B.E. (Electrical and Electronics Engineering)

Revised 2018 Regulations, Curriculum & Syllabi

(Candidates admitted during Academic Year 2021-2022)

Stay Ahead

BANNARI AMMAN INSTITUTE OF TECHNOLOGY

An Autonomous Institution Affiliated to Anna University - Chennai • Approved by AICTE • Accredited by NAAC with "A+" Grade

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CONTENTS

VISION OF THE DEPARTMENT

- To offer world-class education, by providing Academic and Professional competence in tune with technological and societal aspirations.

MISSION OF THE DEPARTMENT

- To produce globally competent Electrical and Electronics Engineers through continuously evolving teaching and learning process.
- To promote the knowledge and skills of students, members of faculty and supporting staff through professional training.
- To induce the young minds of engineers to meet the expectations of industry and society.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

On successful completion of four year BE degree programme quite a few yearsafter graduation our graduates will

PEO1: Apply, analyze, design and create products and solutions for real-life Electrical and ElectronicsEngineering problems.

PEO2: Function effectively in multidisciplinary teams with technical competency to develop sustainablesolutions for global, environmental and societal needs in an ethical way.

PEO3: Update their domain knowledge to attain continuous career enhancement / to be an entrepreneurand to adapt themselves to life-long learning.

PROGRAMME OUTCOMES (POs)

Engineering Graduates will be able to:

a. **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. **Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. **Design/ Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. **Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e. **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

f. **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g. **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

h. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i. **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k. **Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

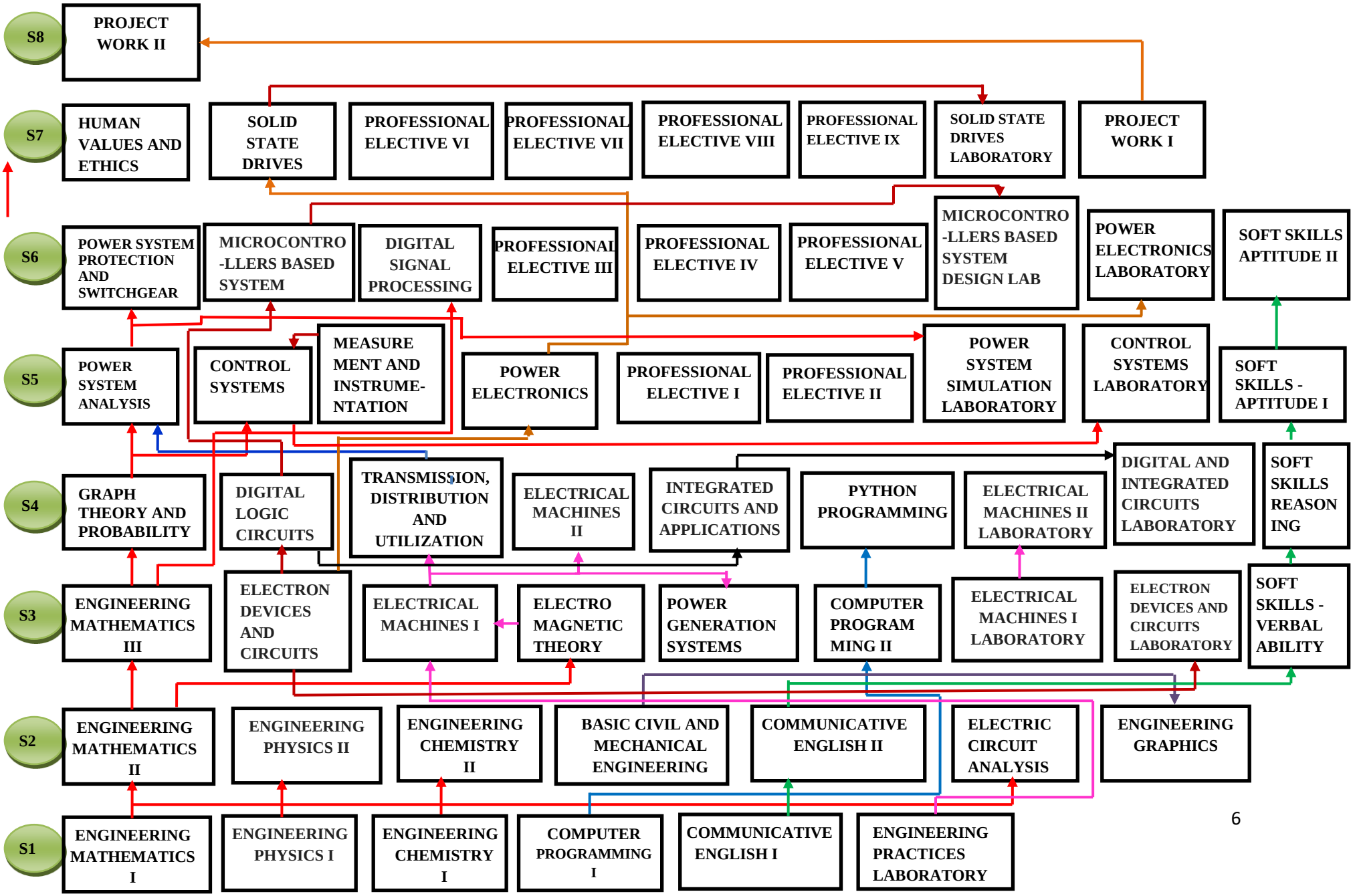
1. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

2. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

MAPPING OF PEOs and POs

POs	a	b	c	d	e	f	g	h	i	j	k	l
PEO1	X	X	X	X	X		X	X	X	X		X
PEO2	X		X	X	X	X		X	X	X	X	
PEO3	X	X		X		X	X				X	X

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING



DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

R2018 (Revised Curriculum)

Minimum Credits to be earned: 162

I SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
18EE101	ENGINEERING MATHEMATICS I	3	1	0	4	4	40	60	100	BS
18EE102	ENGINEERING PHYSICS I	2	0	2	3	4	50	50	100	BS
18EE103	ENGINEERING CHEMISTRY I	2	0	2	3	4	50	50	100	BS
18EE104	COMPUTER PROGRAMMING I	2	0	2	3	4	50	50	100	ES
18HS101	COMMUNICATIVE ENGLISH I	1	0	2	2	3	100	0	100	HS
18EE106	ENGINEERING PRACTICES LABORATORY	0	0	4	2	4	100	0	100	ES
Total		**10**	**1**	**12**	**17**	**23**	**-**	**-**	**-**	**-**
II SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours / Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
18EE201	ENGINEERING MATHEMATICS II	3	1	0	4	4	40	60	100	BS
18EE202	ENGINEERING PHYSICS II	2	0	2	3	4	50	50	100	BS
18EE203	ENGINEERING CHEMISTRY II	2	0	2	3	4	50	50	100	BS
18EE204	BASIC CIVIL AND MECHANICALENGINEERING	3	0	0	3	3	40	60	100	ES
	LANGUAGE ELECTIVE	-	-	-	2	2	100	0	100	HS
18EE206	ELECTRIC CIRCUIT ANALYSIS	3	0	2	4	5	50	50	100	ES
18EE207	ENGINEERING GRAPHICS	1	0	4	3	5	100	0	100	ES
Total		**14**	**1**	**10**	**22**	**27**	**-**	**-**	**-**	**-**

III SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
18EE301	ENGINEERING MATHEMATICS III	3	1	0	4	4	40	60	100	BS
18EE302	ELECTRON DEVICES AND CIRCUITS	3	0	0	3	3	40	60	100	PC
18EE303	ELECTRICAL MACHINES I	3	1	0	4	4	40	60	100	PC
18EE304	ELECTROMAGNETIC THEORY	3	1	0	4	4	40	60	100	ES
18EE305	POWER GENERATION SYSTEMS	3	0	0	3	3	40	60	100	PC
18EE306	COMPUTER PROGRAMMING II	3	0	2	4	5	50	50	100	ES
18EE307	ELECTRICAL MACHINES I LABORATORY	0	0	2	1	2	100	0	100	PC
18EE308	ELECTRON DEVICES AND CIRCUITS LABORATORY	0	0	2	1	2	100	0	100	PC
18GE301	SOFT SKILLS – VERBAL ABILITY	0	0	2	-	2	100	0	100	EEC
Total		**18**	**3**	**8**	**24**	**29**	**-**	**-**	**-**	**-**

IV SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
18EE401	GRAPH THEORY AND PROBABILITY	3	1	0	4	4	40	60	100	BS
18EE402	DIGITAL LOGIC CIRCUITS	3	1	0	4	4	40	60	100	PC
18EE403	TRANSMISSION DISTRIBUTION AND UTILIZATION	3	0	0	3	3	40	60	100	PC
18EE404	ELECTRICAL MACHINES II	3	1	0	4	4	40	60	100	PC
18EE405	INTEGRATED CIRCUITS AND APPLICATIONS	3	0	0	3	3	40	60	100	PC
18EE406	PYTHON PROGRAMMING	2	0	2	3	4	50	50	100	ES
18EE407	ELECTRICAL MACHINES II LABORATORY	0	0	2	1	2	100	0	100	PC
18EE408	DIGITAL AND INTEGRATED CIRCUITS LABORATORY	0	0	2	1	2	100	0	100	PC
18HS001	ENVIRONMENTAL SCIENCE	2	0	0	-	2	100	0	100	HS
18GE401	SOFT SKILLS – BUSINESS ENGLISH	0	0	2	-	2	100	0	100	EEC
Total		**19**	**3**	**8**	**23**	**30**	**-**	**-**	**-**	**-**

V SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
21EE501	POWER SYSTEM ANALYSIS	3	1	0	4	4	40	60	100	PC
21EE502	CONTROL SYSTEMS	3	1	0	4	4	40	60	100	PC
21EE503	MEASUREMENT AND INSTRUMENTATION	3	0	2	4	5	50	50	100	PC
21EE504	POWER ELECTRONICS	3	1	0	4	4	40	60	100	PC
	PROFESSIONAL ELECTIVE I	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE II	3	0	0	3	3	40	60	100	PE
21EE507	POWER SYSTEM SIMULATION LABORATORY	0	0	2	1	2	100	0	100	PC
21EE508	CONTROL SYSTEMS LABORATORY	0	0	2	1	2	100	0	100	PC
18GE501	SOFT SKILLS - APTITUDE I	0	0	2	-	2	100	0	100	EEC
Total		**18**	**3**	**8**	**24**	**29**	**-**	**-**	**-**	**-**

VI SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
21EE601	POWER SYSTEM PROTECTION AND SWITCHGEAR	3	1	0	4	4	40	60	100	PC
21EE602	MICROCONTROLLERS BASED SYSTEM DESIGN	3	0	0	3	3	40	60	100	PC
21EE603	DIGITAL SIGNAL PROCESSING	3	1	0	4	4	40	60	100	PC
	PROFESSIONAL ELECTIVE III	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE IV	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE V	3	0	0	3	3	40	60	100	PE
21EE607	MICROCONTROLLERS BASED SYSTEM DESIGN LABORATORY	0	0	2	1	2	100	0	100	PC
21EE608	POWER ELECTRONICS LABORATORY	0	0	2	1	2	100	0	100	PC
18GE601	SOFT SKILLS - APTITUDE II	0	0	2	-	2	100	0	100	EEC
Total		**18**	**2**	**6**	**22**	**26**	**-**	**-**	**-**	**-**

VII SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
21HS002	HUMAN VALUES ANDETHICS	2	0	0	2	2	40	60	100	HSS
21EE702	SOLID STATE DRIVES	3	0	0	3	3	40	60	100	PC
	PROFESSIONAL ELECTIVE VI	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE VII	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE VIII	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE IX	3	0	0	3	3	40	60	100	PE
21EE707	SOLID STATE DRIVES LABORATORY	0	0	2	1	2	100	0	100	PC
21EE708	PROJECT WORK I	0	0	6	3	6	50	50	100	EEC
Total		**17**	**0**	**8**	**21**	**25**	**-**	**-**	**-**	**-**
VIII SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours /Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
21EE801	PROJECT WORK II	0	0	18	9	18	50	50	100	EEC
Total		**0**	**0**	**18**	**9**	**18**				

ELECTIVES										
LANGUAGE ELECTIVES										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours /Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
18HS201	COMMUNICATIVE ENGLISH II	1	0	2	2	3	100	0	100	HSS
18HSH01	HINDI	1	0	2	2	3	100	0	100	HSS
18HSF01	FRENCH	1	0	2	2	3	100	0	100	HSS
18HSG01	GERMAN	1	0	2	2	3	100	0	100	HSS
18HSC01	CHINESE	1	0	2	2	3	100	0	100	HSS
18HSJ01	JAPANESE	1	0	2	2	3	100	0	100	HSS
ONE CREDIT COURSES										
18EE0XA	EMBEDDED CONTROL OF ELECTRIC DRIVES	1	0	0	1	1	100	0	100	OC
18EE0XB	DESIGN OF EMBEDDED SYSTEM FOR DC MOTOR CONTROL	1	0	0	1	1	100	0	100	OC
18EE0XC	INDUSTRIAL AUTOMATION	1	0	0	1	1	100	0	100	OC
18EE0XD	QUALITY MANAGEMENT SYSTEM	1	0	0	1	1	100	0	100	OC
18EE0XE	PRODUCT LIFECYCLE MANAGEMENT	1	0	0	1	1	100	0	100	OC
18EE0XF	APPLICATIONS OF SYNCHRONOUS GENERATOR IN INDUSTRIES	1	0	0	1	1	100	0	100	OC
18EE0XG	REACTIVE POWER MANAGEMENT AND ENERGY STORAGE DEVICES	1	0	0	1	1	100	0	100	OC
18EE0XH	SUBSTATION DESIGN	1	0	0	1	1	100	0	100	OC
18EE0XI	DESIGN OF GRID TIED SOLAR PV SYSTEM	1	0	0	1	1	100	0	100	OC
18EE0XJ	DESIGN OF INDOOR AND OUTDOOR LIGHTING USING DIALUX	1	0	0	1	1	100	0	100	OC
18EE0XK	DESIGN OF POWER CONVERTERS FOR INDUSTRIAL APPLICATIONS	1	0	0	1	1	100	0	100	OC
18EE0XL	LITHIUM BATTERY TECHNOLOGY FOR EV	1	0	0	1	1	100	0	100	OC
18EE0XM	POWER PLANT AUTOMATION USING SCADA AND DCS	1	0	0	1	1	100	0	100	OC
18EE0XN	POWER SYSTEMS DESIGN AND ANALYSIS USING ETAP	1	0	0	1	1	100	0	100	OC
ADDITIONAL ONE CREDIT COURSES										
18GE0XA	ETYMOLOGY	1	0	0	1	1	100	0	100	-
18GE0XB	GENERAL PSYCHOLOGY	1	0	0	1	1	100	0	100	-

18GE0XC	NEURO BEHAVIOURAL SCIENCE	1	0	0	1	1	100	0	100	-
18GE0XD	VISUAL MEDIA AND FILM MAKING	1	0	0	1	1	100	0	100	-
18GE0XE	YOGA FOR HUMAN EXCELLANCE	1	0	0	1	1	100	0	100	-
18GE0XF	VEDIC MATHEMATICS	1	0	0	1	1	100	0	100	-
18GE0XG	ABNORMAL PSYCHOLOGY	1	0	0	1	1	100	0	100	-
18GE0XH	YOGA FOR ENERGETIC LIFE	1	0	0	1	1	100	0	100	-
18GE0XI	BLOG WRITING	1	0	0	1	1	100	0	100	-
18GE0XJ	INTERPERSONAL SKILLS	1	0	0	1	1	100	0	100	-
18GE0XK	COMMUNITY SERVICE AND LEADERSHIP DEVELOPMENT	1	0	0	1	1	100	0	100	-
18GE0XL	NATIONAL CADET CORPS	1	0	0	1	1	100	0	100	-
18GE0XM	NEW AGE INNOVATION AND ENTREPRENEURSHIP	1	0	0	1	1	100	0	100	-
18GE0XN	DISRUPTIVE INNOVATION BASED STARTUP ACTIVITIES	1	0	0	1	1	100	0	100	-
18GE0XO	SOCIAL PSYCHOLOGY	1	0	0	1	1	100	0	100	-
18GE0XP	FM RADIO BROADCASTING TECHNOLOGY	1	0	0	1	1	100	0	100	-

VALUE ADDED COURSES	
18EEV01	ORCAD
18EEV02	HANDS ON TRAINING ON DESIGN OF CONTROLLERS FOR POWERCONVERTERS
18EEV03	IOT BASED SYSTEM DESIGN
18EEV04	ELECTRONIC CIRCUIT DESIGN
18EEV05	COMPUTER AIDED DESIGN AND ANALYSIS OF ELECTRICAL SYSTEM
18EEV06	DESIGN OF POWER CONVERTERS FOR ELECTRICAL MACHINES
18EEV07	INDUSTRIAL CONTROL
18EEV08	ANALOG AND DIGITAL CIRCUIT DESIGN

PROFESSIONAL ELECTIVES										
VERTICAL I - POWER SYSTEMS										
21EE001	Power System Operation andControl	3	0	0	3	3	40	60	100	PE
21EE002	Power Quality	3	0	0	3	3	40	60	100	PE
21EE003	High Voltage Transmission	3	0	0	3	3	40	60	100	PE
21EE004	Demand Side Management	3	0	0	3	3	40	60	100	PE
21EE005	Smart Grid Technologies	3	0	0	3	3	40	60	100	PE
21EE006	Power System Deregulation	3	0	0	3	3	40	60	100	PE
VERTICAL II - POWER ELECTRONICS AND DRIVES										
21EE007	Advanced Power Semiconductor Devices	3	0	0	3	3	40	60	100	PE
21EE008	Advanced Power Converters	3	0	0	3	3	40	60	100	PE
21EE009	Modern Rectifiers andResonant Converters	3	0	0	3	3	40	60	100	PE
21EE010	Electromagnetic Interferenceand Compatibility	3	0	0	3	3	40	60	100	PE
21EE011	Electric Drives and Control	3	0	0	3	3	40	60	100	PE
21EE012	Power Electronic Interfacesfor Renewable Energy Sources	3	0	0	3	3	40	60	100	PE
VERTICAL III - ELECTRIC VEHICLE TECHNOLOGY										
21EE013	Electric Vehicle Architecture	3	0	0	3	3	40	60	100	PE
21EE014	Design of Motor and PowerConverters for Electric Vehicles	3	0	0	3	3	40	60	100	PE
21EE015	Electric Vehicle Design,Mechanics and Control	3	0	0	3	3	40	60	100	PE
21EE016	Design of Electric VehicleCharging System	3	0	0	3	3	40	60	100	PE
21EE017	Grid Integration of ElectricVehicles	3	0	0	3	3	40	60	100	PE
21EE018	Intelligent Control of ElectricVehicles	3	0	0	3	3	40	60	100	PE
VERTICAL IV - GREEN ENERGY TECHNOLOGY										
21EE019	Solar Energy ConversionSystems	3	0	0	3	3	40	60	100	PE
21EE020	Wind Power Technology	3	0	0	3	3	40	60	100	PE
21EE021	Fuel Cell Systems	3	0	0	3	3	40	60	100	PE
21EE022	Renewable Energy Systems Installations and Maintenance	3	0	0	3	3	40	60	100	PE

