electrical Energy	EE4211	3-0-0	3

Prerequisites:

1. Power Electronics.
2. Control Systems.
3. Electrical Machines.
4. Electric Drives

Course Outcome:

At the end of the course the student will be able to:

COs	Course Outcome statement	Bloom's Level
CO1	Understand the suitability of different motor drives to be used for a specific purpose such as industrial drives, Traction motor drive, Electric Vehicles and Elevator motor drive	Understand Level-2
CO2	Review, analyze and control the operation of various electric appliances used	Analyze Level-4
CO3	Develop, select, and apply appropriate techniques for designing indoor & outdoor lighting schemes	Apply/Develop Level-3/6
CO4	Design and develop smart electrical heating, welding and electrolysis systems through the use of modern intelligent sensing and control tools	Design/Develop Level-4/6

Module-I (12 Hours)

Electric Drives:

Advantages of electric drives, Characteristics of different mechanical loads, Components of electric drives, close loop operation of electric drive system, Selection of motors for different types of domestic loads, Selection of drive for applications such as textile mill, paper mill, steel mill, printing press, crane and lift etc. Introduction to Electric and Hybrid Vehicles, Configuration and performance of electrical vehicles

Elevators: Function, Application, Types, Motors and safety

Electric Traction: Advantages of electric traction, Different systems of electric traction, DC and AC systems, diesel electric system, types of services – urban, sub-urban, and main lines and their speed-time curves, traction motor characteristics, tractive effort, vehicle performance and energy consumption. Different accessories for track electrification; such as overhead capacitor wire, conductor rail system, current collector-pantograph.

Module-2 (8 Hours)

Illumination:

Nature of light, visibility spectrum curve of relative sensitivity of human eye and wave length of light, , Different type of lamps, construction and working of incandescent and discharge lamps – their characteristics, fittings required for filament lamp, mercury vapour lamp, fluorescent lamp, metal halide lamp, neon lamp, General ideas about street lighting, flood lighting, monument lighting and decorative lighting, light characteristics etc.

Module-3 (8 Hours)

Heating and Welding:

Electrical heating-advantages, methods and applications, resistance heating, design of heating elements, efficiency and losses, control. Induction heating: core type furnaces, core less furnaces and high frequency eddy current heating, dielectric heating: principle and special applications, arc furnaces: direct arc furnaces, Indirect arc furnaces, electrodes, design of heating elements, power supply and control.

Different methods of electrical welding: resistance welding, arc welding, energy storage welding, laser welding, electro-beam welding, and electrical equipment for them. Arc furnaces transformer and welding transformers.

Module-4 (8 Hours)

Electrolysis and Domestic Appliances:

Review of electrolytic principles, laws of electrolysis, electroplating, anodizing-electro-cleaning, extraction of refinery metals, power supply for electrolytic process, current and energy efficiency

Electrical components and circuits used in Refrigeration, Air Conditioning and Water Coolers: Principle of air conditioning, vapour pressure, refrigeration cycle, eco-friendly Refrigerants

Text Books:

1. "Utilization of electrical energy" by E.O.Taylor, Orient Longmans, 1962.
2. H. Pratap, Art and Science of Utilization of Electrical Energy, Dhanpat Rai& Co.
3. Mehrdad, Ehsani, Yimin Gao, Sabastien. E. Gay, Ali Emadi, "Modern electric, hybrid electric and fuel cell vehicles", CRC Press.

Reference Books:

1. "Electrical Drives: Concept and applications" by Vedam Subrahmanyam
2. N V Suryanarayan, Utilization of Elect. Power including Electric Drives and Elect. Traction, New Age International.
3. Gupta, J.B., Utilization of Elect. Energy, Katariya and sons, New Delhi.
4. Garg, G.C., Utilization of Elect. Power and Elect. Traction.

CO-PO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	-	1	1	2	1
CO2	3	2	3	3	-	-	-	-	-	-	2	2	3	2
CO3	3	3	3	3	2	-	-	-	-	-	2	2	3	3
CO4	3	3	3	3	2	-	-	-	-	-	3	2	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Distribution System Engineering	EE4213	3-0-0	3

Prerequisites:

1. Electrical Power Transmission and Distribution

Course Outcomes

At the end of the course, students will be able to:

Course code	Course Outcome	Bloom's Level
CO1	Design and analyze on distribution substation layouts, nature of loads	Analyze Level-4
CO2	Gain knowledge of voltage drops and power loss calculations for uniformly distributed loads and various geometric configurations.	Understand Level-2
CO3	Understand and analyze, Load flow and short-circuit analysis of single-phase and three-phase systems, Reliability, energy efficiency, future smart-grid and distribution system analysis and operation	Understand/ Analyze Leve-2/4
CO4	To familiarize with the operations of a distribution system	Understand Level-2

Module 1 :(06 hours)

Introduction: Structure of distribution system, distribution feeder configurations, distribution substation layouts, North American and European systems, nature of loads, computation of transformer and feeder loadings.Load Allocation in a Distribution System.

Module 2: (12 hours)

Approximate methods of analysis: "K" Factors, voltage drop, and power loss calculations for uniformly distributed loads and various geometric configurations. Modeling of the distribution system components. Modeling of single and three-phase overhead lines, transformers, loads, and distributed generators.

Module 3 :(12 hours)

Distribution system analysis: Load flow and short-circuit analysis of single-phase and three-phase systems.

Operation of Distribution system: Reliability, energy efficiency, demand side management, reactive power management, and volt-var control, load balancing, reconfiguration, integration of renewable generation and storage, future smart-grid and distribution system analysis and operation.

Module 4: (06 hours)

DER and microgrid, regulating reforms, two-part tariff, electrical safety, electrical billing and smart metering, automatic metering reading, and automatic metering infrastructure.

Text books:

1. W. H. Kersting, Distribution System Modeling and Analysis, CRC Press, New York, 2002.

2. Electric Power Distribution Engineering, ByTuranGönen, Chee-Wooi Ten, Ali Mehrizi-Sani · 2024, CRC Press

Reference Books:

1. A. A. Sallam and O. P. Malik, Electric Distribution System, IEEE Press, Piscataway, NJ, 2011.
2. Edited by B. Das, Power Distribution Automation, IET Power and Energy Series, 75, London, 2016.
3. J. M. Gers, Distribution System Analysis and Automation, IET Power and Energy Series, 68, London, 2013.
4. R. F. Arritt and R. C. Dugan, "Distribution system analysis and the future smart grid," IEEE Transactions on Industry Applications, vol. 47, no. 6, pp. 2343-2350, November/ December 2011.

CO-PO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	3	2	2	-	-	-	-	-	-	-	3	2
CO2	3	3	2	3	2	-	-	-	-	-	-	-	2	2
CO3	1	3	3	2	3	-	-	-	-	2	1	-	3	3
CO4	3	3	2	3	2	-	-	-	-	-	-	1	3	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power System Dynamics and Control	EE4215	3-0-0	3

Prerequisites:

1. Control System-I.
2. Power System Analysis and Operation
3. Electrical Machines-II

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

CO Code	Course Outcome	Bloom's Level
CO1	Explain the fundamental concepts of power system stability, rotor angle dynamics, and control loops including AVR and AGC.	Understand
CO2	Analyze small signal and transient stability of power systems using state-space models, energy function methods, and simulation techniques.	Analyze
CO3	Evaluate the effects of low-frequency oscillations and sub-synchronous resonance on power system performance and propose suitable damping methods.	Evaluate
CO4	Assess voltage stability conditions using analytical tools and propose enhancement techniques for voltage collapse prevention in complex systems.	Evaluate

Module 1: (10 Hours)

Power System Stability Problems: Basic concepts and definitions, rotor angle stability, synchronous machine characteristics, power versus angle relationship, modeling of synchronous machines and various loads (composite load model), modeling of excitation systems, turbine and governor systems

Generation Control Loops: Automatic Voltage Regulator (AVR) loop, Performance and response of AVR, Automatic Generation Control (AGC) of single and multi-area systems, Static and dynamic response of AGC loops.

Small Signal Stability: State space concepts, basic linearization techniques, participation factors, Eigen properties of state matrix, small signal stability of a single machine infinite bus system, hoft-bifurcation, electromechanical oscillatory modes

Module 2: (10 Hours)

Large Perturbation Stability: Transient stability: time domain simulation and direct stability analysis techniques (extended equal area criterion), energy function methods: physical and mathematical aspects of the problem, Lyapunov's method, modeling issues, energy function formulation, potential energy boundary surface (PEBS), energy function formulation of a single machine infinite bus system, equal area criterion and energy function, Transient stability analysis of multi machine systems.

Module 3: (08 Hours)

Low Frequency Oscillations: Power system model for low frequency oscillation study, Eigen value analysis, Improvement of system damping characteristics, Power system stabilizer (PSS) model, Turbine-generator torsional characteristics, shaft system model, torsional natural frequencies and mode shapes, torsional interaction with power system controls; Sub Synchronous Resonance (SSR) and remedial measures.

Module 4: (08 Hours)

<u>Voltage Stability Analysis:</u> Real and reactive power flow in long transmission lines, Effect of On Load Tap Changing (OLTC) transformers and load characteristics on voltage stability, Voltage stability assessment by P-V curves, Voltage stability limit, Static and dynamic modelling of power systems. Voltage Collapse Proximity Indicators (VCPI), Voltage stability enhancement techniques.

Text Books:

1. P. Kundur, "Power system stability and control", McGraw Hill, NY, 2nd Edition -2022
2. P.Sauer and M.Pai, "Power System Dynamics an Stability", 3rd Edition Prentice Hall, 2020.
3. K.R. Padiyar, "Power System Dynamics, stability and control", Interline Publishing, Bangalore, India, 1999
4. M.A.Pai, D.P.Sengupta, K.R.Padiyar, "Small signal analysis of power systems", Narosa Series in Power and Energy Systems, 2004

Reference Books:

1. **Paul M. Anderson, A.A. Fouad**, *Power System Control and Stability*, IEEE Press / Wiley, 2nd Edition, 2002
2. **Jan Machowski, Janusz W. Bialek, James R. Bumby**, *Power System Dynamics: Stability and Control*, Wiley, 3rd Edition, 2020
3. **K. Uma Rao**, *Power System Operation and Control*, Wiley India, 2nd Edition, 2013

CO-PO MAPPING

(1-Weak Correlation; 2-Medium correlation; 3-Strong Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	-	-	-	-	1	-	-	3	2
CO2	3	3	3	3	2	-	-	-	-	1	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	1	-	-	3	3
CO4	3	3	3	2	2	-	-	-	-	1	-	-	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Electrical Engineering Materials	EE4217	3-0-0	3

PREREQUISITES:

1. Basic Electrical Engineering,
2. Basic Electronics Engineering

COURSEOUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Classify metals, describe physical properties, and analyze electrical and thermal conductivity for engineering and materials science applications.	Remember/Analyze (L1, L4)
CO2	Identify dielectric materials, explain polarization mechanisms, compare properties and conductivity across solid, liquid, and gaseous dielectrics.	Remember/Understand (L1, L2)
CO3	Identify magnetic materials, explain its magnetic behavior, losses, types and evaluate applications in engineering.	Remember/Evaluate (L1, L5)
CO4	Understand the characteristics of semiconductor, conductor, and insulator, analyze electrical properties, evaluate applications in electrical, electronics and material science.	Understand/Analyze (L2, L4)

MODULE 1 **(07hours)**

Classification and Conductivity of metals:

Classification of Electrical Engineering Materials, Electrical properties of materials, Electron theory of metals, Energy levels for Conductors, Insulators and Semiconductors, factors affecting electrical resistance of materials, Ohm's Law, Heat developed in a current carrying conductor, thermal conductivity of metals, emission of electrons from metals, temperature effect on electrical conductivity of metals, Superconductivity, HTLS (High Tension Low Sag) Conductors

MODULE2 **(08 hours)**

Dielectric properties of materials:

Dielectric as an electric field medium, Breakdown voltage and dielectric strength, Breakdown in solid dielectrics, Liquid and gases as dielectrics, polarisation, Electrical conductivity in solid, liquid and gaseous dielectrics, dielectric losses, significance of the loss tangent, dipolar relaxation, frequency and temperature dependence of the dielectric constant, ferroelectricity, piezoelectricity, Different dielectric materials for ultra-capacitor and super- capacitor.