21EE023	Energy Storage Systems	3	0	0	3	3	40	60	100	PE
21EE024	Grid Integration of RenewableSources	3	0	0	3	3	40	60	100	PE
VERTICAL V - EMBEDDED SYSTEM DESIGN										
21EE025	Advanced Processor Architectures	3	0	0	3	3	40	60	100	PE
21EE026	Communication Protocols andStandards	3	0	0	3	3	40	60	100	PE
21EE027	Embedded C Programming	3	0	0	3	3	40	60	100	PE
21EE028	Real Time Operating Systems	3	0	0	3	3	40	60	100	PE
21EE029	Embedded Linux	3	0	0	3	3	40	60	100	PE
21EE030	Virtual Instrumentation inEmbedded Systems	3	0	0	3	3	40	60	100	PE
VERTICAL VI - ELECTRICAL TECHNOLOGY										
21EE031	Utilization of ElectricalEnergy	3	0	0	3	3	40	60	100	PE
21EE032	Industrial Electronics	3	0	0	3	3	40	60	100	PE
21EE033	Illumination Engineering	3	0	0	3	3	40	60	100	PE
21EE034	Electrical Safety	3	0	0	3	3	40	60	100	PE
21EE035	Energy Auditing and Management	3	0	0	3	3	40	60	100	PE
21EE036	PLC and SCADA	3	0	0	3	3	40	60	100	PE
21EE037	Artificial Intelligence inElectrical Engineering	3	0	0	3	3	40	60	100	PE
21EE038	Big Data Analytics for SmartGrid	3	0	0	3	3	40	60	100	PE
21EE039	Industry 4.0	3	0	0	3	3	40	60	100	PE

HONOURS DEGREE (With Specialization)										
VERTICAL I - POWER SYSTEMS										
21EEH01	Power System Operation and Control	3	0	0	3	3	40	60	100	PE
21EEH02	Power Quality	3	0	0	3	3	40	60	100	PE
21EEH03	High Voltage Transmission	3	0	0	3	3	40	60	100	PE
21EEH04	Demand Side Management	3	0	0	3	3	40	60	100	PE
21EEH05	Smart Grid Technologies	3	0	0	3	3	40	60	100	PE
21EEH06	Power System Deregulation	3	0	0	3	3	40	60	100	PE

MINOR DEGREE (Other than EEE Students)										
VERTICAL I - POWER SYSTEMS										
21EEM01	Power System Operation and Control	3	0	0	3	3	40	60	100	PE
21EEM02	Power Quality	3	0	0	3	3	40	60	100	PE
21EEM03	High Voltage Transmission	3	0	0	3	3	40	60	100	PE
21EEM04	Demand Side Management	3	0	0	3	3	40	60	100	PE
21EEM05	Smart Grid Technologies	3	0	0	3	3	40	60	100	PE
21EEM06	Power System Deregulation	3	0	0	3	3	40	60	100	PE

18EE101 ENGINEERING MATHEMATICS I 3 1 0 4

Course Objectives

- Understand the concepts of vectors and Eigen vectors for different matrices to describe the stability of the linear systems in engineering fields.
- Exemplify the concepts of differentiation and integration to identify the area of 2D and 3D surfaces in engineering problems
- Explain the concepts of analytic functions in complex domain to predict the nature of different engineering systems.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Represent the different forms of coordinate system in complex plane and characteristics of linear systems by Eigenvalues and Eigenvectors.
2. Analyse various types of functions and their differentiation techniques involved in engineering fields.
3. Implement different methods of integration used in engineering problems.
4. Execute the suitable integration technique to calculate the area and volume of different surfaces.
5. Apply the concept of analytic function to estimate the integral in complex plane.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1												2	
2		2											3	
3	1												2	
4	1												2	
5		2											3	

UNIT I **9 Hours**

COMPLEX NUMBERS, VECTORS AND MATRICES

Complex plane, polar coordinates and polar form of complex numbers, powers and roots, fundamental theorem of algebra. Vector algebra in 2-D and 3-D space, dot product and cross product. Matrices: Eigen values and Eigen vectors, Properties of eigen values and eigen vectors.

UNIT II **9 Hours**

CALCULUS

Limits and Continuity of Functions: Limits of functions, types of limits, evaluation of limits, continuity of functions, properties of continuous functions. Derivatives: Derivatives, differentiability, rules and properties, differentiation of transcendental functions, higher order derivatives, implicit differentiation, and differentiation of hyperbolic functions. Integration: Anti-derivatives, Riemann Sum, indefinite and definite integration, Mean Value Theorem for definite integral, Fundamental Theorem of Calculus.

UNIT III **9 Hours**

INTEGRATION METHODS

Basic integration formulae for algebraic and transcendental functions. Integration by special devices: integration by parts, rationalizing substitution or trigonometric substitution, partial fractions, reduction formulas, improper integrals, convergence tests.

UNIT IV **9 Hours**

APPLICATIONS OF DERIVATIVES AND INTEGRATIONS

Extreme values, points of inflection and curve sketching, Rolles Theorem, Mean Value Theorem, optimization, indeterminate forms, L-Hopitals Rule. Area between curves, volume of a general solid by slicing and cylindrical shell methods, volume of a solid of revolution, length of plane curves, area of a surface of revolution.

UNIT V **9 Hours**

COMPLEX ANALYSIS

Analytic Functions- Properties of Analytic function - Determination of Analytic Function using Milne Thompson method. Cauchy s Integral Formula - Classification of Singularities - Cauchy s Residue Theorem.

FOR FURTHER READING

Quadratic forms - Application of conic sections, quadratic surfaces - discrete dynamical systems - Triple integral in polar Coordinates-Formation of Bus Admittance Matrices. Applications of mass spring system in ordinary differential equations of higher order.

Total: 60 Hours

Reference(s)

1. Finney RL, Weir MD and Giordano FR, Thomas Calculus, 10th edition, Addison-Wesley, 2001
2. Erwin Kreyszig, Advanced Engineering Mathematics, Tenth Edition, Wiley India Private Limited, New Delhi, 2016.
3. Anton H, Calculus with Analytic Geometry, 5th edition, John Wiley & Sons, 1995
4. Ayres F Jr and Mendelson E, Schaum s Outline of Theory and Problems of Calculus, 4th edition, McGraw Hill, 1999.
5. Smith RT and Minton RB, Calculus, 2nd edition, McGraw Hill, 2002.

18EE102 ENGINEERING PHYSICS I 2 0 2 3

Course Objectives

- Illustrate the Newtons laws of motion and wave motion with applications
- Understand the basic properties of electricity, magnetism and optics
- Differentiate the special theory of relativity and quantum physics from classical physics

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Illustrate the Newton's three laws of motion and apply the same to solve the real world problems involving elevator, at wood machine and acceleration of objects.
2. Exemplify the physical characteristics of simple harmonic motion, wave motion and find the solutions for wave equations.
3. Infer the fundamental laws, properties of electricity and magnetism and apply the same to electric and magnetic elements.
4. Apply the principles of physical and geometrical optics in the mirrors, lenses, microscopes and diffraction gratings.
5. Outline the importance of special theory of relativity, quantum physics and analyse the wave and particle nature of matter.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1							2				1	
2	2								2				2	
3	2	2											1	
4	2	2							2				2	
5	2	1							2				1	

UNIT I **6 Hours**

MECHANICS

Newtons laws of motion: Concept of force and its nature - Newtons first law and inertial frames - definition of mass - Newtons second law-gravitational force and weight - Newtons third law. Applications of Newtons laws: particle in equilibrium, particle under net force - weighing a mass in an elevator, the atwood machine and acceleration of two objects connected by a cord

UNIT II **6 Hours**

OSCILLATIONS AND WAVES

Fundamentals of simple harmonic motion - energy of simple harmonic oscillator - spring mass system - time period of simple pendulum, compound pendulum and torsional pendulum - Damped oscillations. Travelling wave motion - sinusoidal waves on strings - speed of a wave - reflection and transmission - rate of energy transfer in wave motion

UNIT III **6 Hours**

ELECTRICITY AND MAGNETISM

Point charges - electric fields - Gauss law and its applications - electric potential - capacitance - energy stored in a capacitor. Concept and source of magnetic fields - Amperes theorem - determination of magnetic field due to different current distributions - Faradays law - self-induction and mutual induction- energy stored in an inductor

UNIT IV **6 Hours**

LIGHT AND OPTICS

Nature of light - laws of reflection and refraction - refractive index and Snells law - dispersion of light - total internal reflection - image formation: concave mirrors - convex mirrors - thin lenses - compound microscope - human eye. Conditions of interference - Youngs double slit experiment - intensity distribution of interference - phase change due to reflection - diffraction-narrow slit diffraction - single slit and two slit - intensity distribution - diffraction grating – applications

UNIT V **6 Hours**

MODERN PHYSICS

Special theory of relativity - simultaneity and time dilation - twin paradox - length contraction - relativistic mass variation - space time graph. Black body radiation and Planck hypothesis - allowed energy levels - thermal radiation from different objects - photoelectric and Compton effect. Matter waves - de-Broglie hypothesis - wave nature of particles - Davission-Germer experiment

1 **5 Hours**

EXPERIMENT 1

Determination of resultant of system of concurrent coplanar forces-Parallelogram law of forces

2 **5 Hours**

EXPERIMENT 2

Determination of moment of inertia-Torsional pendulum

3 **5 Hours**

EXPERIMENT 3

Determination of wavelength of mercury spectral lines-spectrometer

4 **4 Hours**

EXPERIMENT 4

Determination of refractive index of solid and liquid-travelling microscope

5 **3 Hours**

EXPERIMENT 5

Determination of wavelength of laser-diffraction grating

6 **4 Hours**

EXPERIMENT 6

Determination of frequency of a tuning fork-Meldes apparatus

7 **4 Hours**

EXPERIMENT 7

Thickness of a thin wire using interference of light-Air wedge method

Total: 60 Hours

Reference(s)

1. R A Serway and J W Jewitt, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2011
2. Halliday and Resnick, Fundamentals of Physics, John Wiley and Sons, Inc, 2011
3. H C Verma, Concepts of Physics (Vol I & II), Bharathi Bhawan Publishers & Distributors, New Delhi, 2017
4. H D Young and R A Freedman, Sears and Zemanskys University Physics with Modern Physics, Pearson education, 2016
5. R K Gaur and S L Gupta, Engineering Physics, Dhanpat Rai Publications, 2012.

18EE103 ENGINEERING CHEMISTRY I 2 0 2 3

Course Objectives

- Recall the terminologies of electrochemistry and explain the function of electrode with its electrochemical reactions.
- Infer the construction, cell reactions and working in batteries.
- Classify the conducting property of the material based on resistivity and predict their applications.
- Outline the fundamentals of corrosion, its types and protection methods.
- Outline the purpose of alloying, properties and its application.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Construct an electrochemical cell and measure its potential using selected reference electrode.
2. Analyze the cell reactions in batteries, applications and disposal methods.
3. Compare the low and high resistivity metals based on their conductance.
4. Identify the type of corrosion and find suitable corrosion protection method.
5. Apply the properties of ferrous and non-ferrous alloys in electronics industries.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2													2
2	2	1											3	
3	1	2			1								2	
4	1	1			2								1	
5	2	2			1								2	

UNIT I **7 Hours**

BASICS OF ELECTROCHEMISTRY

Electrodes - types of electrodes. Cells - types - applications - redox reactions and its determination.

UNIT II **6 Hours**

BATTERIES

Batteries - construction - types - primary and secondary -modern batteries - cell reactions andapplications - disposal of batteries.

UNIT III **6 Hours**

ELECTRICAL CONDUCTING MATERIALS

Electrical conducting materials - classification based on resistivity - significance of low resistivity metals(Cu, Al and Fe) - thermal conductivity of metals - high resistivity materials and their applications (manganin, constantin, nichrome, mercury, and tungsten.

UNIT IV **6 Hours**

CORROSION CONTROL AND PROTECTIVE COATING

Corrosion - types - galvanic series and its applications. Corrosion control methods: Sacrificial anode and impressed current cathodic method- protective coating - electroplating - electroless plating - application in Printed Circuit Board (PCB).

UNIT V **5 Hours**

ALLOYS

Purpose of alloying - properties and classification of alloys - manufacturing of alloys for electrical machineries.

FURTHER READING

Fuel cells: Principle, construction and applications of hydrogen-oxygen fuel cell, solid oxide fuel cell (SOFC) and proton exchange membrane fuel cell.

1 **4 Hours**

EXPERIMENT 1

Determination of standard electrode potential of electrical conducting metal using calomel as reference electrode.

2 **4 Hours**

EXPERIMENT 2

Construct a cell (using scrap metal/ other sources) exhibiting valid output and compare it with the existing commercial batteries based on output.

3 **4 Hours**

EXPERIMENT 3

Evaluation of chemical earthing materials by the given data analyzed by AAS spectroscopy and their output.

4 **5 Hours**

EXPERIMENT 4

Electroplating of copper on a given target object and estimate the amount of copper at anode.

5 **9 Hours**

EXPERIMENT 5

(a) Determination of corrosion percentage of electrical materials by weight loss method.
(b) Correlation between conductivity and corrosion rates in Fe- Carbon- Steels- Cu under different environments (5)

6 **4 Hours**

EXPERIMENT 6

Estimation of Cu content in brass by EDTA method.

Total: 60 Hours

Reference(s)

1. Jain and Jain, Engineering Chemistry, 16th Edition, Dhanpat Rai Publishing Company, NewDelhi, 2013.
2. P.H. Rieger, Electrochemistry, Second Edition (Reprint), Springer, Netherland, 2012.
3. E.Mc Cafferty, Introduction to Corrosion Science, Springer; 2010 Edition, January 2010.
4. S. Vairam, Engineering Chemistry, John Wiley & sons, 2014.
5. O.P Khanna, Materials Science and Metallurgy, Dhanpat Rai Publishing Company, New Delhi, 2013.
6. Electrical and Electronic Engineering Materials, SK Bhattacharya, Khanna Publishers, New Delhi.

18EE104 COMPUTER PROGRAMMING I 2 0 2 3

Course Objectives

- Understand the basics of C primitives, operators and expressions.
- Gain knowledge about the different primitive and user defined data types.
- Impart knowledge about the structural programming concepts.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations, substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Implement C programs using operators, type conversion and input-output functions.
2. Apply decision making and looping statements in writing C programs.
3. Develop C programs using the concepts of Arrays and strings.
4. Apply the concepts of functions and pointers in writing C programs.
5. Design applications using structures, unions and files in C.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2												3	
2		2											3	
3			2										3	
4		3											3	
5			3										3	

UNIT I **6 Hours**

INTRODUCTORY CONCEPTS

C Primitives: Introduction to C- Planning and writing a C program- Character Set - Keywords and Identifiers - Data Types - Variables and Constants - Compiling and executing the C program Operators and Expressions: Arithmetic - Relational - Logical - Increment and decrement - Conditional -Bitwise - Comma - Sizeof() - Assignment - Shift operator - Precedence and order of evaluation - TypeConversion

UNIT II **6 Hours**

CONTROL STATEMENTS

Decision Making and Branching: simple if statement - if else statement - nesting of if else Statement – Switch Statement.

Decision Making and Looping: while statement - do while statement - for statement Jump Statements: goto - break - continue - return statement

UNIT III **6 Hours**

ARRAYS AND STRINGS

Arrays: Introduction, one dimensional array, two-dimensional arrays and multi dimensional arrays. Strings: Declaring and initializing string variables- Reading and writing strings - String handling functions.

UNIT IV **6 Hours**

FUNCTIONS AND POINTERS

User Defined Functions: Elements of user defined functions - Definition of functions - return values and their types - function calls - categories of function - call by value and call by reference - recursion Pointers: Understanding Pointers - accessing the address of the variable - declaring pointer variables - Initialization of pointer variables - Accessing a variable through its pointer

UNIT V **6 Hours**

STRUCTURES AND FILES

Storage Class Specifiers: Auto - registers - static - extern - typedef Structures and Unions: Introduction - defining a structure - declaring structure variables - accessing structure members - structure initialization -Unions File Management in C: Defining and opening a file - closing a file - Input/output operations on files.

FOR FURTHER READING

Problem solving - Logical thinking - logic - symbolic logic - truth tables - Math puzzles – magic triangles - magic squares - alphabetic puzzles - Cross number puzzles. Creating and manipulating document using word - Mail merge - Creating spread sheet with charts and formula using excel - developing power point presentation with Animations.

1 **3 Hours**

EXPERIMENT 1

Write a C program to perform arithmetic operations on integers and floating point numbers.

2 **3 Hours**

EXPERIMENT 2

Write a C program to implement ternary operator and relational operators.

3 **3 Hours**

EXPERIMENT 3

Write a C program to read the values of A,B,C through the keyboard. Add them and after addition check if it is in the range of 100 to 200 or not. Print separate message for each.

4 **3 Hours**

EXPERIMENT 4

Write a C program to display the roots of a quadratic equation with their types using switch case.

5 **3 Hours**

EXPERIMENT 5

Write a C program to generate the following triangle.1
1 2 3
1 2 3 4 5
1 2 3 4 5 6 7

6 **3 Hours**

EXPERIMENT 6

Write a C program to get a matrix of order 3x3 and display a matrix of order of 4x4, with the fourth row and column as the sum of rows and columns respectively.

7 **3 Hours**

EXPERIMENT 7

Write a C program to remove the occurrence of "the" word from entered string.

8 **3 Hours**

EXPERIMENT 8

Write a C program to find the factorial of given number.

9 **3 Hours**

EXPERIMENT 9

Design a structure to hold the following details of a student. Read the details of a student and displaythem in the following format Student

details: rollno, name, branch, year, section, cgpa.

**********NAME:
ROLL NO:
BRANCH:
YEAR:
SECTION:
CGPA:

10 **3 Hours**

EXPERIMENT 10

Create two files test1.txt and test2.txt and write a C program to read the file text1.txt character by character on the screen and paste it at the end of test2.txt.