MODULE3 **(06 hours)**

Magnetic properties of materials:

Classification of magnetic materials, Ferromagnetism, Magnetisation, Properties of Ferromagnetic materials, spontaneous magnetisation in ferromagnetic materials, Magnetic Anisotropy, Magnetostriction, Paramagnetism, Diamagnetism, B-H curves of soft and hard magnetic materials, Losses in magnetic materials, permanent magnet materials, rare-earth materials, materials used for PV panels, storage materials

MODULE4 **(09 hours)**

Semiconductors, conducting and insulating materials:

Semiconductor materials: Characteristics of semiconductors, Intrinsic and Extrinsic semiconductors, P-N-P and N-P-N transistors, Thermal Conductivity of Semiconductors, Applications of Semiconductor Materials

conducting materials: Materials of low resistivity and high conductivity, Materials of high resistivity and low conductivity, Applications of conducting Materials

Insulating Materials: Characteristics of a good insulating material, Classification of insulating materials, Solid, liquid and gases insulating materials, Applications of Insulating Materials

TEXT BOOKS:

1. An Introduction to Electrical Engineering Materials- Dr. C.S.Indulkar and Dr. S. Thiruvengadam- S CHAND and Company Pvt. Ltd.
2. A Textbook of Electrical Engineering Materials- R.K.Rajput.- Laxmi Publications (P)Ltd.

REFERENCE BOOKS:

1. Engineering Materials- Kenneth G. Budinski and Michael K. Budinski -Prentice Hall of India Pvt. Ltd.
2. Electrical Engineering Materials-A. J. Dekker- Prentice Hall of India Pvt. Ltd.
3. Seth, Gupta, Electrical Engineering Materials

CO-PO MAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	2	3	2	-	1	1	-	2	3	2
CO2	3	3	2	2	1	3	2	-	1	1	-	2	3	2
CO3	3	3	3	2	1	3	2	-	1	1	-	2	3	2
CO4	3	3	3	3	2	3	3	-	1	2	-	3	3	2

Honors Course offered by School of Electrical Sciences

Sl. No.	Course Code	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	SEM-5	EE3171	Machine Learning Applications in Smart Grid Systems	3-0-0	3
2	SEM-6	EE3172	Electricity Markets and Regulatory Frameworks	3-0-0	3
3	SEM-7	EE4171	Load Forecasting and Reliability in Power Systems	3-0-0	3
4	SEM-7	EE4173	Advanced Power Converter	3-0-0	3
5	SEM-8	EE4172	System Identification and Adaptive Control	3-0-0	3
Subject (Sessional)					
6	SEM-6	EE3572	Advanced Power System Lab	0-0-3	1.5
7	SEM-7	EE4571	Advanced Power Electronics Simulation Lab	0-0-3	1.5
			Total	**15-0-6**	**18**

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Machine Learning Applications in Smart Grid Systems	EE3171	3-0-0	3

PRE-REQUISITES:

1. Basics of Power Systems
2. Fundamentals of Smart Grids

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to:

CO Code	Course Outcome	Bloom's Level
CO1	Understand the structure, types, and challenges of smart grid data	Understand (L2)
CO2	Apply core ML techniques to load forecasting, anomaly detection, and profiling	Apply (L3)
CO3	Analyze smart grid operations using supervised and unsupervised models	Analyze (L4)
CO4	Evaluate and implement advanced AI/ML solutions for intelligent grid decisions	Evaluate/Create (L5)

MODULE 1: (8 Hours)

Introduction to Data Analytics and Smart Grid Data Sources: Overview of smart grid architecture and data flow, Data types in smart grids: AMI, SCADA, PMU, DERs, EVs. Characteristics of smart grid data: volume, velocity, variety, veracity, Basics of data analytics: pre-processing, normalization, missing data handling, Exploratory data analysis and visualization (using Python/Pandas/Matplotlib), Introduction to time-series data and multivariate sensor datasets

MODULE 2: (8 Hours)

Machine Learning Fundamentals for Smart Grids: Overview of supervised and unsupervised learning, Regression models: Linear, Polynomial, Classification models: kNN, SVM, Decision Trees, Random Forests, Clustering: k-means, hierarchical clustering for load pattern analysis, Model selection, performance evaluation (RMSE, accuracy, F1 score, AUC)

MODULE 3: (8 Hours)

Applications in Load Forecasting, Demand Response, and Power Quality: Short-term and long-term load forecasting using ML models, Load disaggregation and customer profiling, Energy theft detection using anomaly detection techniques, Power quality classification using sensor data, Predictive models for demand response and price elasticity, Case studies using real or simulated smart meter datasets (e.g., UCI or Smart Meter Texas)

MODULE 4: (8 Hours)

Deep learning: Introduction to ANN, RNN, and LSTM for sequential grid data, Real-time analytics and edge computing in smart grids. AI for fault detection, predictive maintenance, and cyberattack detection, Big data platforms: Hadoop, Spark, and cloud analytics for smart grids, Data privacy and cybersecurity in ML for energy systems,India Smart Grid Forum.

TEXT BOOKS:

1. James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley, 1st edition, 2012
2. S. Chakrabarti et al., *Data Analytics for Intelligent Grid Systems*, CRC Press
3. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly, 2019

REFERENCE BOOKS:

1. Mini S. Thomas and John D. McDonald, *Power System SCADA and Smart Grids*, CRC Press, 2015
2. Gellings, C., *The Smart Grid: Enabling Energy Efficiency and Demand Response*, CRC Press, 2009
3. CEA & ISGF reports on Smart Metering and DSM in India

CO-PO MAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	–	2	–	–	–	–	–	–	2	2	2
CO2	3	3	2	2	3	–	–	–	–	–	–	2	3	3
CO3	3	3	3	2	3	–	–	–	–	–	–	2	3	3
CO4	3	3	3	3	3	–	–	–	–	–	–	3	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Electricity Market and Regulatory Framework	EE3172	3-0-0	3

PREREQUISITES:

1. Power Systems-I.
2. Power Systems-II.

COURSEOUTCOMES:

At the end of this course, students will demonstrate the ability to

CO No.	Course Outcome Description	Bloom's Level
CO1	Explain the structure, evolution, and key concepts of competitive electricity markets and their participants.	Understand (L2)
CO2	Analyze electricity market pricing mechanisms, including LMP and congestion management strategies.	Analyze (L4)
CO3	Evaluate regulatory frameworks, policies, and the roles of institutions in the electricity sector.	Evaluate (L5)
CO4	Compare Indian and international electricity markets and interpret the impact of regulatory and operational practices.	Analyze (L4)

MODULE 1: (10 Hours)

FUNDAMENTALS OF ELECTRICITY MARKETS: Evolution of the power sector: Monopoly to competition, Characteristics of electricity as a commodity, Types of electricity markets (Spot, Day-ahead, Ancillary), Market players: Generators, Discoms, Traders, Consumers, Introduction to Market Design: Pool vs bilateral, single vs multi-settlement

MODULE 2: (10 Hours)

PRICING MECHANISMS AND MARKET OPERATION: Economic dispatch and marginal cost pricing, Locational Marginal Pricing (LMP) and nodal pricing, Congestion management techniques, Ancillary services and their procurement, Risk management: Contracts, hedging, Financial Transmission Rights (FTRs)

MODULE 3: (8 Hours)

Regulatory Framework and Institutions: Regulatory principles and tariff setting, Role of CERC, SERCs, APTEL, Open access, cross-subsidy surcharge, and wheeling, Electricity Act 2003 and policy reforms, Legal and judicial aspects of electricity regulation

MODULE 4: (8 Hours)

Indian and International Market Practices: Indian electricity market: IEX, PXIL, Market-Based Economic Dispatch, Role of NLDC, RLDCs, SLDCs, and POSOCO, Real-time markets and DSM regulations, International case studies: PJM (USA), Nord Pool (EU), NEM (Australia), Future trends: Green energy markets, cross-border trading, and digital platforms

TEXT BOOKS:

1. Loi Lei Lai, “Power System Restructuring and Deregulation”, John Wiley & Sons Ltd, England, 2001
2. Mohammad Shahidehpour, MuwaffaqAlomoush, “Restructured Electric Power Systems: Operation, Trading and Volatility”, Marcel Dekker, Inc, 2014
3. D. S. Kirschen and G. Strbac, “Fundamentals of power system economics”, John Wiley & Sons, 2018

REFERENCE BOOKS:

1. Geoffrey Rothwell, Tomas Gomez (Eds.), "Electricity Economics Regulation and Deregulation", IEEE Press Power Engineering Series, John Wiley & Sons, 2003.
2. Electricity Act 2003 (Govt. of India)
3. CERC & POSOCO reports
4. Market data from IEX and PXIL websites.

CO-PO-PSOMAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

CO \ PO/PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	–	–	–	1	–	–	–	2	–	2	3	2
CO2	3	3	2	2	2	–	–	–	–	2	–	2	3	3
CO3	3	3	2	2	–	3	2	2	1	2	2	2	2	3
CO4	2	3	2	2	2	2	2	2	2	3	2	3	2	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Load Forecasting and Reliability in Power Systems	EE4171	3-0-0	3

PREREQUISITES:

1. Power system

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Apply load forecasting techniques using classical and AI-based models	Apply (L3)
CO2	Analyze power system reliability using probabilistic and state-based methods	Analyze (L4)
CO3	Evaluate reliability metrics using Monte Carlo, UGF, and Markov models	Evaluate (L5)
CO4	Assess and model power system resilience using standard frameworks and tools	Evaluate (L5)

MODULE 1: **(8 hours)**

Load Forecasting: Load Forecasting Categories-Long term, Medium term, short term, very short term Applications of Load Forecasting, Factors Affecting Load Patterns Medium and long term load forecasting methods- end use models, econometric models, statistical model based learning. Short Term Load Forecasting (STLF): Applications of Load Forecasting, methods- similar day approach, regression methods, time series, ANN, Expert systems, Fuzzy logic based method, support vector machines ANN architecture for STLF, Seasonal ANN, Adaptive Weight, Multiple-Day Forecast, sensitivity analysis in STLF.

MODULE 2: **(12 hours)**

Concepts of Power System Reliability: Basic Notions of Power System Reliability- sub systems, reliability indices, outage classification, value of reliability tools, Concepts and methodologies, power system structure, Reliability based planning in power systems, Effect of failures on power system, Planning criteria, Risk analysis in power system planning, multi-state systems.

Basic Tools and Techniques: random processes methods & Markov models, Computation of power system reliability measures by using Markov reward models, Evaluation of reliability indices, Universal Generating Function (UGF) Method, Monte Carlo simulation.

MODULE 3: **(8 hours)**

Analysis of Power System Reliability: Capacity outage calculations, reliability indices using the loss of load probability method, unit commitment and operating constraints, optimal reserve management, single and multi-stage expansion. Reliability Assessment for Elements of Transmission and Transformation Systems- reliability indices of substations based on the overload capability of the transformers, evaluation and analysis of substation configurations, Reliability analysis of protection systems for high voltage transmission lines.

MODULE 4: (8 Hours)

Introduction to Resilience: Definition: Resilience vs Reliability, Importance of resilience in modern power systems, Impact of extreme events: natural disasters, cyber-physical attacks, Key metrics and terminologies, Role of distributed energy resources (DERs), microgrids**.**

Power System Disturbances: Types: Faults, Natural disasters, Electro-Magnetic Pulse (EMP), Historical blackouts and case studies, Vulnerability analysis and identification

Modeling Power System Resilience: Component-level vs system-level resilience, Resilience curve and quantification, Basic models for disturbance and recovery, Emergency restoration planning

TEXT BOOKS:

1. Markey operations in electric power systems Forecasting, Scheduling, and Risk Management, Shahidehpour M, Yamin H, Li z, John Willey & sons, 2002.