Total: 60 Hours

Reference(s)

1. Herbert Schildt, C -The complete Reference, Tata McGraw-Hill, 2013
2. Byron Gottfried , Programming with C, Schaum's Outlines, Tata Mcgraw-Hill, 2013
3. E.Balagurusamy, Programming in ANSI C, Tata McGraw-Hill, 2012
4. Kernighan B W and Ritchie O M, The C Programming Language. Prentice-Hall of India, 2009
5. Kelley A and I. Pohl, A Book on C : Programming in C, Pearson Education, 1998
6. Ashok.N. Kamthane, Programming in C,Pearson education,2013

18HS101 COMMUNICATIVE ENGLISH I 1 0 2 2

Course Objectives

- Read and understand the main points on familiar matters regularly encountered in work, school, or leisure
- Listen and respond in most common situations where English is spoken
- Write simple connected texts on topics which are familiar or of personal interest
- Describe experiences and events, hopes and ambitions and briefly give reasons and explanations for opinions and plans

Programme Outcomes (POs)

i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Use appropriate grammar and vocabulary that is expected at the BEC Preliminary exam level
2. Understand the general meaning of non-routine letters within own work area, and short reports of a predictable nature
3. Write formal, routine letters of factual nature, and make notes on routine matters, such as taking/placing orders
4. Follow simple presentations/demonstrations
5. Deal with predictable requests from a visitor, state routine requirements, and offer advice within own job area on simple matters

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									1				1	
2									2				1	
3									3				1	
4										1			1	
5										2			1	

UNIT I **9 Hours**

GRAMMAR

Tenses Future continuous, Past continuous, Past perfect, Past simple, Past tense responses, Present perfect continuous, Present perfect/past simple Reported speech Adverbs intensifiers Comparatives and superlatives Conditionals 2nd and 3rd Connecting words expressing cause and effect, contrast Phrasal verbs Prepositions of place Simple passive - Wh-questions in the past Question tags Will and going to, for prediction.

UNIT II **9 Hours**

READING

Understanding short real-world notices, messages Detailed comprehension of factual material; skimmingand scanning skills - Interpreting visual information Reading for detailed factual information Reading for gist and specific information - Grammatical accuracy and understanding of text structure - Reading and information transfer.

UNIT III **9 Hours**

WRITING

Internal communication including note, message, memo or email - arranging / rearranging appointments, asking for permission, giving instructions - Business correspondence including letter, fax, email apologising and offering compensation, making or altering reservations, dealing with requests, giving information about a product.

UNIT IV **9 Hours**

LISTENING

Listening for specific information Listening for numbers and letters Note completion Listening for gist listening to monologues (presentations, lectures, announcements and briefings) listening to interacting speakers (telephone conversations, face-to-face conversations, interviews and discussions).

UNIT V **9 Hours**

SPEAKING

Exchanging personal and factual information expressing and finding out about attitudes and opinions organise a larger unit of discourse Turn-taking, negotiating, collaborating, exchanging information, expressing and justifying opinions, agreeing and/or disagreeing, suggesting, speculating, comparing andcontrasting, and decision-making.

1.Goodbye party for Miss Pushpa T S - Nissim Ezekiel2.Our Casuarina Tree - Toru Dutt
3.Palanquin Bearers - Sarojini Naidu4.The Tyger - William Blake
5. Ode on a Grecian Urn - John Keats

Total: 45 Hours

Reference(s)

1. Alexander Garrett, Cambridge BEC Preliminary Students Book with Answers, Cambridge University Press, 2016.
2. Lan Wood, Anne Williams and Anna Cowper. Pass Cambridge BEC Preliminary, Second Edition, New Delhi, 2014.
3. Norman Whitby. Cambridge Business Benchmark. Pre-Intermediate to Intermediate, Students Book. South Asian Edition, 2018.

18EE106 ENGINEERING PRACTICES LABORATORY 0 0 4 2

Course Objectives

- To provide hands on training for dismantling and assembling of starters and transformers.
- To develop the skills for making simple electrical wiring connections using suitable tools.
- To develop the skill for trouble shooting and maintenance of home appliances.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems

reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1.Design and Fabrication of miniature DC machines and measurement of electricalparameters using multimeters.

2.Construct different types of electrical wiring using suitable tools.

3.Perform troubleshooting and maintenance of home appliances and also measure earth resistance.

4.Perform dismantling and assembling of single phase starters, three phase starters and transformers.

5.Develop soldering in simple PCB board.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1		3						1				3	
2	1	3							1					3
3	2	3							1				2	
4	2	3							1				1	2
5	2	3	1						1					2

1 **6 Hours**

EXPERIMENT 1

Measurement of electrical parameters using multimeters.

2 **6 Hours**

EXPERIMENT 2

Verification of current division for parallel circuit.

3 **6 Hours**

EXPERIMENT 3

Verification of voltage division for series circuit.

4 **6 Hours**

EXPERIMENT 4

Soldering Practice for simple Printed Circuit Board (PCB).

5 **6 Hours**

EXPERIMENT 5

Verification of Logic gates truth table.

6 **6 Hours**

EXPERIMENT 6

Construct electrical wire connections for staircase wiring and godown wiring with MCB.

7 **6 Hours**

EXPERIMENT 7

Trouble shooting and Maintenance of Table Fan/Ceiling Fan.

8 **6 Hours**

EXPERIMENT 8

Trouble shooting and Maintenance of grinder/ mixer grinder.

9 **6 Hours**

EXPERIMENT 9

Trouble shooting and Maintenance of Fluorescent Lamp circuit.

10 **6 Hours**

EXPERIMENT 10

Measurement of earth resistance.

Total: 60 Hours

18EE201 ENGINEERING MATHEMATICS II 3 1 0 4

Course Objectives

- Understand the concepts of partial derivatives and multiple integrals to define the area, volume and extreme values of various surfaces in engineering fields.
- Classify the sequences and series in linear systems is convergent or divergent.
- Formulate the real time engineering problem into mathematical model using ordinarydifferential equation and solve it by appropriate method.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems

Course Outcomes (COs)

1. Illustrate the various parameters in partial differentiation and characterize the maxima andminima functions for signals and systems.
2. Apply multiple integral concepts to calculate the area and volume by appropriate vector integraltheorems.
3. Analyse the convergence and divergence of sequences and series by various tests.
4. Construct first order differential equations from real time phenomena and solve it by suitable method.
5. Execute the appropriate method to solve the second order differential equations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1												1	
2		2											2	
3	1												2	
4	1												1	

5		2											1	

UNIT I **9 Hours**

PARTIAL DIFFERENTIATION

Functions of several variables, plotting of 2-variable functions, introduction to cylindrical and spherical coordinates, chain rule, total differential, gradient, directional derivatives, normal lines and tangent planes, extreme of functions of two variables, applications.

UNIT II **9 Hours**

MULTIPLE INTEGRALS

Double integrals, regions of integrations, triple integrals, applications (Cartesian coordinates only- Greens theorem and Gauss Divergence theorem).

UNIT III **9 Hours**

SEQUENCES AND SERIES

Sequences and series, convergence and divergence of series, absolute convergence, conditional convergence, test for convergence and divergence. Power series for functions, interval of convergence, Taylor and Maclaurin series, Taylors Theorem with remainder.

UNIT IV **9 Hours**

FIRST ORDER DIFFERENTIAL EQUATIONS

Separable differential equations, homogeneous differential equations, exact differential equations, integrating factor, Bernoullis equation, applications.

UNIT V **9 Hours**

SECOND ORDER DIFFERENTIAL EQUATIONS

Second order homogeneous and non-homogeneous equations with constant coefficients, variation of parameters, method of undetermined coefficients, series solutions of differential equations, applications.

FOR FURTHER READING

Applications to Electrostatic and Fluid Flow.

Total: 60 Hours

Reference(s)

1. Finney RL, Weir MD and Giordano FR, Thomas Calculus, 10th edition, Addison-Wesley, 2001
2. Erwin Kreyszig , Advanced Engineering Mathematics, Tenth Edition, Wiley India Private Limited, New Delhi 2016.
3. Smith RT and Minton RB, Calculus, 2nd Edition, McGraw Hill, 2002.
4. Ray Wylie and C Louis Barrett, Advanced Engineering Mathematics, Sixth Edition, Tata McGraw-Hill Publishing Company Ltd, 2003.
5. Peter V. O Neil , Advanced Engineering Mathematics, Seventh Edition , Cengage LearningIndia Private Limited, 2012.
6. Glyn James, Advanced Engineering Mathematics, Third Edition,Wiley India, 2014.

18EE202 ENGINEERING PHYSICS II 2 0 2 3

Course Objectives

- Understand the fundamentals of crystal, transport properties of semiconductors and magnetic materials
- Differentiate passive and active components
- Compare different display devices and their functions

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Identify the seven types of crystal systems, crystal planes and illustrate unit cell characteristics of SC, BCC, FCC and HCP crystal structures
2. Exemplify the characteristics of semiconducting materials in terms of crystal lattice, charge carriers and energy band diagrams
3. Differentiate the active and passive components in an electronic circuit and outline the working mechanisms of diodes.
4. Analyse the properties of magnetic materials, domain theory of ferromagnetism and the applications of recording and readout process.
5. Outline the interaction of electromagnetic radiation with matter and working principle of LED, LCD and OLED display devices

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1							2				2	
2	2	1							2				2	
3	2	1							2				2	
4	2	1							2				2	
5	2	1							2				1	

UNIT I **6 Hours**

CRYSTAL PHYSICS

Classification of solids - crystal structure - lattice points and space lattic - unit cell and lattice parameters- crystal systems and Bravais lattices - crystallographic planes - Miller indices - interplanar space of lattice planes - anisotropic properties of crystal - unit cell characteristics of SC, BCC, FCC and HCP structures

UNIT II **7 Hours**

SEMICONDUCTING MATERIALS

Band theory of solids - classification of solids - electrical and thermal conductivity - Semiconductors: elemental and compound semiconductor - intrinsic and extrinsic semiconductors - energy band diagram and electrical conduction - variation of Fermi level with temperature and impurity concentration - temperature dependence of carrier concentration in extrinsic semiconductor - Hall effect - determination of Hall coefficient - solar cells.

UNIT III **5 Hours**

PASSIVE AND ACTIVE COMPONENTS

Fundamental definitions - types of resistors, capacitors, inductors and transformers - characteristics of PN junction. Diodes: laser diode - PIN diode - Schottky diode - step recovery diode - tunnel diode - varactordiode - Zener diode

UNIT IV **6 Hours**

MAGNETIC MATERIALS

Basic definitions - origin of magnetic moment - classification of magnetic materials - influence of temperature on magnetic behaviour - domain theory of ferromagnetism - hysteresis of ferromagnetic materials - soft and hard magnetic materials - applications: magnetic recording - giant magneto resistance(GMR) effect

UNIT V **6 Hours**

DISPLAY DEVICES

Electromagnetic radiation - interaction of radiation with solids - classification of optical materials - luminescence - types of luminescence - LED and OLED: principle, construction, working, advantages and disadvantages. LCD: characteristics of liquid crystals - types - phases - twisted nematicdisplay: construction, working, merits and demerits. Comparison of LED, OLED and LCD

1 **5 Hours**

EXPERIMENT 1

Measurement of resistivity of a given material by four probe method

2 **5 Hours**

EXPERIMENT 2

Find the Hall coefficient and carrier concentration of semiconducting material using Hall effect apparatus

3 **5 Hours**

EXPERIMENT 3

Determine the V-I characteristics of a solar cell

4 **5 Hours**

EXPERIMENT 4

Find the band gap value of the given semiconductor diode. Based on the band gap value, identify the given semiconductor

5 **5 Hours**

EXPERIMENT 5

Determine the V-I characteristics of P-N diode and Zener diode

6 **5 Hours**

EXPERIMENT 6

Determine the thermal conductivity of a bad conductor by using Lee's disc method

Total: 60 Hours

Reference(s)

1. Balasubramaniam, R. "Callister""s Materials Science and Engineering". Wiley India Pvt.Ltd.,2014.
2. Kasap, S.O. "Principles of Electronic Materials and Devices". McGraw-Hill Education,2017
3. William D. Callister, Jr. & David G. Rethwisch "Fundamentals of Materials Science and Engineering". John Wiley and Sons Incl.,2008.
4. Wahab, M.A. "Solid State Physics: Structure and Properties of Materials". Alpha Science International Ltd., 2017

5. Donald A. Neamen. "Semiconductor Physics and Devices", Mc Graw-Hill, 2011
6. Palanisamy P. K."Physics for electronics and information science". Dipti Press Pvt. Ltd., 2018.
7. Papadopoulos, Christo, Solid-State Electronic Devices an Introduction, Springer, NewYork, 2014.
8. Raghavan, V. "Materials Science and Engineering: A First course". PHI Learning, 2015.
9. B.L. Theraja, Basic Electronics Solid State, S.Chand & Company Ltd, New Delhi, 2000.

18EE203 ENGINEERING CHEMISTRY II 2 0 2 3

Course Objectives

- Summarize the unique properties of group IV elements and their applications in electronics
- Apply the basic knowledge of conducting polymers for electrical applications
- Infer the materials used in insulation of electrical signals
- Outline the chemistry of materials used in ceramic insulators and resistors
- Illustrate the novel nanofabrication techniques for nano electronic applications

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Indicate the role of oxides of silicon and germanium for electronics applications
2. Classify commercially available conducting polymers and list its electronic applications
3. Apply the knowledge of insulating materials in designing electrical appliances
4. Analyze the ceramic-based insulators and carbon-based resistors for electrical applications
5. Identify the role of nanofabrication techniques in nano electronics and analyze the morphology of materials using AFM, SEM, TEM techniques.

Articulation Matrix

CO No	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
1	2	2											1	
2	2	1											2	
3	3	2											3	
4	2	1												2
5	2	-											1	

UNIT I **6 Hours**

CHEMISTRY OF SEMICONDUCTORS

Group IV elements - structure and properties - oxides of silicon and germanium - applications in electronics- IC device and VLSI design fabrication.

UNIT II **6 Hours**

POLYMERS AND CONDUCTING POLYMERS

Polymers - conducting polymers - commercial polymers: Synthesis and applications - optical fibres - functions and applications.

UNIT III **5 Hours**

INSULATING MATERIALS

Dielectrics - characteristics and types - insulating materials - resins - thermal insulators.

UNIT IV **7 Hours**

ELECTRONIC CERAMICS

Properties of ceramic insulators - ceramic capacitor materials - ferrite (magnetic) ceramics - ceramic sensors. Application and characterization of ZnO varistors. Resistor materials: Carbon based materials - metal-based materials.

UNIT V **6 Hours**

NANOELECTRONICS

Nanoelectronics - introduction - nanoelectronic architectures: Nanofabrication - nanopatterning of metallic/semiconducting nanostructures, structural characterization (SEM, TEM, AFM).

FOR FURTHER READING

Basics and applications of electromagnetic spectrum - electronic, vibrational and rotational transitions. Principle, instrumentation -block diagram and applications of UV visible and IR spectroscopy.

1 **3 Hours**

EXPERIMENT 1

Determination of silica content in potassium silicate by titration methods

2 **8 Hours**

EXPERIMENT 2

(a) Preparation of conducting polymer by electro deposition method

(b) Identification of functional group in conducting polymer compounds using IR spectroscopy.

3 **4 Hours**

EXPERIMENT 3

Interpretation of dielectric materials using DTA curve analysis

4 **7 Hours**

EXPERIMENT 4

(a) Estimation of Zn in ceramics using EDTA method

(b) Comparison of different types of ceramics used in electrical/electronics by IR spectroscopy

5 **4 Hours**

EXPERIMENT 5

Preparation of CdS nanocrystals using thiourea

6 **4 Hours**

EXPERIMENT 6

Preparation of metal nanoparticles and their characterization

Total: 60 Hours

Reference(s)

1. Jain and Jain, Engineering Chemistry, 16th Edition, DhanpatRai Publishing Company, NewDelhi, 2013.
2. R. Gowariker, N. V. Viswanathan, J. Sreedhar, Polymer Science, 1st Edition, New age

International Publishers, New Delhi, 2014.

3. Sergio pizzini, Physical chemistry of semiconductor materials and processes, John Wiley & Sons, 2015.
4. T. Pradeep, Nano: The Essentials: Understanding Nanoscience and Nanotechnology, McGrawHill, 2012.
5. George W. Hanson, Fundamentals of nano electronics, Prentice Hall, 2008.
6. Van Vleck Elements of Materials Science Addison Wesley Publishers, 2010. 7. Rolf. E, Hummel, Electronic Properties of Materials, 4ed. Springer, New York, 2011.

18EE204 BASICS OF CIVIL AND MECHANICAL ENGINEERING 3 0 0 3

Course Objectives

- To impart basic knowledge in the field of Civil Engineering.
- To create awareness on green building systems with its energy.
- To impart knowledge on various infrastructural systems.
- To familiarize students with all commonly used mechanical elements.
- To understand the working principles of various Internal Combustion Engines, Refrigeration and air conditioning.
- To impart knowledge on various types of Boilers and turbines.

Programme Outcomes (POs)

a.Apply the knowledge of mathematics, science, engineering fundamentals, andan engineering specialization to the solution of complex engineering problems.
g.Understand the impact of the professional engineering solutions in societaland environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Illustrate the essential features and requirements of structures.
2. Identify the requirements of green building systems and energy efficiency.
3. Explain the classifications under Infrastructural systems.
4. Identify any commonly known mechanical component along with its application and its working principle.
5. Explain the working principles of Internal Combustion Engines, Refrigeration and air conditioning.
6. Explain the working principles of Boilers and turbines.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3												1	
2	3						2						1	
3	3						2						2	
4	2													2
5	2													2

6	2												1	

UNIT I **7 Hours**

BASIC REQUIREMENTS OF STRUCTURES

Scope of Civil Engineering- Principles of Planning of buildings: orientation, energy efficiency, utility. Components of building-classification of buildings. Site selection for power plants, wind mill -Site measurements using chain and tape.

UNIT II **7 Hours**

GREEN BUILDINGS

Conventional versus green building delivery systems- LEED building assessment standard - LEED certification process - Building rating system in India and its future - Building energy issues - Building energy design strategies - Building envelope.

UNIT III **7 Hours**

INFRASTRUCTURAL SYSTEMS

Water supply systems- Rain Water Harvesting Trenches. Classification of Highways- Types of bridges- Lighting of infrastructure facilities: indoor & outdoor.

UNIT IV **8 Hours**

MECHANICAL ELEMENTS

Basic Concepts, Bearings - ball bearing, roller bearing, thrust bearing, tapper roller bearing, journal / bush bearing, bearing blocks, one way bearings - Gears - spur, helical, bevel gear, worm gears, rack and pinion. Couplings - rigid coupling - sleeve, flange, clamp couplings. Flexible coupling - Oldham, universal, jaw and fluid couplings. Torque limiter - Belt drives - flat belt, V belt, timing belt drives. Chain drives, rope drives, chain block - Conveyers - roller conveyer, belt conveyer, vertical conveyer, pneumatic conveyer, chain conveyer, screw conveyer - Shafts, keys, spline shafts - Fasteners - screws, bolts, nuts and their specifications in mm and inch scale.

UNIT V **8 Hours**

INTERNAL COMBUSTION ENGINES AND REFRIGERATION

Internal Combustion (IC) Classification, main components, working principle of two and four stroke petrol and diesel engines, differences Refrigeration working principle of vapour compression and absorption system. Introduction to Air conditioning.