2. Reliability evaluation of power systems, Billinton R, Allan R Plenum Press New York, 1996.

3. Computational Methods in Power system Reliability, D. Elmakias, Springer-Verlag, 2008

REFERENCE BOOKS:

1. J.J. Grainger &W.D. Stevenson, "Power system analysis", McGraw Hill ,2003
2. 2. A. R. Bergen & Vijay Vittal, "Power System Analysis", Pearson, 2000
3. 3. L.P. Singh, "Advanced Power System Analysis and Dynamics", New Age International, 2006
4. G.L. Kusic, "Computer aided power system analysis", Prentice Hall India, 1986
5. A.J. Wood, "Power generation, operation and control", John Wiley, 1994 6. P.M. Anderson, "Faulted power system analysis", IEEE Press, 1995

CO-POMAPPING

(1- Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	–	–	–	–	–	–	2	3	3
CO2	3	3	2	3	2	–	–	–	–	–	–	2	3	2
CO3	3	3	2	3	2	–	–	–	–	–	–	2	3	3
CO4	3	3	3	3	3	2	–	–	–	–	–	3	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Advanced Power Converter	EE4173	3-0-0	3

PREREQUISITES:

1. Power Electronics

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Analyze the operation of non-isolated and isolated DC-DC converters under continuous and discontinuous conduction modes considering non-idealities.	Analyze (L4)
CO2	Compare various resonant DC-DC converter topologies and evaluate their performance based on switching characteristics and loss profiles.	Evaluate (L5)
CO3	Explain the need for multilevel inverters and differentiate between common multilevel inverter topologies and their applications.	Understand (L2)
CO4	Apply the knowledge of AC-AC controllers and matrix converters to improve power factor in converter-based systems.	Apply (L3)

MODULE 1: **(10hours)**

Non-isolated DC-DC Converters: DC-DC Converter operation in DCM and CCM. Classification, effects of converter non-idealities: Inductor Resistance, Transistor and Diode Voltage Drop, Switch Resistance on converter performance

Isolated DC-DC Converters: Buck and boost derived isolated converters, single-ended fly-back, single-ended forward, Push–Pull Converter, Half-Bridge and Full-Bridge Converter operation and design

MODULE 2: **(8 hours)**

Resonant DC-DC converters: Operating principle of resonant converters, Classification, waveforms, switching trajectory, losses and control, Zero-Current-Switching Resonant Converters, L-Type ZCS Resonant Converter, M-Type ZCS Resonant Converter, Zero-Voltage-Switching Resonant Converters, Comparisons between ZCS and ZVS Resonant Converters

MODULE 3: **(8 hours)**

Multi-level Inverters: Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, flying capacitor and Cascaded H-bridge multilevel Converters configurations, features and relative comparison of these configurations

MODULE 4: **(8 hours)**

AC-AC voltage controller, Matrix Converter, power factor improvement techniques used in converters

TEXT BOOKS:

1. N. Mohan, T. M. Underland & W.P. Robbing, Power Electronics: Converter, Applications & Design, John Wiley & Sons , 2003
2. M. H. Rashid, Power Electronics Circuits, Devices, and Applications, Pearson Education , 2014

REFERENCE BOOKS:

1. L. Umanand, Power Electronics Essentials and Applications, Wiley India Pvt Ltd., 2009
2. Erickson and Maksimovic, Fundamentals of Power Electronics, Springer, 2nd edition, 2006

CO-PO MAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	2	1	0	0	1	2	0	1	**2**	**-**
CO2	3	3	2	3	2	1	1	0	2	2	0	2	**2**	**2**
CO3	2	2	2	1	1	0	0	0	1	1	0	1	**2**	**-**
CO4	2	3	3	3	2	2	1	0	2	2	1	2	**2**	**1**

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
System Identification and Adaptive Control	EE4172	3-0-0	3

PREREQUISITES:

1. Control Systems
2. Probability and Statistics

COURSE OUTCOMES:

At the end of this course , students will demonstrate the ability to

CO	Course Outcome	Bloom's Level
CO1	Design and implement system identification experiments	Apply (L3)
CO2	Utilize input-output experimental data for the identification of dynamical models for physical systems	Analyze (L4)
CO3	Design various adaptive control techniques for identified dynamical systems	Create (L5)
CO4	Understand the advantages and disadvantages of adaptive control techniques relative to other conventional control approaches	Understand (L2)

MODULE 1 **(8 hours)**

Introduction to System Identification: Introduction to dynamic systems and modelling**,** Concept of system identification and its need**,** Types of models: white-box, black-box, grey-box**,** Basic concepts of signals, noise, and data collection**,** Overview of time-domain and frequency-domain identification

MODULE 2: **(8 hours)**

Parametric Model Structures and Estimation: ARX, ARMAX, Output Error (OE), and Box-Jenkins models**,** Least Squares (LS) and Recursive Least Squares (RLS) estimation**,** Model validation and selection**,** Identification using MATLAB/System Identification Toolbox

MODULE 3 **(8 hours)**

Fundamentals of Adaptive Control: Need for adaptive control**,** Difference between adaptive and robust control**,** Gain scheduling**,** Model Reference Adaptive Systems (MRAS)**,** Direct and indirect adaptive control schemes

MODULE 4 **(10 hours)**

Design of Adaptive Controllers: Lyapunov-based design methods, Self-tuning regulators, Adaptive pole placement techniques, Stability and convergence of adaptive systems

Practical issues in system identification and adaptive control implementation

TEXT BOOKS:

1. K.J. Astrom and B. Wittenmark, Adaptive Control, Pearson, 2011.
2. L. Ljung, System Identification Theory for the user, Prentice-Hall, 2007

REFERENCE BOOKS:

1. K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems,, Prentice-Hall, 1989.
2. Arun K. Tangirala, Principles of system identification: theory and practice., CRC press, 2018.
3. Goodwin, G. C., and Sin, K. S. *Adaptive Filtering Prediction and Control*. Dover Publications, 2009.
4. Isermann, R. *System Identification: An Introduction*. Springer, 2018.
5. Landau, I. D., and Lozano, R. *Adaptive Control: Algorithms, Analysis and Applications*. Springer, 2011.

CO-POMAPPING

(1- Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	1	0	0	0	2	1	0	1	3	2
CO2	3	3	2	2	2	0	1	0	2	2	0	2	3	3
CO3	3	3	3	3	2	1	2	0	3	3	1	2	3	3
CO4	2	2	1	2	1	1	1	0	2	2	1	2	2	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Advanced Power Systems Lab	EE3572	0-0-3	1.5

PREREQUISITES:
1. Electrical Machines Lab
2. Power System-I
3. Power System-II

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO No.	Course Outcome	Bloom's Level
CO1	Demonstrate the working and application of different protection relays through simulation.	Apply (L3)
CO2	Implement and compare different load flow analysis techniques using MATLAB.	Analyze (L4)
CO3	Simulate fault analysis and security assessment in modern power systems.	Analyze (L4)
CO4	Apply optimization and market simulation tools for economic dispatch and OPF studies.	Apply (L3)

List of Experiments

Any 10 experiments to be performed

1. To determine the operating characteristics of Distance Relay and determination of the location of fault in transmission line.
2. Write a program to solve the Load Flow problem of a given network using Gauss-Seidel Method.
3. Write a program to solve the Load Flow problem of a given network using Newton-Raphson Method.
4. Write a program to solve the Load Flow problem of a given network using Decoupled Load Flow Method.
5. Simulation of Load Flow Studies using Participation factor-based Load Flow Method.
6. Simulation of Fault Studies without fault and neutral impedance (LG/LLG/LLL).
7. Simulation of Fault Studies with fault and neutral impedance (LG/LLG/LLL).
8. To perform unsymmetrical fault analysis in a power system.
9. Simulation for overload security Analysis
10. Simulation for voltage security Analysis

TEXT BOOKS:

1. J. J. Grainger and W. D. Stevenson, Power System Analysis, McGraw-Hill Education, 2017
2. R. Bergen and V. Vittal, Power System Analysis, Pearson Education, 1999.
3. P. Kundur, Power System Stability and Control, McGraw-Hill, 2006.

REFERENCE BOOKS:

1. Hadi Saadat, Power System Analysis, McGraw-Hill, 1998.
2. D. P. Kothari and I. J. Nagrath, Modern Power System Analysis, Tata McGraw-Hill.
3. Chakrabarti & Halder, Power System Analysis: Operation and Control, PHI Learning.

CO-PO-PSO MAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

CO \ PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	–	–	1	2	2	–	2	3	2
CO2	3	3	3	3	3	–	–	–	1	2	1	3	3	3
CO3	3	3	2	3	3	1	2	–	2	2	–	3	3	3
CO4	2	3	3	2	3	–	–	–	2	3	2	3	2	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Advanced Power Electronics Simulation Lab	EE4572	0-0-3	1.5

PREREQUISITES:
1. Power Electronics.
2. Electrical Machines.

COURSEOUTCOMES:
At the end of this course, students will able to

CO Code	Course Outcome	Bloom's Level
CO1	To simulate and analyze advanced power electronic circuits using modern simulation tools.	Analyze(L4)
CO2	To understand the behavior and performance of converters, inverters, and control schemes under various conditions.	Understand(L2)
CO3	To gain hands-on experience in MATLAB/ Simulink, PSIM, or similar platforms for modeling power electronic systems.	Create (L6)
CO4	To verify dynamic model of induction motor in reference frames through simulation using MATLAB programming.	Evaluate(L5)

List of Experiments
Any 10 to be performed

1. Simulation of Buck-Boost DC-DC Converters.
2. Modeling and Simulation of Single-phase Inverters using PWM techniques (SPWM, SVM).
3. Modeling and Simulation of Three-phase Inverters using PWM techniques (SPWM, SVM).
4. Simulation of Flyback converter.
5. Harmonic Analysis of Power Electronic Converters using FFT tools.
6. Closed-loop Control of DC Motor Drive Using Chopper Circuit using PI controller.
7. Closed-loop Control of Induction motor drive using P-I controller.
8. Modeling and Simulation of Resonant Converters (Series/Parallel).
9. Simulation of Renewable Energy-based Power Converters using Solar PV inverter systems and MPPT algorithms.
10. Speed Control of Induction Motor Using V/f Technique with scalar control method.
11. Simulation of dynamic model induction motor to plot torque vs. speed characteristics for free acceleration.
12. Speed Control of DC motor drive using universal bridge PWM converter.

TEXT BOOKS:

1. M. H. Rashid,” Power electronics: circuits, devices, and applications”, Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland,” Power Electronics: Converters, Applications and Design”, John Wiley & Sons,2007.

REFERENCE BOOKS:

1. R. W. Erickson and D. Maksimovic,” Fundamentals of Power Electronics”, SpringerScience & Business Media,2007.
2. L. Umanand,” Power Electronics: Essentials and Applications”, Wiley India,2009.