UNIT VI **8 Hours**

BOILERS AND TURBINE

Introduction to heat transfer - conduction, convection, radiation. Introduction to Boilers, classification, differences between fire tube and water tube boiler, super critical boiler. Steam turbines - working principle of single stage impulse and reaction turbine, Hydraulic turbine - working principle of Francis turbine, Kaplan turbine and Pelton wheel.

Total: 45 Hours

Reference(s)

1. N. Arunachalam, Bascis of Civil Engineering, Pratheeba Publishers, 2000.
2. M. Bauer, P. Mosle and M. Schwarz, Green Building: Guidebook for Sustainable Architecture, Springer - Verlag Berlin Heidelberg, 2010.
3. Charles. J. Kibert, Sustainable Construction: Green Building Design and Delivery, John Wiley & Sons, Inc., New Jersey, 2008.
4. G. Shanmugam and M. S. Palanichamy, Basic Civil and Mechanical Engineering, Tata McGraw Hill Publishing Co., New Delhi, 2014.
5. Traffic Engineering manual -2007. 6. http://www.sasurieengg.com/e-course-material/I-year-E-course-material-II-sem/9.GE6251-BCM.pdf

6. Basant C.M. Agrawal, Basic of Mechanical Engineering, Wiley India Pvt. Ltd., New Delhi 2014. V. B. Bhandari, Design of Machine Elements, Tata McGraw-Hill Publishing Company Pvt. Ltd., New Delhi, 2010. V. Ganesan, Internal Combustion Engines, Tata McGraw Hill Publishing Company Private limited., New Delhi, 2012.
7. R. K. Bansal, A Textbook of Fluid Mechanics and Machinery, Laxmi Publications (P) Ltd., New Delhi, Revised Ninth edition, 2014.

18EE206 ELECTRIC CIRCUIT ANALYSIS 3 0 2 4

Course Objectives

- To analyze the electric circuits using basic laws
- To compute electrical parameters like current and voltage using network theorems for AC and DC circuits
- To differentiate single phase and three phase circuits
- To analyze R, L, C components for resonance, coupling and transient response

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply the Kirchhoffs laws to the electric circuit to compute the electrical parameters.
2. Apply the network theorems to compute various parameters of electric network.
3. Analyze the three phase circuit with different types of loads.
4. Design a tank circuit for given frequency and analyze the coupled circuits in series and parallel.
5. Analyze the transient response of RL, RC and RLC circuits.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	3		1									3	
2	1	3		1									3	
3		2		1									3	
4	1			2	2								3	1
5	2	2		1									2	

UNITI **10 Hours**

ELECTRIC CIRCUITS

Active and Passive elements - Ohm's law - Kirchhoff's Laws - Resistance in series and parallel - voltage division and current division - Mesh and Nodal analysis - Source Transformation - Generation of alternating emf - RMS value, average value, peak factor and form factor - Analysis of Pure Resistive, Inductive and Capacitive circuits

UNIT II **10 Hours**

NETWORK THEOREMS FOR DC

Analysis of circuits using Thevenin' s theorem, Norton 's theorem, Maximum power transfer theorem and Superposition theorem - Applications.

UNIT III **8 Hours**

THREE PHASE CIRCUITS

Introduction - Analysis of Three phase balanced and unbalanced systems with star and delta connected loads - Phasor diagram - Star-Delta transformation - Measurement of Power and Power factor.

UNIT IV **10 Hours**

RESONANCE AND COUPLED CIRCUITS

Series and parallel resonance - Q factor and bandwidth - Resonant frequency of a tank circuit - Basics of magnetic circuits - Simple and Composite magnetic circuits - Self and Mutual inductances - Coefficient of Coupling - Coupled circuits - Dot convention - Coupled circuits in Series and Parallel.

UNIT V **7 Hours**

TRANSIENTS

Steady state and Transient response - Transient Response of RL, RC and RLC Circuits with step and ramp input - Time Constant Analysis.

FOR FURTHER READING

Super Mesh and Super Node analysis - Reciprocity theorem - Millman' s Theorem - Two port networks.

1 **6 Hours**

EXPERIMENT 1

Experimental verification of Kirchhoff’s voltage and current laws.

2 **6 Hours**

EXPERIMENT 2

Experimental verification of Thevenin’s and Norton Theorem**.**

3 **6 Hours**

EXPERIMENT 3

Study of CRO and measurement of voltage and frequency using function generator.

4 **6 Hours**

EXPERIMENT 4

Experimental determination of power in three phase circuits by two-watt meter method.

5 **6 Hours**

EXPERIMENT 5

Frequency Response of a series R-L-C Circuit

Total: 75 Hours

Reference(s)

1. William H. Hayt, Jack E. Kemmerly, and Steven M. Durbin, Engineering Circuit Analysis,Eighth Edition, Tata McGraw Hill, 2013.

2. Charles K. Alexander, Fundamentals of Electric Circuits, Fifth Edition, Tata McGraw HillPublishing Co Ltd, 2013.
3. Mahmood Nahvi, Joseph A Edminister, Electric Circuits, Fifth Edition, Tata McGraw HillPublishing Company Limited, 2017.
4. S P Ghosh, A K Chakraborty, Network Analysis and Synthesis, Tata McGraw Hill Education Private Limited, 2010.
5. Sudhakar and S. P. Shyam Mohan, Circuits and Network Analysis and Synthesis, Fifth Edition,Tata McGraw Hill, 2015.

18EE207 ENGINEERING GRAPHICS 1 0 4 3

Course Objectives

- Provide knowledge on projection of points and lines.
- Impart skill in drawing projection of simple solids.
- Familiarize creation of orthographic views from isometric projections of simple solids and vice versa.
- Build the proficiency to create two dimensional sketches using software.
- Provide the skill to build three dimensional models and its orthographic views using software.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Illustrate the projection of points and lines in different quadrants.
2. Construct orthographic projections of simple solids.
3. Create the orthographic and isometric projections of simple solids.
4. Sketch the two dimensional views of engineering components using software.
5. Construct three dimensional models of engineering components and its orthographic views using software.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2								2				1	
2	2								2				2	
3	2								2				1	
4	2								2				3	
5	2								2				3	

UNIT I **3 Hours**

PROJECTION OF POINTS AND LINES

Practices on lettering, numbering and dimensioning of drawings. Principles of projection, Projection of points in four quadrants, first angle projection of straight lines - parallel, perpendicular and inclined to anyone plane.

UNIT II **3 Hours**

PROJECTION OF SOLIDS

Orthographic projection of simple solids - parallel, perpendicular and inclined to one plane using changeof position method.

UNIT III **3 Hours**

ISOMETRIC AND PERSPECTIVE PROJECTION

Conversion of isometric to orthographic projection and vice versa. Perspective projection of simple solids.

UNIT IV **3 Hours**

CREATION OF 2D SKETCHES USING SOFTWARE

Sketch Entities - line, circle, arc, rectangle, slots, polygon, text, snap, and grid. Sketch Tools-fillet, chamfer, offset, convert entities, trim, extend, mirror, move, copy, rotate, scale, stretch, sketch pattern. Geometrical constraints, Dimensioning - smart, horizontal, vertical, ordinate

UNIT V

3 Hours PART MODELING AND DRAFTING USING SOFTWARE

Part Modeling - extrude, cut, revolve, creation of planes, fillet, chamfer, shell, rib, pattern, mirror, loft, draft and swept. Drafting - Converting 3D models to orthographic views with dimensions.

1 **12 Hours**

EXPERIMENT 1

Create 2D sketch of different components used in engineering applications.

2 **12 Hours**

EXPERIMENT 2

Create part model of a component from given isometric drawings.

3 **12 Hours**

EXPERIMENT 3

Create part model of a component from given orthographic views.

4 **12 Hours**

EXPERIMENT 4

Create an assembly model of product from detailed parts drawing.

5 **12 Hours**

EXPERIMENT 5

Create stl file from CAD model, transfer file to 3D printer, setup the machine parameters, build and post process the component using Additive Manufacturing Technology.

Total: 75 Hours

Reference(s)

1. K Venugpoal, Engineering Drawing and Graphics, Third edition, New Age International,2005.
2. Basant Agrawal, Mechanical drawing, Tata McGraw-Hill Education, 2008.
3. Engineering Drawing Practice for Schools & Colleges, Bureau of Indian Standards-Sp46,2008.

4. N. D. Bhatt and V. M. Panchal, Engineering Drawing, Charotar Publishing House Pvt. Limited,2008.
5. K.V. Natarajan, A Text Book of Engineering Graphics, Dhanalakshmi Publishers, 2013.
6. Ian Gibson, David W Rosen, Brent Stucker., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
7.

18EE301 ENGINEERING MATHEMATICS III 3 1 0 4

Course Objectives

- Understand the concepts of Fourier series, Transforms and Boundary Conditions, which will enable them to model and analyze the physical phenomena
- Implement the Fourier analysis, an elegant method in the study of heat flow, fluid mechanics and electromagnetic fields.
- Develop enough confidence to identify and model mathematical patterns in real world and offer appropriate solutions, using the skills learned in their interactive and supporting environment

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Classify a partial differential equation to solve them.
2. Identify the periodicity of a function and formulate the same as a combination of sine and cosine using Fourier series and Formulate a function in frequency domain whenever the function is defined in time domain.
3. Formulate a function in frequency domain whenever the function is defined in time domain.
4. Use the Z-transform to convert a discrete-time signal, which is a sequence of real or complex numbers, into a complex frequency domain representation.
5. Apply basic statistical inference techniques, including confidence intervals, hypothesis testing to science/engineering problems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3											3	
2	3	3											3	
3	3	3											2	
4	2	2											2	
5	2	2											2	

UNIT I **9 Hours**

FOURIER SERIES

Dirichlet's conditions - General Fourier series - Odd and even functions - Half range cosine and sine series - Root mean square value- Harmonic analysis

UNIT II **9 Hours**

FOURIER TRANSFORM

Fourier Integral Theorem- Fourier Transform and Inverse Fourier Transform- Sine and Cosine Transforms - Properties - Transforms of Simple Functions - Convolution Theorem - Parseval's Identity.