CO-POMAPPING

(1-Weak correlation; 2-Mediumcorrelation; 3-Strong correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	1	3	-	-	-	-	-	-	-	3	2
CO2	2	3	2	3	2	-	-	-	-	-	-	-	3	2
CO3	2	2	3	3	3	-	-	-	-	-	-	-	3	3
CO4	2	2	2	2	3	-	-	-	-	-	-	-	3	3

Minor Course offered by School of Electrical Sciences

“Minor in Smart Grid Management”

Sl. No.	Course Code	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	SEM-5	EE3261	Electrical Power Transmission and Distribution	3-0-0	3
2	SEM-6	EE3262	Power Electronics	3-0-0	3
3	SEM-7	EE4261	Smart Grid Technologies and Architectures	3-0-0	3
4	SEM-7	EE4263	Advanced Metering Infrastructure (AMI) and Demand Side Management	3-0-0	3
5	SEM-8	EE4262	Data Analytics and Machine Learning for Smart Grid Applications	3-0-0	3
Subject (Sessional)					
6	SEM-6	EE3562	Power System and Power Electronics Lab	0-0-3	1.5
7	SEM-7	EE4561	Smart Grid Simulation Lab	0-0-3	1.5
			Total	**15-0-6**	**18**

SUBJECT NAME	SUBJECTCODE	L-T-P	CREDIT
Electrical Power Transmission and Distribution	EE3261	3-0-0	3

PRE-REQUISITES:

1. Basic Electrical Engineering.
2. Electrical Circuit Analysis.

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Understand the basics of various fundamentals of electrical power generation, transmission & distribution.	Understand (L2)
CO2	Analyse transmission line parameters and its effects on transmission lines.	Analyze (L4)
CO3	Applyelectrical characteristics of transmission line such as types of trans-mission lines, various effects on transmission & per unit representation of power system.	Apply (L3)
CO4	Mechanical designwith the types ofconductors, insulators, underground cable parameters and power system earthing.	Create (L5)

MODULE 1: (8 Hours)

Transmission Line Parameters: Inductance of a Conductor due to Internal Flux, Flux Linkages between Two Points External to an Isolated Conductor, Inductance of a Single Phase Two Wire Line, Flux Linkages of one Conductor in a Group, Inductance of Composite-Conductor Lines. Inductance of a Three Phase Line with symmetrical and Unsymmetrical Spacing. Inductance Calculations for Bundled Conductors, Skin effect and Proximity effect, Corona Effect. Capacitance of a Two Wire Line, Capacitance of a Three Phase Line with symmetrical and Unsymmetrical Spacing, Effect of Earth on the Capacitance of a Three Phase Line, Capacitance Calculations for Bundled Conductors, Parallel- Circuit Three Phase Lines.

MODULE 2: (7 Hours)

Transmission Line Performances: Analysis of Short, medium and long Transmission Line, Equivalent Circuit, Representation of lines and calculation of transmission parameters, Voltage Profile of transmission lines, Ferranti Effect, Power Flow Through Transmission Line, Power Flow capability and Surge Impedance Loading, Reactive Compensation of Transmission Line.

MODULE 3: (7 Hours)

Overhead Line Conductors and Insulators: Types of conductors: ACSR, AAAC, HTLSetc.InsulatorMaterials,TypesofInsulators:Porcelain,Glass,Polymer, Hydrophobicity,CreepageDistance,VoltageDistributioninsuspensiontypeinsulators, Improvement of String Efficiency, Insulator Failure, Testing of Insulators, Concept of Sag and Tension.

MODULE 4: (8 Hours)

Distribution: Classification of Distribution Systems, Primary and secondary distribution network, Voltage Drop in DC Distributors, Voltage Drop in AC Distributors, Kelvin’s Law, Limitations of Kelvin’s Law, Application of Capacitors to Distribution Systems.

Underground Cables: Type and construction, Classification of Cables, Parameters of Single Core Cables, Grading of Cables, Capacitance of Three Core Cable.

Power System Earthing.

TEXT BOOKS:

1. J. Grainger and W. D. Stevenson," Power System Analysis", McGraw Hill Education,1994.
2. D.P.KothariandI.J.Nagrath,"ModernPowerSystemAnalysis",McGrawHillEduca tion, 2003.
3. C.L. Wadhwa – Electrical Power Systems, Fifth Edition, New Age International,2009.

REFERENCE BOOKS:

1. J. B. Gupta ,"A course in power systems", S K KATARIA & SONS publications, 2010
2. V.K Mehta and Rohit Mehta, "Principles of Power Systems", Third Edison, S. Chand & Company Ltd, New Delhi, 2004.

CO-PO-PSO MAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	3	2	2	-	-	-	-	2	3	-
CO2	3	3	3	3	3	2	-	-	-	-	-	2	3	-
CO3	3	3	3	3	3	2	-	-	-	-	-	2	3	2
CO4	3	3	3	3	3	2	-	-	-	-	-	2	3	2

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Power Electronics	EE3262	3-0-0	3

PREREQUISITES:

1. Basic Electronics

COURSE OUTCOMES:

At the end of this, course students will able to:

CO	Course Outcome	Bloom's Level
CO1	Explain the structure, characteristics, and operation of high-power semiconductor devices including IGBT, MOSFET, SCR, and wide band gap devices like SiC and GaN.	Understand (Level 2)
CO2	Analyze different controlled rectifier circuits and computing their performances	Analyze (Level 4)
CO3	Evaluate the performance of non-isolated and isolated DC-DC converters under steady-state continuous and discontinuous current conditions.	Evaluate (Level 5)
CO4	Design and compare various inverter topologies including PWM and multilevel inverters, and explain the working of cycloconverters.	Apply/Create (Level 3/6)

MODULE 1: (8 Hours)

Introduction to High-Power Semiconductor Devices - Insulated Gate Bipolar Transistors (IGBTs): Design and operation principles, Power MOSFETs: Structure, operation, and characteristics, Comparison with other high-power devices Thyristors and Related Switching characteristics and applications

MODULE 2: (7 Hours)

Phase Controlled rectifiers: full/half-controlled converters for R, RL, RLE load, dual converters,Single-phase full wave fully controlled rectifier with R-L and R-L-E load; Three-phase full wave fully controlled rectifier with R-L and R-L-E load; Input current wave shape and power factor. Single phase semi converter with R-L and R-L-E load,

MODULE 3: (7 Hours)

DC-DC converter: Buck converter: analysis and waveforms at steady state for continuous and discontinuous load current operations, duty ratio control of output voltage. Boost converter: analysis and waveforms at steady state, relation between duty ratio and average output voltage, continuous and discontinuous load current operations, Buck-Boost converter.

MODULE4: (8 Hours)

Voltage source inverter: Single-phase bridge inverter, three-phase inverter: 180^0& 120^0conduction. Voltageandfrequencycontrolofinverter;singlepulsewidthmodulation,multiplepulsewidthmodulation, sinusoidal pulse width modulation (SinPWM), Space Vector PWM of 3-phaseinverter. Current source inverter: 1-phase & 3-phase. Introduction to multilevel inverter.

TEXT BOOKS:

1. M. H. Rashid," Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland," Power Electronics: Converters, Applications and Design", John Wiley & Sons,2007.

REFERENCE BOOKS:

1. R. W. Erickson and D. Maksimovic," Fundamentals of Power Electronics", SpringerScience& Business Media,2007.
2. L. Umanand," Power Electronics: Essentials and Applications", Wiley India,2009.

CO-POMAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	2	–	2	–	–	–	–	1	3	2
CO2	3	3	2	2	2	–	2	–	–	–	–	2	3	2
CO3	3	3	2	2	3	–	2	–	–	–	–	2	3	3
CO4	3	3	3	2	3	–	2	–	–	1	2	3	3	3

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Smart Grid Technology and Architecture	EE4261	3-0-0	3

PREREQUISITES:

1. Power Systems
2. Power Electronics

COURSEOUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Understand the basics of various features and fundamentals of smart grid.	Understand (L2)
CO2	Analyse the role of automation and digitization for designing smarttransmission and distribution system.	Analyze (L4)
CO3	Apply various advanced technology like communication, IoT, artificial intelligence and optimization in designing Smartgrid.	Apply (L3)
CO4	Create and design the standards for smart electrical system withintegration of renewable energy, emerging devices and technologies.	Create (L5)

MODULE-1 (8 Hours)

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. Concept of Resilient &Self-Healing Grid.International policies and global initiatives on Smart Grid.Smart Grid developments in India.

MODULE-2 (8 Hours)

Smart Grid Architecture and Design: Layered architecture: Physical, communication, cyber, control layers. Power system components in Smart Grid (DERs, EVs, storage, PMUs). Distribution automation and control.

Smart sensors, PMUs, and IEDs for monitoring and protection, Smart substations and Substation Automation, Feeder Automation, Energy Management System (EMS), FACTS and HVDC systems in Smart Grids.

MODULE-3 (10 Hours)

Wide area monitoring, Protection and control, Distribution systems: distribution management system (DMS), Volt/VAR control, Fault Detection, Isolation and service restoration, Outage management, High Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

MODULE-4 (10 Hours)

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.

Computational Techniques: Static and Dynamic Optimization Techniques for power applications such as Economic load dispatch, Artificial Intelligent Techniques and Evolutionary Algorithm Applications in power system,

Text Books:

1. S.Borlase,“SmartGrids, Infrastructure, Technology and Solutions”,CRCPress,1stEdition, 2013.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.

References Books:

1. A. G. Phadke and J. S. Thorp, “Synchronized Phasor Measurements and their Applications”, Springer, 2nd Edition, 2017.
2. T. Ackermann,“Wind Power in Power Systems”, Hoboken, N J, USA, John Wiley, 2ndEdition, 2012.
3. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014.
4. G.Masters,“RenewableandEfficientElectricPowerSystem”,Wiley–IEEEPress,2nd Edition, 2013.
5. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015.

CO-POMAPPING

(1- WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	2	2	2	-	-	-	-	-	-	1	3	2
CO3	3	3	2	3	2	-	-	-	-	-	-	1	3	3
CO4	2	3	2	2	-	1	-	-	-	-	-	2	2	2

SUBJECT NAME	SUBJECTCODE	L-T-P	CREDIT
Advanced Metering Infrastructure (AMI) and Demand Side Management	EE4263	3-0-0	3

PRE-REQUISITES:

1. Smart Grid Fundamentals
2. Power Systems

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome	Bloom's Level
CO1	Explain the architecture, standards, and components of AMI	Understand (L2)
CO2	Analyze communication technologies and data management in AMI	Analyze (L4)
CO3	Apply DSM strategies and pricing mechanisms for load optimization	Apply (L3)
CO4	Integrate AMI and DSM tools to improve energy efficiency and grid responsiveness	Evaluate/Create (L5)

MODULE 1: (8 Hours)

Introduction to AMI and Metering Technologies: Overview of Smart Metering and AMI. Components of AMI: Smart Meters, MDMS, Communication Networks. AMI Functionalities: Data logging, remote connect/disconnect, outage reporting. Standards: DLMS/COSEM, IEC 62056, IEEE 1701/1703. Interoperability and Data Models. Consumer and utility benefits of AMI.

MODULE 2: (7 Hours)

Communication Infrastructure for AMI: Network architecture: HAN, NAN, WAN,Communication protocols: ZigBee, PLC, RF Mesh, 5G, LoRaWAN, Data acquisition, telemetry, and cybersecurity, Role of IoT and Cloud in AMI, Time synchronization and GPS-enabled smart meters, Privacy and legal aspects of data sharing.

MODULE 3: (7 Hours)

Demand Side Management (DSM) Concepts and Programs:DSM objectives and benefits: Peak shaving, load shifting, energy conservation, Types of DSM: Strategic conservation, load management, strategic load growth, Tariff structures: Time-of-Use (TOU), Critical Peak Pricing (CPP), Real-Time Pricing (RTP), Demand Response: Direct Load Control, Incentive-based programs, Role of aggregators and demand response markets

MODULE 4: (8 Hours)

Integration of AMI and DSM for Smart Grids: AMI as an enabler of DSM and DR, Load forecasting using smart meter data, Consumer behavior analytics and energy dashboards, Home Energy Management Systems (HEMS), Role of AI/ML in predictive DSM, Policy frameworks and regulatory guidelines (CEA, CERC, FERC), Case studies: India

TEXT BOOKS:

1. Smart Grid: Technology and Applications, Janaka Ekanayake et al., Wiley, 2012

2. Smart Grids: Infrastructure, Technology and Solutions, Stuart Borlase, CRC Press, 2013

REFERENCE BOOKS:

1. Mini S. Thomas and John D. McDonald, *Power System SCADA and Smart Grids*, CRC Press, 2015
2. Gellings, C., *The Smart Grid: Enabling Energy Efficiency and Demand Response*, CRC Press, 2020
3. CEA & ISGF reports on Smart Metering and DSM in India

CO-PO-PSO MAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	–	–	–	–	–	–	–	–	1	2	1
CO2	3	3	2	2	2	–	–	–	–	–	–	2	3	2
CO3	2	2	3	2	2	1	–	–	–	–	–	2	3	3
CO4	2	3	3	3	2	2	–	–	–	–	–	3	3	3

SUBJECT NAME	SUBJECTCODE	L-T-P	CREDIT
Data Analytics and Machine Learning for Smart Grid Applications	EE4262	3-0-0	3

PRE-REQUISITES:

1. Basics of Power Systems
2. Fundamentals of Smart Grids

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to:

CO Code	Course Outcome	Bloom's Level
CO1	Understand the structure, types, and challenges of smart grid data	Understand (L2)
CO2	Apply core ML techniques to load forecasting, anomaly detection, and profiling	Apply (L3)
CO3	Analyze smart grid operations using supervised and unsupervised models	Analyze (L4)
CO4	Evaluate and implement advanced AI/ML solutions for intelligent grid decisions	Evaluate/Create (L5)

MODULE 1: (8 Hours)

Introduction to Data Analytics and Smart Grid Data Sources: Overview of smart grid architecture and data flow, Data types in smart grids: AMI, SCADA, PMU, DERs, EVs. Characteristics of smart grid data: volume, velocity, variety, veracity, Basics of data analytics: pre-processing, normalization, missing data handling, Exploratory data analysis and visualization (using Python/Pandas/Matplotlib), Introduction to time-series data and multivariate sensor datasets

MODULE 2: (8 Hours)

Machine Learning Fundamentals for Smart Grids: Overview of supervised and unsupervised learning, Regression models: Linear, Polynomial, Classification models: kNN, SVM, Decision Trees, Random Forests, Clustering: k-means, hierarchical clustering for load pattern analysis, Model selection, performance evaluation (RMSE, accuracy, F1 score, AUC)

MODULE 3: (8 Hours)

Applications in Load Forecasting, Demand Response, and Power Quality: Short-term and long-term load forecasting using ML models, Load disaggregation and customer profiling, Energy theft detection using anomaly detection techniques, Power quality classification using sensor data, Predictive models for demand response and price elasticity, Case studies using real or simulated smart meter datasets (e.g., UCI or Smart Meter Texas)

MODULE 4: (8 Hours)

Deep learning: Introduction to ANN, RNN, and LSTM for sequential grid data, Real-time analytics and edge computing in smart grids. AI for fault detection, predictive maintenance, and cyberattack detection, Big data platforms: Hadoop, Spark, and cloud analytics for smart grids, Data privacy and cybersecurity in ML for energy systems,India Smart Grid Forum.

TEXT BOOKS:

1. James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley, 1st edition, 2012
2. S. Chakrabarti et al., *Data Analytics for Intelligent Grid Systems*, CRC Press
3. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly, 2019

REFERENCE BOOKS:

1. Mini S. Thomas and John D. McDonald, *Power System SCADA and Smart Grids*, CRC Press, 2015
2. Gellings, C., *The Smart Grid: Enabling Energy Efficiency and Demand Response*, CRC Press, 2009
3. CEA & ISGF reports on Smart Metering and DSM in India

CO-POMAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	–	2	–	–	–	–	–	–	2	2	2
CO2	3	3	2	2	3	–	–	–	–	–	–	2	3	3
CO3	3	3	3	2	3	–	–	–	–	–	–	2	3	3
CO4	3	3	3	3	3	–	–	–	–	–	–	3	3	3

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Power System and PowerElectronics Lab	EE3562	0-0-3	1.5

PREREQUISITES:

2. Power System
3. Basic Electronics

COURSEOUTCOMES:

At the end of this course, students will able to

CO Code	Course Outcome	Bloom's Level
CO1	Investigate the performance of protective relays, such as over-current relays, biased differential relays, distance relays, and over/under voltage relays and plot their characteristics.	Analyze(L4)
CO2	Conduct steady-state and fault analysis of power systems, including short-circuit, load flow, and fault location analysis.	Apply (L3)
CO3	Acquire knowledge of V-I characteristics of various Power Semiconductor devices and able to design and simulate their base/gate drive circuits and understand the design of cosine controlled triggering circuit of SCR.	Design (L6)
CO4	Validate the output performances of different controlled rectifier circuits with various loading conditions and design of different DC-DC converter circuits	Evaluate(L5)

List of Experiments
Any 10 to be performed

1. To determine negative and zero sequence synchronous reactance of an alternator.
2. To determine sub-transient direct axis and sub-transient quadrature axis synchronous reactance of a 3-phase salient pole alternator.
3. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation.
4. To study the Electromechanical type IDMT over-current relay and with different plug setting and time setting multipliers and plot its time - current characteristics.
5. To determine the operating characteristics of biased different relay with different bias settings.
6. Study of the V-I characteristics of SCR, TRIAC and MOSFET.
7. Study of single-phase full wavecontrolled rectifier circuits (mid-point and Bridge type) with R and R-L Load.
8. Study of three phase full-wave controlled rectifier circuits (Full and Semi converter) with R and R- L Load.
9. Study of the Buck converter and boost converter.
10. Study of single phase ac voltage regulator.
11. Study of the three phase PWM voltage source inverter.

TEXT BOOKS:

1. J. Grainger, W. D. Stevenson and G. W. Chang,” Power System Analysis”, McGraw Hill Education, 1994.
2. M. H. Rashid,” Power electronics: circuits, devices, and applications”, Pearson Education India, 2009.

REFERENCE BOOKS:

1. J. Grainger and W. D. Stevenson,” Power System Analysis”, McGraw Hill Education, 2017.
2. A. R. Bergen and V. Vittal,” Power System Analysis”, Pearson Education Inc, 1999.
3. N. Mohan and T. M. Undeland,” Power Electronics: Converters, Applications and Design”, John Wiley & Sons, 2007.

CO-PO-PSOMAPPING

(1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	2	-	-	-	2	1	-	3	3	3
CO2	3	3	3	2	3	-	-	-	2	1	2	3	3	2
CO3	3	2	3	1	3	-	-	-	-	-	-	-	3	2
CO4	2	3	2	3	2	-	-	-	-	-	-	-	3	2

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Smart Grid Simulation Lab	EE4561	0-0-3	1.5

PREREQUISITES:

1. Power System
2. Smart Grid

COURSEOUTCOMES:

At the end of this course, students will able to

CO Code	Course Outcome	Bloom's Level
CO1	Understand various aspects of smart grid technologies, components, architectures, and applications	Understand (L2)
CO2	Study and compare the advanced metering and communication infrastructure and justify the feasibility of the same for smart grid applications.	Analyze (L4)
CO3	To have a better understanding and identify the scope for power quality management, demand side management and communication system for the smart grids	Evaluate (L5)
CO4	Apply load modeling techniques, demand side management, demand response implementation, power quality assessment techniques in smart grid operations	Apply (L3)

List of Experiments

1. Study and analysis of Smart Grid components: Understanding the architecture, layers (physical, communication, control), and role of AMI, DERs, PMUs, and smart meters.
2. Simulation and analysis of DC Microgrid System: Configuration, control strategy, power flow management, and stability in DC-based systems with solar PV and battery.
3. Simulation and analysis of AC Microgrid System: Study grid-connected vs islanded modes, synchronization, reactive power management, and voltage control.
4. Study and simulation of protection schemes for distributed energy resources (DERs) like solar PV and wind using overcurrent, directional relays
5. Modeling and simulation of grid-connected solar PV with MPPT (Perturb & Observe method) under varying irradiance.
6. Simulation of a hybrid power system (PV + Battery Energy Storage System + Diesel Generator): Power management strategy and SOC tracking using MATLAB/Simulink.
7. Modeling and simulation of an Electric Vehicle (EV) Charging Infrastructure: Analyze grid impact, charging profiles, and integration with solar PV in a smart grid.
8. Design and simulation of protection schemes for active distribution networks with distributed generation using ETAP, including fault analysis and relay coordination.

9. Design and visualization of an integrated smart grid system comprising generation, transmission, distribution, and DER integration using simulation tools like MATLAB/ETAP/OpenDSS.

TEXT BOOKS:

1. Ekanayake J, Jenkins N., Liyanage K., Wu, J., Yokoyama A., Smart Grid: Technology and applications, Wiley Publications, 2012.
2. Stuart Borlase, Smart Grid: Infrastructure, Technology and Solutions, CRC Press, 2017.

REFERENCE BOOKS:

1. Momoh J., “Smart Grid: Fundamentals of design and analysis”, John Wiley & Sons, 2012.
2. S. K. Salman, “Introduction to the Smart Grid: Concepts, Technologies and Evolution”, IET Energy Engineering Series, 1st Edition, 2017.

CO-PO-PSOMAPPING

(1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	–	2	–	–	–	–	–	–	1	2	1
CO2	3	3	2	2	3	–	–	–	–	–	–	2	3	2
CO3	2	3	2	2	2	1	–	–	–	–	–	2	3	2
CO4	3	3	3	3	3	2	–	–	–	–	–	3	3	3

Minor Course offered by School of Electrical Sciences

"Minor in Electric Vehicle and E-mobility"

Sl. No.	Course Code	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	SEM-5	EE3263	Basics of Electrical Vehicles	3-0-0	3
2	SEM-6	EE3264	Power Electronics for E-Mobility	3-0-0	3
3	SEM-7	EE4265	Energy Storage Systems and Battery Management	3-0-0	3
4	SEM-7	EE4267	EV Charging Infrastructure and Grid Integration	3-0-0	3
5	SEM-8	EE4264	Motors for E-mobility and their control	3-0-0	3
Subject (Sessional)					
6	SEM-6	EE3564	Power Electronics and Drives Lab	0-0-3	1.5
7	SEM-7	EE3563	Electric Vehicle Lab	0-0-3	1.5
			Total	**15-0-6**	**18**

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Basics of Electrical Vehicles	EE3263	0-0-3	3

Prerequisites: Basic Electrical Engineering, Engineering Mechanics or Physics

Course Outcome:

At the end of the course, the students will able to:

CO Code	Course Outcome	Bloom's Level
CO1	Understand the evolution, motivation, and policies behind electric vehicle development	Understand (L2)
CO2	Classify EV types and analyze their architectures, components, and energy sources	Analyze (L4)
CO3	Evaluate vehicle dynamics and performance characteristics of electric vehicles	Evaluate (L5)
CO4	Apply knowledge of propulsion systems, charging infrastructure, and identify emerging EV trends	Apply (L3)

Module 1: Introduction, Evolution, and Classification of EVs (9 Hours)

Evolution of automotive propulsion: From steam and ICE to hybrids and EVs**,** Historical milestones and technological breakthroughs in EV development**,** Environmental and economic motivations: Emissions, energy efficiency, lifecycle cost.

Comparison of ICE vs EV in terms of emissions, maintenance, performance, Overview of global and Indian EV markets. Major manufacturers and models.

Government policies and missions: FAME I & II, NEMMP 2020, GST & tax benefits.

Classification of EVs: 2W, 3W, 4W, Buses, Passenger vs Commercial, Introduction to Vehicle-to-Grid (V2G), bidirectional power flow.

Module 2: Types, Architectures, and Energy Storage in EVs (9 Hours)

EV Types: Battery Electric Vehicles (BEV), Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV), Fuel Cell Electric Vehicles (FCEV), Block diagrams of typical BEV and HEV systems, Hybrid configurations: Series, Parallel, Series-Parallel, Plug-in

Energy sources: Battery types (Lead-acid, NiMH, Li-ion, LFP, NMC), Fuel cells (PEMFC basics), Super capacitors, Battery specifications: Capacity, C-rate, SOC/SOH, efficiency

BMS: Functionality, protection, thermal management, balancing, Overview of energy management strategies in hybrids and EVs

Module 3: Vehicle Dynamics and Performance Analysis (10 Hours)

Forces on vehicle: Aerodynamic drag, rolling resistance, gradient force, Tractive effort, motor torque and power calculation, Acceleration, deceleration, and braking performance, Introduction to drive cycles: NEDC, WLTP, UDDS, FTP, IDC. Energy consumption estimation from drive cycles, Range estimation and influencing factors: terrain, speed, auxiliary loads

Basics of regenerative braking and energy recovery, Case studies: Performance analysis of real-world EVs in different environments.

Module 4: EV Components, Charging Infrastructure, and Trends (8 Hours)

Electric propulsion systems: DC Motors, Induction Motors, BLDC, PMSM (structure, efficiency, use cases)

Power converters: Inverters, DC-DC converters, on-board/ off board chargers

Controllers: Motor controller basics, switching strategies

Charging Infrastructure: Charging levels (AC Level 1, Level 2, DC fast charging), Charging connectors: CHAdeMO, CCS, Bharat AC/DC, Charging types: Slow/fast, on-board/off-board, wireless (intro).

Smart charging, connected charging, and V2G, Future technologies: Solid-state batteries, AI-based BMS, autonomous EVs.

Textbooks:

1. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Edition, 2012
2. Mehrdad Ehsani, Yimin Gao, Stefano Longo, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press, 2004
3. K.T. Chau, *Electric Vehicle Machines and Drives*, Wiley, 2015

References books:

1. NITI Aayog – *EV Vision Documents & Roadmaps*
2. ARAI – AIS Standards for EV Safety and Testing
3. Ministry of Power, MNRE, FAME II Policy Reports
4. OEM Tech Reports – Tata Motors, Mahindra, Tesla, Bosch EV whitepapers

CO-PO-PSO MAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	1	2	-	-	-	-	-	1	-
CO2	2	2	2	-	-	-	2	-	-	-	-	-	2	1
CO3	3	2	2	2	-	-	-	-	-	-	-	-	2	2
CO4	2	2	2	1	2	1	3	-	-	1	-	1	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power Electronics for E-Mobility	EE3264	0-0-3	3

Prerequisites: Basic Electronics

Course Outcome:

At the end of the course, the students will able to:

CO Code	Course Outcome	Bloom's Level
CO1	Understand the operation and characteristics of power semiconductor devices and their gate drive requirements in EV applications.	Understand (Level 2)
CO2	Analyze and compare AC-DC and DC-DC converter topologies used in EV charging, traction, and auxiliary systems.	Analyze (Level 4)
CO3	Design and simulate inverter circuits and control strategies for driving electric motors in EVs.	Design (Level 6)
CO4	Evaluate the performance and integration of advanced converter systems for high-efficiency and fault-tolerant EV operation.	Evaluate (Level 5)

Module 1: Power Semiconductor Devices and AC-DC Converters for EV (9 Hours)

Review of Power Semiconductor Switches: Ideal vs practical switch characteristics. Power Diode, SCR, Power MOSFET, IGBT: Static and dynamic characteristics, Switching losses, thermal considerations.

Introduction to Power Electronics in EVs: Role of converters in EVs: Traction, charging, auxiliary loads, Overview of EV powertrain and energy flow

AC-DC Converters for EV Charging: Basics of single-phase Uncontrolled and controlled rectifiers, Bidirectional converters for V2G applications, Grid interface issues: Harmonics, power quality (IEEE 519, IEC standards)

Module 2: DC-DC Converters for Traction and Auxiliary Systems (8 Hours)

Non-Isolated DC-DC Converters: Buck, Boost, Buck-Boost converters: Operation, waveforms, design equations.

Isolated DC-DC Converters: Need for isolation in EV systems. Half-bridge and Full-bridge converters.

Bidirectional DC-DC Converters: Importance in regenerative braking and BMS, Bidirectional Buck-Boost converters, Design considerations for traction and energy storage interface

Module 3: DC-AC Converters (Inverters) for Motor Drives (8 Hours)

Voltage Source Inverters (VSI): Single-phase and three-phase inverters, Sinusoidal PWM (SPWM), Modified SPWM, and SVPWM, Role of Inverters in EV Traction.

Module 4: Advanced Converter Topologies & Integration in EV Systems (7 Hours)

Advanced Converter Concepts: Interleaved converters, Dual Active Bridge (DAB) converter, Applications in fast chargers

Converter Integration: Onboard Charger (OBC) converter design and topology selection

Textbooks:

1. M. H. Rashid, *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson Education, 2014.
2. Ali Emadi, *Electric and Hybrid Vehicles: Technologies, Modeling and Control* , CRC Press, 2014.

References books:

1. N. Mohan, *Power Electronics: Converters, Applications and Design* , 3rd Edition, Wiley India, 2003.

CO-PO-PSO MAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

COs \ POs / PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	
CO2	3	3	2										3	1
CO3	3	2	3	2	3								3	3
CO4	2	3	3	2	2								3	2

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Energy Storage Systems and Battery Management	EE4265	3-0-0	3

Prerequisites: Engineering Chemistry, Basic Electrical Engineering

Course Outcome:

At the end of the course, the students will able to:

CO	Course Outcome	Bloom's Level
CO1	Understand the characteristics, performance parameters, and classification of different energy storage systems used in electric vehicles.	Understand (Level 2)
CO2	Analyze the electrical and thermal behavior of batteries and apply suitable charging techniques for EV applications.	Analyze (Level 4)
CO3	Design and evaluate Battery Management System (BMS) architectures, balancing methods, and protection mechanisms for EV batteries.	Design (Level 6)
CO4	Estimate state parameters (SoC, SoH) and integrate battery packs and BMS with electric vehicle powertrain systems.	Evaluate (Level 5)

Module 1: Introduction to Energy Storage Technologies (9 Hours)

Importance of energy storage in EVs. Classification of energy storage systems: Mechanical (flywheels), Electrical (supercapacitors), Electrochemical (batteries, fuel cells). Selection criteria for EV applications: Energy density, power density, charge/discharge rate, life cycle, cost

Overview of: Lead-Acid Batteries, Nickel-based batteries (NiMH), Lithium-based batteries (Li-ion, $LiFePO_4$, LTO, NMC). Supercapacitors: Types, characteristics, and comparison with batteries.

Module 2: Battery Modelling, Charging, and Thermal Management (9 Hours)

Electrical equivalent circuit models (Thevenin, R_{int}, RC models). Battery performance parameters: SoC, DoD, C-rate, efficiency.

Battery charging techniques: CC-CV (Constant Current–Constant Voltage), Multistage and pulse charging. Fast charging impact on battery life, Battery degradation and aging models

Battery thermal characteristics, Thermal management systems: Air, liquid, PCM-based cooling

Module 3: Battery Management System (BMS) Architecture and Operation (8 Hours)

Functions of a BMS: Monitoring, Protection, Balancing, Communication, Logging. BMS architecture: Centralized, Distributed, Modular. Sensing circuits: Voltage, current, temperature. Battery cell balancing techniques: Passive vs active balancing. Communication protocols: CAN, LIN. Protection strategies: Overvoltage, under voltage, short circuit, over temperature. Integration with vehicle control unit (VCU) and motor drive systems

Module 4: State Estimation and Integration with EV Systems (8 Hours)

State of Charge (SoC) estimation methods: Coulomb counting, open-circuit voltage (OCV), Kalman filters. State of Health (SoH) and State of Power (SoP) estimation. Battery diagnostics and fault detection. Battery pack design and integration: Series/parallel configuration, Safety and packaging considerations. Battery and BMS integration with EV powertrain: Energy flow control, power distribution, regenerative braking, Case studies of commercial EV battery systems

Textbooks:

1. M. Ehsani, Y. Gao, S. E. Gay, and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, 2nd Edition, CRC Press, 2009.

2. G. Pistoia, Battery Operated Devices and Systems: From Portable Electronics to Industrial Products, Elsevier, 2008.

References:

1. Rui Xiong, Battery Management Algorithm for Electric Vehicles, Springer, 2019.

CO-PO-PSO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs \ POs / PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	
CO2	2	3	2	2	2								3	1
CO3	2	2	3	3	3								3	2
CO4	2	3	2	2	3								3	3

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
EV Charging Infrastructure and Grid Integration	EE4267	3-0-0	3

PREREQUISITES:

1. Basics of EV
2. Power Electronics

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO	Course Outcome	Bloom's Level
CO1	Understand the fundamentals of Electric Vehicle (EV) charging infrastructure	Understand (L2)
CO2	Analyze the integration of EV charging systems with the electrical grid	Analyze (L4)
CO3	Explore standards, protocols, and emerging technologies in EV charging	Apply (L3)
CO4	Evaluate the impact of EV charging on grid stability and energy management	Create (L5)

MODULE 1 **(8 hours)**

Fundamentals of Electric Vehicles and Charging: Overview of electric vehicles (EVs): Types, architecture, and components, Battery characteristics and charging requirements, EV charging infrastructure: Types (Level 1, Level 2, DC fast charging)

MODULE 2 **(8 hours)**

EV Charging Technologies: AC and DC charging technologies, On-board and off-board chargers, Wireless (inductive) charging techniques, Smart and bidirectional charging (V2G and V2H concepts), Emerging trends in EV charging -ultra-fast charging, battery swapping, brief idea on power electronics converter used for EV charging

MODULE 3 **(8hours)**

Grid Integration of EVs: Impact of EV charging on the power grid, Load management and demand response strategies, Grid codes and interconnection standards, Energy storage integration and renewable energy support

MODULE 4 **(10 hours)**

Planning and Deployment of Charging Infrastructure: Site selection and planning of EV charging stations, Power requirements and utility coordination, Economics and business models of charging infrastructure, Case studies and policy frameworks, Cybersecurity and communication protocols (OCPP, ISO 15118), brief idea on AI and IoT applications in EV infrastructure, Government policies and incentives (global and Indian context)

TEXT BOOKS:

1. Electric Vehicle Technology Explained – James Larminie and John Lowry, Wiley online library,
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles – Mehrdad Ehsani, Yimin Gao, Stefano Longo, and Kambiz Ebrahimi, CRC Press, 3rd edition, 2018

REFERENCE BOOKS:

1. Electric Vehicles: Prospects and Challenges – Tariq Muneer, Irene Illescas García, and Mohammad Asif
2. EV Charging Done Right: The Promises and Perils of Offering Electric Vehicle Charging Services, Emily V Rogers , Sheri Mueller, John P Mitton , 2024

CO-PO-PSO MAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	2	-	-	-	-	2	2	1
CO2	3	3	2	2	2	-	2	-	-	-	-	2	2	2
CO3	3	3	3	3	2	2	3	-	-	-	-	2	2	3
CO4	3	2	3	2	3	2	3	-	-	2	2	3	2	3

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Motors for E-mobility and their control	EE4264	3-0-0	3

Pre-requisites: Electrical Machines, Power Electronics, Basics of Electric Vehicles

Course Outcome:

At the end of the course, the students will able to:

CO Code	Course Outcome	Bloom's Level
CO1	Understand the operating principles, characteristics, and applications of various electric motors used in electric vehicles.	Understand (Level 2)
CO2	Analyze and model BLDC, PMSM, and IM drives and their control strategies such as FOC, DTC, and sensorless methods.	Analyze (Level 4)
CO3	Design control systems for EV motor drives including torque, speed, and current controllers for BLDC, PMSM, IM, and SRM.	Design (Level 6)
CO4	Evaluate the suitability of different motor technologies for EV applications based on performance, efficiency, cost, and control complexity.	Evaluate (Level 5)

Module 1: Overview of Electric Motors for E-Mobility (8 Hours)

Motor requirements for EVs: torque-speed characteristics, efficiency, size, cost, control flexibility. Comparison of motor types for EVs: DC, AC, BLDC, PMSM, IM, SRM. Classification based on operation and construction. Torque-speed profiles of EV drive cycles (city, highway, hill). Losses in motors: copper, core, stray, mechanical. Regenerative braking potential and impact on motor design.

Module 2: BLDC and PMSM Drives (10 Hours)

Brushless DC Motor (BLDC): Construction, operation, trapezoidal back-EMF. Electronic commutation. Hall sensor and sensorless control. Current control and torque control. Applications in 2-wheelers, light EVs.

Permanent Magnet Synchronous Motor (PMSM): Construction, sinusoidal back-EMF. d-q axis modelling. Torque equation and field-oriented control (FOC). Comparison with BLDC (performance and control). Torque ripple, demagnetization, thermal management in PM motors.

Module 3: Induction Motor (IM) Drives for EVs (9 Hours)

IM construction and types (squirrel cage, wound rotor), Principle of operation and equivalent circuit. Torque-slip characteristics and efficiency. Field-oriented control (FOC) and vector control. Direct Torque Control (DTC), Applications in high-power EVs.

Module 4: SRM and Motor Control Integration in EVs (8 Hours)

SRM construction and working principle, Torque production and inductance profile, Voltage and torque equations. Power converter topology for SRM, Turn-on/turn-off angle control. Advantages: fault tolerance, low cost; Challenges: torque ripple, acoustic noise

Integration of motor, controller, inverter in EV drive systems. Case studies on motor drive system design for EVs.

Textbooks:

1. I. Husain, Electric and Hybrid Vehicles: Design Fundamentals, 2nd Edition, CRC Press, 2011.
2. R. Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Pearson Education, 2001.

References:

1. Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson Education, 2002.
2. Ned Mohan, Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB/Simulink, Wiley, 2014.

CO-PO-PSO MAPPING

(*1-Weak Correlation;2-Medium correlation;3-Strong Correlation)*

COs \ POs / PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	
CO2	3	3	2	2	2								3	2
CO3	2	2	3	2	3								3	3
CO4	2	3	2	2	2								3	2

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Power Electronics and Drives Laboratory	EE3564	0-0-3	1.5

Prerequisites:
1. Power Electronics.
2. Electrical Machines.

COURSE OUTCOMES:
At the end of this course, students will able to

CO Code	Course Outcome	Bloom's Level
CO1	Acquire knowledge of V-I characteristics of various Power Semiconductor devices and able to design and simulate their base/gate drive circuits and understand the design of cosine controlled triggering circuit of SCR.	Design (L6)
CO2	Validate the output performances of different controlled rectifier circuits with various loading conditions and design of different DC-DC converter circuits	Evaluate (L5)
CO3	Analyze and verify the speed-torque characteristics of DC and AC motors using different control techniques.	Analyze (L4)
CO4	Implement and test power electronic converter circuits for controlling electric drives.	Apply (L3)

List of Experiments
Any 10 to be performed

1. Study of the V-I characteristics of SCR, TRIAC and MOSFET.
2. Study of single-phase full-wave controlled rectifier circuits (mid-point and Bridge type) with R and R-L Load.
3. Study of three phase full-wave controlled rectifier circuits (Full and Semi converter) with R and R- L Load.
4. Study of the Buck converter and boost converter.
5. Study of single-phase ac voltage regulator.
6. Study of the three phase PWM voltage source inverter using lamp load.
7. Speed Control of Separately Excited DC Shunt Motor using Single Phase Fully Controlled AC to DC Converter.
8. Speed Control of Separately Excited DC Shunt Motor using Three Phase Fully Controlled AC to DC Converter.
9. Speed Control of Single-Phase Induction Motor by using Single Phase AC to AC Converter.
10. Speed Control of Three Phase Slip Ring Induction Motor using Rheostatic Control Method.
11. Speed Control of Separately Excited DC Shunt Motor using Single Phase Dual Converter.
12. Speed Control of Three Phase Squirrel Cage Induction Motor using Variable Voltage Variable Frequency Three Phase PWM Inverter.

TEXT BOOKS:

1. M. H. Rashid,” Power electronics: circuits, devices, and applications”, Pearson Education India, 2009.
2. G. K. Dubey,” Fundamentals of Electrical Drives”, CRC Press, 2002.

REFERENCE BOOKS:

1. R. W. Erickson and D. Maksimovic,” Fundamentals of Power Electronics”, Springer Science& Business Media,2007.
2. R. Krishnan,” Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall 2001.

CO-PO-PSO MAPPING

(1-Weak Correlation;2-Medium correlation;3-Strong Correlation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	1	3	-	-	-	-	-	-	-	3	2
CO2	2	3	2	3	2	-	-	-	-	-	-	-	3	2
CO3	2	2	3	3	3	-	-	-	-	-	-	-	3	3
CO4	2	2	2	2	3	-	-	-	-	-	-	-	3	3

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Electric Vehicle Lab	EE3563	0-0-3	1.5

Course Outcome:

At the end of the course, the students will able to:

CO Code	Course Outcome	Bloom's Level
CO1	Understand the modeling and simulation of electric vehicle subsystems including drivetrain, battery, and motor drives.	Understand (Level 2)
CO2	Simulate and analyze power electronic converter circuits and their control for EV traction and charging applications.	Analyze (Level 4)
CO3	Implement state estimation and control strategies for battery management, energy recovery, and grid integration in EV systems.	Apply, Analyze (L3, L4)
CO4	Design and evaluate motor control algorithms (FOC, DTC, commutation) for BLDC, PMSM, IM, and SRM motors in EVs using simulation tools.	Design, Evaluate (L6, L5)

List of Experiments
Any 10 to be performed

1. Modeling and Simulation of a Basic Electric Vehicle Drive train
2. Simulation of DC-DC Buck Converter for EV
3. Simulation of DC-DC Boost Converter for EV
4. Simulation of Bidirectional DC-DC Converter for EV
5. Simulation of a single-phase DC-AC converter for EV
6. Simulation of three phase DC-AC converter for EV
7. Simulation of a Single-phase Controlled Rectifier for Onboard EV Charger (AC-DC conversion)
8. Battery Modeling for EV
9. State-of-Charge (SoC) Estimation of battery for EV
10. Speed control of Induction Motor for EV applications
11. Speed control of Switched Reluctance Motor for EV applications

TEXT BOOKS:

1. M. H. Rashid," Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
2. G. K. Dubey," Fundamentals of Electrical Drives", CRC Press, 2002.

REFERENCE BOOKS:

1. R. W. Erickson and D. Maksimovic," Fundamentals of Power Electronics", Springer Science& Business Media,2007.
2. R. Krishnan," Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall 2001.

CO-PO-PSO MAPPING

(*1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)*

COs \ POs / PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2			2								3	
CO2	2	3	2	2	3								3	2
CO3	2	3	2	2	3								3	3
CO4	3	3	3	2	3								3	3

List of Open Elective Subjects offered by School of Electrical Sciences:

OPEN ELECTIVES I (ODD SEM)

1. EE4301 Renewable Energy Technologies
2. EE4303: Electric and Hybrid Vehicle

OPEN ELECTIVES II, III & IV (EVEN SEM)

1. EE4302: Energy Management and Auditing
2. EE4304: Energy Conversion Devices
3. EE4306: Hybrid Storage Systems

SUBJECT NAME	SUBJECTCODE	L-T-P	CREDIT
Renewable Energy Technologies	EE4301	3-0-0	3

Prerequisites:

1. Basic Electrical Engineering
2. Basic Electronics Engineering

COURSE OUTCOMES:

After successfully completing this course a student will able to:

CO	Course Outcome Statement	Bloom's Taxonomy Level
CO1	Analyze the energy scenario and the consequent growth of the power generation from renewable energy sources	Understand (Level 2)
CO2	Explain the basic physics of wind and solar power generation	Analyze (Level 4)
CO3	Synthesize the power electronic interfaces for wind and solar generation	Apply (Level 3)
CO4	Resolve the issues related to the grid-integration of solar and wind energy systems.	Evaluate (Level 5)

Module 1: (10 Hours)

Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources.

Wind Generator Topologies: Wind power statistics of India and world, Wind physics; roll, yaw and pitch; Betz limit, tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions.
Review of modern Wind turbine technologies: HAWT, VAWT, fixed and variable speed Wind turbines

Module 2: (10 Hours)

Solar Energy Basics- extra-terrestrial and terrestrial radiation, solar radiation measuring instruments, Solar Geometry concepts

Solar Photovoltaic and Solar Thermal Power Generation: Solar photovoltaic: Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, power electronic converters for solar systems, introduction to maximum power point tracking (MPPT) algorithm – P&O, INC

Solar thermal technologies: flat plate collector, parabolic trough, central receivers, parabolic dish, Fresnel, solar pond

Module 3: (10 Hours)

Biomass Power: Principles of biomass conversion, Combustion and fermentation, Anaerobic digestion, Types of biogas digester, Wood gasifier, Pyrolysis, Applications, Biogas, Biodiesel

Brief idea on Fuel cells, Battery Storage Technology.

Basics of Geothermal Energy and Hydro Energy

Text Books:

1. T. Ackermann,” Wind Power in Power Systems”, John Wiley and Sons Ltd.,2005.
2. G. M. Masters,” Renewable and Efficient Electric Power Systems”, John Wiley and Sons,2004.
3. H. Siegfried and R. Waddington,” Grid integration of wind energy con- version systems”, John Wiley and Sons Ltd.,2006.
4. C. S. Solanki,” Solar Photovoltaics Fundamentals, Technologies and Applications”, PHI Learning Private limited, third edition April2015.

Reference Books:

1. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
2. D.P.Kothari, K.C.Singal, RakeshRanjan, Renewable Energy Sources and Emerging Technologies, Prentice Hall of India, New Delhi, 2009.
3. A. K. Tripathy. Multiple Choice Questions on Renewable Energy. ISBN: 9788179931288
4. Seema Behera, Bishnupriya Dash, Renewable Energy System, Engineer's Mind Publications, 2012 (first edition).
5. S. N. Bhadra, D. Kastha, S. Banerjee - Wind Electrical Systems-Oxford University Press (2013).

CO-PO MAPPING

(1-Weak Correlation; 2-Medium correlation; 3-Strong Correlation)

CO s	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	3	3	0	0	0	0	0	3	3
CO2	3	3	2	3	2	3	3	0	0	0	0	0	3	3
CO3	3	3	3	3	2	3	3	0	0	0	0	0	3	3
CO4	3	3	2	2	2	3	3	0	0	0	0	0	3	3

SUBJECT NAME	SUBJECTCODE	L-T-P	CREDIT
Electric and Hybrid Vehicles	EE4311	3-0-0	3

COURSE OUTCOMES:
After successfully completing this course a student will able to:

CO	Course Outcome Statement	Bloom's Taxonomy Level
CO1	Describe the architecture, classifications, and components of electric vehicles, and explain their operation.	Understand (Level 2)
CO2	Analyze power flow, vehicle dynamics, and control strategies for electric propulsion systems using fundamental engineering principles.	Analyze (Level 4)
CO3	Apply the principles of power electronics and electric drives to evaluate the performance of EV propulsion systems and regenerative braking techniques.	Apply (Level 3)
CO4	Evaluate energy storage technologies, grid integration techniques for EVs, including V2G and smart charging concepts.	Evaluate (Level 5)

Module-I **(08 Hours)**
Introduction to Hybrid Electric Vehicles(EVs):
Overview of Electric Vehicles: Past, Present & Future of EV, Current market trends and major challenges, Comparison of EVs with Internal Combustion Engine (ICE) vehicles
Fundamentals of EVs & Hybridization: Classification of BEV, HEV, PHEV, FCEV. Series, Parallel & Series-Parallel Hybrid Systems. Power flow control & fuel efficiency analysis. In-wheel drives and multiple motor configurations.
Vehicle Dynamics Fundamentals: Vehicle kinematics and resistances (rolling, aerodynamic, grading). Dynamic equations for EVs. Maximum tractive effort and powertrain considerations.

Module-II **(09 Hours)**
Power Electronics & Electric Drives in EVs:
Power Electronics in EVs: DC/DC converters for EV applications, non-isolated bidirectional DC-DC converter. Voltage source inverters and PWM techniques. Regenerative braking systems. Onboard & offboard EV battery chargers
Electric Machines and Drives: Overview of Induction Motor (IM), Permanent Magnet Synchronous Motor (PMSM), Brushless DC Motor (BLDC), Switched Reluctance Motor (SRM) for EV application.
Fundamental of Motor control strategies.

Module-III **(06 Hours)**
EV Charging & Grid Integration:
EV Charging Infrastructure & Technologies: Types of EV charging (Slow, Fast, DC Fast Charging), Charging station components & requirements, Wireless charging & ultra-fast charging trends.
Grid Integration & Vehicle-to-Grid (V2G) Technology: Grid-to-Vehicle (G2V) & Vehicle-to-Grid (V2G) concepts, Impact of EVs on the power grid, smart charging & energy management.

Module-IV **(07 Hours)**
Energy Storage Systems & Battery Management
Battery Technologies for EVs: Battery chemistry, characteristics & performance analysis of Lead-acid, NiMH, Li-ion. Supercapacitors & Basics of Hydrogen Fuel Cells.
Battery Management System (BMS): Functions & need for BMS in EVs. State-of-charge (SoC) and state-of-health (SoH) estimation. Thermal management & safety concerns.

Future Trends & Developments in EVs: Solid-state batteries & alternative energy sources, Autonomous & connected EV technologies**,** Sustainable mobility & policy trends.

Text Book:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2021
2. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2012.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2005.
3. hrisMi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011
4. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	2	2	-	-	-	-	2	2	1
CO2	3	3	3	3	2	1	2	-	-	-	-	2	3	2
CO3	3	3	3	2	3	0	1	-	-	-	-	2	3	3
CO4	3	3	3	3	2	2	3	-	-	-	-	2	3	2

SUBJECT NAME	SUBJECTCODE	L-T-P	CREDIT
Energy Management and Auditing	EE4302	3-0-0	3

Prerequisites:

1. Basic Electrical Engineering

Course Outcomes

At the end of the course, students will be able to:

Course code	Course Outcome	Bloom's Level
CO1	Understand the importance of energy conservation from both financial and environmental perspectives.	Understand Level-2
CO2	Analyze the different energy efficient technologies in electrical system	Analyze Level-4
CO3	Evaluate a detailed energy audit and evaluation of energy-saving opportunities in electrical systems.	Evaluate Level-5
CO4	Apply the concepts of energy efficiency in electrical, lighting, and industrial Systems.	Apply Level-3

Module 1 **(10 Hours)**

Energy Scenario and Economics:

Energy Scenario -An overview of Indian Energy Scenario, Energy Conservation and its importance, Energy Conservation Act and related policies, Bureau of Energy Efficiency (BEE) Regulations,Star Rating, Carbon Credit, PAT Scheme.Classification of energy conservation measures, plantenergy performance, benchmarking, and energy performance.

Energy Economics -Cash flow diagram, discount rate, payback period,internal rate of return, net present value, and life cycle cost., understanding energy costs.

Module 2 **(10 Hours)**

Energy Conservation in Electrical Systems

Energy conservation opportunities inEnergy generation, energydistribution, energy usage by processes, Electricity billing,Efficient operations of transformers, Electric motors (motor efficiencycomputation, energy efficient motors), pumps, fans, blowers, cooling towers, power factor improvement, and harmonics.

Module 3 **(08 Hours)**

Electrical Energy Audit:

Energy audit concepts, Energy auditing: Need, types, methodology and approaches; Preliminary energy auditmethodology, Detail energy audit methodology, detailedenergy audit activities,Evaluation of savingopportunities, Energy audit reporting and Energy audit instruments. Case study of energy audit in different industrial organisations / electrical utilities

Module 4 **(08 Hours)**

Energy Efficient Building: Understanding the Building Envelope, HAVC systems, Introduction to Smart Buildings, Introduction to Renewable Energy Use in building,Illumination, luminous flux, lumen, luminous intensity, candela power,brightness, glare, types of lighting (incandescent, CFL, and LED), Energy Efficient Lighting Systems, Cost Effectiveness of Efficient Lightning Technologies, Energy Saving Calculations.

TextBooks:

1. Kumar, O. Prakash, P. S. Chauhan, and S. Gautam, *Energy Management: Conservation and Audits*, 1st ed. Boca Raton, FL: CRC Press, 2020.
2. U. Desideri and F. Asdrubali, Eds., *Handbook of Energy Efficiency in Buildings: A Life Cycle Approach*, 1st ed. Oxford, UK: Butterworth-Heinemann, 2018.

Reference Books:

1. Callaghn, P. W.” Design and Management for Energy Conservation”, Pergamon Press, Oxford, 1981.
2. Dryden. I. G. C.,” The Efficient Use of Energy”, Butterworths, London, 1982.
3. I. G. C. Dryden, Ed., *The Efficient Use of Energy*, 2nd ed. London, U.K.: Butterworth Scientific, 1982
4. D. R. Patrick, S. W. Fardo, R. E. Richardson, B. W. Fardo, and M. Barron, *Energy Conservation Guidebook*, 4th ed. River Publishers, 2023.
5. A. V. Desai, Ed., *Energy Economics*. New Delhi, India: Wiley Eastern Ltd., 1990.
6. A. Thumann, W. J. Younger, and T. Niehus, *Handbook of Energy Audits*, 8th ed. Boca Raton, FL: CRC Press, 2009.
7. D. Y. Goswami and F. Kreith, Eds., *Handbook of Energy Efficiency and Renewable Energy*, 2nd ed. Boca Raton, FL: CRC Press, 2015.
8. Handbook on Energy Audit and Environment Management, Y P Abbi and Shashank Jain, TERI, 2006.
9. Howard E. Jordan, Energy-Efficient Electric Motors and TheirApplications, Plenum Pub Corp., 2nd edition, 1994.
10. CPRI Training Manual on Energy Conservation and Auditing/ Website of CPRI and BEE

CO-POMAPPING

(1-WeakCorrelation;2-Mediumcorrelation;3-StrongCorrelation)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	-	-	-	-	-	-	-	3	1
CO2	3	2	3	2	2	-	-	-	-	-	-	-	3	1
CO3	3	2	2	2	1	-	-	-	-	-	-	-	3	2
CO4	3	2	2	1	2	-	-	-	-	-	-	-	3	2

Energy Conversion Devices (3-0-0)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
Energy Conversion Devices	EE4304	3-0-0	3

Prerequisites: Basic Electrical Engineering

Course Outcomes (COs):

CO Code	Course Outcome	Bloom's Level
CO1	Explain the fundamental principles, constructional details and performance of DC machines.	Understand (Level 2)
CO2	Analyze and compare the characteristics, speed control methods and applications of various types of DC motors and generators.	Analyze (Level 4)
CO3	Describe and evaluate the operation, testing methods, voltage regulation and efficiency of single-phase and three-phase transformers.	Understand & Evaluate (Levels 2 & 5)
CO4	Explain and analyze the construction, operating principles, performance characteristics and applications of synchronous machines, induction motors and special electrical machines.	Understand & Analyze (Levels 2 & 4)

Module–I (8-Hours)

Principles of electromechanical energy conversion, construction and operation of DC machines, methods of excitation, EMF and torque equations.

DC Generator: Open circuit characteristics of separately excited and shunt generators, conditions for voltage build-up, critical resistance and critical speed, types of losses and efficiency calculation.

Module–II (7-Hours)

DC Motor: Characteristics of DC motors including separately excited, shunt, and series. Speed–armature current, torque–armature current, and speed–torque characteristics.

Speed control: Armature voltage control and field flux control of Shunt motor. Applications.

Module–III (8-Hours)

Transformer: Constructional features, EMF equation, equivalent circuit. Open circuit and Short circuit test, Losses and Efficiency.

Three-phase transformers: Constructional features, single unit and bank of three single-phase transformers, various types of connections including star-star, delta-delta, delta-star, star-delta.

Module–IV (9-Hours)

Three-Phase Synchronous Machines: Construction, principle of operation and EMF equation of synchronous generators. Operation and starting of synchronous motors.

Three-phase induction motors: Principle of operation, types, concept of slip. Torque–slip characteristics, effect of voltage and frequency on it, power flow and efficiency.

Introduction to single-phase induction motors and their applications.

TEXTBOOK(S):

3. P.S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011
4. Stephen J. Chapman, "Electric Machinery Fundamentals", McGraw Hill Education

REFERENCE BOOK(S):

5. D.P. Kothari & I.J. Nagrath, "Electric Machines", McGraw Hill Education, 2010.
6. A. E. Fitzgerald and C. Kingsley," Electric Machinery", McGraw Hill Education, 2013.
7. M. G. Say," Performance and design of AC machines", CBS Publishers, 2002.
8. A. S. Langsdorf," Alternating current machines", McGraw Hill Education, 1984.
9. P. C. Sen," Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.

Course Articulation Matrix (CO–PO Mapping):

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	–	–	–	–	1
CO2	3	3	2	2	1	1	1	–	–	–	–	1
CO3	3	3	2	2	1	1	1	–	–	–	–	1
CO4	3	3	2	2	1	1	1	–	–	–	–	1

(3: Highly related; 2: Moderately related; 1: Slightly related; –: Not related)

SUBJECTNAME	SUBJECTCODE	L-T-P	CREDIT
Hybrid Storage Systems	EE4306	3-0-0	3

Prerequisites:

6. Chemistry

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

CO Code	Course Outcome Statement	Bloom's Level
CO1	Explain the need for energy storage systems and differentiate between various conventional and modern storage technologies.	Understand (L2)
CO2	Analyze the characteristics and configurations of battery packs and evaluate their suitability for electric vehicle applications.	Analyze/Evaluate (L4/L5)
CO3	Design an optimized energy storage solution for integration with renewable energy systems and smart grid applications.	Create (L6)
CO4	Assess the safety, efficiency, and lifecycle issues in battery systems, and propose solutions for effective thermal and health management.	Evaluate/Create (L5/L6)

Module 1 (8 hours)

Introduction to Energy Storage: Relevance and scenario, Perspective on development of Energy Storage systems, Energy storage criteria, General concepts and Conventional batteries: their fundamentals andapplications. Grid connected and Off grid energy storage systems and requirements.

Module 2 (10 hours)

Introduction to energy storage for power systems: Role of energy storage systems, applications.
Overview of energy storage technologies: Thermal, Mechanical, Chemical, And Electrochemical, Electrical energy storage: Batteries, Super capacitors, Superconducting Magnetic Energy Storage (SMES), Hydrogen production and storage, introduction to fuel cell technology.

Module 3 (10 Hours)

Classification of batteries and their characteristics,Battery design for transportation, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced BatteryAssisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation, Recycling of Batteries from Electric Vehicles.

Module 4 (8 hours)

Storage for renewable energy systems: Solar energy, Wind energy, pumped hydro energy, fuel cells, energy storage in micro-grid and smart grid, and energy management with storage systems.Hybrid Energy storage systems: configurations and applications.

Text Book

1. Robert Huggins, Energy Storage, Springer, 2014th Edition.
2. Andrei G. Ter-Gazarian, Energy Storage for Power Systems (3rd Edition), IET, ISBN: 978-1-78561-867-3, 2020.

Reference Book

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.

2. Yuping Wu, Lithium-Ion Batteries: Fundamentals and Applications (Electrochemical Energy Storage and Conversion), CRC Press, 2015.
3. Patrick T. Moseley, Jürgen Garche, Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Elsevier, 2015.

CO_PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	2	1	3	–	–	–	–	1	3	2
CO2	3	3	3	2	3	–	2	–	–	1	1	2	3	3
CO3	3	3	3	2	3	–	3	–	–	2	2	3	3	3
CO4	2	3	3	2	3	–	3	–	–	1	2	3	3	3