UNIT III **9 Hours**

LAPLACE TRANSFORM

Properties and theorems of Laplace transform - Shifting theorems- Inverse Laplace transforms - Convolution Applications to ordinary differential equations - Applications to linear system analysis.

UNIT IV **9 Hours**

Z -TRANSFORM

Z-Transform - Elementary Properties - Inverse Z-Transform - Convolution Method- Partial fraction method - Solution of Difference Equations using Z-Transform.

UNIT V **9 Hours**

PARTIAL DIFFERENTIAL EQUATION

Introduction to partial differential equations, One-dimensional wave equation, Method of separation of variables, D"Alembert"s solution of the wave equation - Heat equation, Laplace"s equation , Laplace transform method of solution.

Total: 60 Hours

Reference(s)

1. Kreyszig Erwin, Advanced Engineering Mathematics,10 Edition, John Wiley, 2015.
2. Johnson Richard A. and Bhaltacharyya Gouri K., Statistics, Principles and Methods, 7th Edition, John Wiley, 2014.
3. O'Neil Peter V., Advanced Engineering Mathematics, 4th Edition, PWS-Kent, 1997.
4. James Glyn, Advanced Modern Engineering Mathematics, Addison-Wesley, 4th edition 2011.
5. Greenberg Michael D., Advanced Engineering Mathematics, Prentice-Hall International Inc,2nd Edition 2006.

3 0 0 3

18EE302 ELECTRON DEVICES AND CIRCUITS

Course Objectives

- To understand the construction, operation and characteristics of solid state switching devices.
- To understand the operation of voltage amplifiers
- To analyze the performance of power amplifiers and feedback amplifiers.
- To understand the construction and operation of oscillators and multivibrators.
- To analyze the performance of wave shaping circuits

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the characteristics of various semiconductor devices.
2. Design and analyze the performance of BJT based voltage Amplifiers.
3. Analyze the performance of power amplifiers and feedback amplifiers.
4. Apply the Oscillator and Multivibrator circuits for waveform generation
5. Design a voltage regulator using rectifiers for power supply applications and construct the wave shaping circuits.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2											3	
2	2		3										3	2
3	2	2	1										3	2
4	2	1	3										3	2
5	2	2	3										3	3

UNIT I **8 Hours**

SEMICONDUCTOR DEVICES

Construction, Operation and characteristics of PN Junction Diode, Zener diode, BJT, MOSFET and UJT, Photodiode, Photo Transistor, LED.

UNIT II **8 Hours**

VOLTAGE AMPLIFIERS

Biasing of BJT-RC Coupled Amplifier - Differential amplifier using BJT -Differential and Common mode gain, CMRR

UNIT III **9 Hours**

POWER AND FEEDBACK AMPLIFIERS

Performance analysis of Class A, Class B, Class C and Class D - Basic concepts of feedback amplifiers- Topologies - Effect of negative feedback on input and output resistances, gain stability, distortion, bandwidth.

UNIT IV **10 Hours**

OSCILLATOR AND MULTIVIBRATORS

Oscillators, Barkhausen Criterian, RC phase shift oscillators, Wien Bridge and Hartley oscillators, Colpitts oscillators and UJT based saw tooth oscillator, Astable, Monostable, Bistable Multivibrators - operation

UNIT V **10 Hours**

POWER SUPPLY AND WAVESHAPING CIRCUITS

Performance analysis Half wave rectifier and full wave rectifier, Filters -Series and Shunt Voltage Regulator - Clippers and Clampers.

Total: 45 Hours

Reference(s)

1. Jacob. Millman, Christos C.Halkias, Electronic Devices and Circuits, 3rd Edition ,Tata McGraw Hill Publishing Limited, New Delhi.
2. David A. Bell, Electronic Devices and Circuits,5th Edition, Oxford University Press,
3. N.P. Deshpande, Electronic Devices and Circuits,1st Edition, Tata McGraw Hill Publishing Limited, New Delhi,2013.
4. Thomas L Floyd, Electronic Devices, Prentice Hall of India, New Delhi,2011.

18EE303 ELECTRICAL MACHINES I 3 1 0 4

Course Objectives

- To understand the production of torque and EMF.
- To understand the construction, operation and characteristics of various types of DC machines.
- To understand the operation and performance of special machines
- To understand the construction, operation and characteristics of transformers
- To estimate the performance of Transformers.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the electro-mechanical energy conversion process in rotating electrical machines
2. Analyze the various types and characteristics of DC Generator and DC motor
3. Examine the performance of special electrical machines
4. Construct the equivalent circuit and analyze the performance of the transformers
5. Evaluate the losses and regulation of transformers using different testing methods

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1											3	
2	2	3											2	
3	2	1												3
4	2	2											3	
5	3	3		3									3	

UNIT I **8 Hours**

PRINCIPLES OF ENERGY CONVERSION

Faraday's law of electromagnetic induction -singly and doubly excited magnetic field systems -EMF and torque production in rotating machines.

UNIT II **12 Hours**

DC MACHINES

Generator and Motor- Construction - Principle of operation - Types - Characteristics - Armature reaction and commutation - Starting and Speed control -Various testing-Braking -Applications

UNIT III **8 Hours**

SPECIAL MACHINES

Stepper motor, permanent magnet brushless D.C. motor and switched reluctance motors -construction-principle of operation-types- applications

UNIT IV **9 Hours**

TRANSFORMERS

Construction - Principle of operation - Types - Equivalent circuit -Voltage regulation and efficiency - Auto transformer

UNIT V **8 Hours**

TRANSFORMER TESTING

Testing of transformers -Polarity, open circuit, short circuit and Sumpner's test - Three phase transformers connections- Parallel operation

Total: 60 Hours

Reference(s)

1. D. P. Kothari and I. J. Nagrath, Electric Machines, Tata McGraw Hill Publishing Company Ltd, 2017
2. P. S. Bimbhra, Electrical Machinery, Khanna Publishers, Delhi, 2018
3. E. Fitzgerald, Charles Kingsley, Stephen.D.Umans, Electric Machinery, Tata McGraw Hill publishing Company Ltd, New Delhi ,2015
4. Stephen J.Chapman, Electric Machinery Fundamentals, Tata McGraw Hill, New Delhi, 2018.
5. T.Kenjo, Stepping motors and their microprocessor controls, Oxford University press, New Delhi, 2011
6. T.Kenjo and S.Nagamori,Permanent magnet and Brushless DC motors, Clarendon press, London, 2015.

18EE304 ELECTROMAGNETIC THEORY 3 1 0 4

Course Objectives

- To understand the application of vector calculus in electromagnetic theory.
- To understand the concept of Coulombs law and Gauss law.
- To calculate magnetic density and magnetic field intensity using Biot-savarat law and amperes law.
- To compute Maxwell's equations using Faraday’s Law, Gauss Law and Amperes law.
- To examine Electromagnetic wave propagation in different medium.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Compute differential length, area and volume for different coordinate systems.
2. Apply Coulomb's Law and Gauss Law to compute electric potential and electric flux density.
3. Apply Biot-savart Law and Ampere's Law to find Magnetic potential.
4. Analyze static and dynamic electromagnetic fields.
5. Analyze the parameters of electromagnetic wave propagation in different medium.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3											2	
2	3	3											2	
3	3	3											2	
4	3	3											3	1
5	3	3											3	1

UNIT I **10 Hours**

INTRODUCTION

Different co-ordinate systems: Cartesian coordinates, cylindrical coordinates, spherical coordinates - Vector calculus: Differential length, area and volume, line surface and volume integrals - gradient of a scalar, divergence of a vector and divergence theorem - curl of a vector and Stoke's theorem - Laplacian of a scalar.

UNIT II **10 Hours**

ELECTROSTATICS

Coulomb's Law - Electric field intensity - Field due to point and continuous charges - Gauss's law and it's applications to calculate electric field - Electric scalar potential - Polarization-Boundary conditions-Poisson's and Laplace's equations - Capacitance-energy density.

UNIT III **9 Hours**

MAGNETOSTATICS

Magnetic field intensity - Biot-savart Law - Ampere's Law - Magnetic field due to straight conductors, circular loop, infinite sheet carrying current -Magnetization-Boundary Conditions-Magnetic vector potential.

UNIT IV **8 Hours**

ELECTRODYNAMICFIELDS

Faraday's laws, induced EMF - Static and dynamic EMF, Maxwell's equations (differential and integral forms), Poynting theorem.

UNIT V **8 Hours**

ELECTROMAGNETIC WAVES

Electro Magnetic Wave equations - Wave parameters: velocity, intrinsic impedance, propagation constant - Waves in free space - skin depth.

Total: 60

Hours

Reference(s)

1. William H. Hayt, Jr. John A. Buck, Engineering Electromagnetics, McGraw Hill Higher Education, 8th revised Edition, 2011.
2. K. A. Gangadhar, P.M. Ramanathan, Electromagnetic Field Theory, Khanna Publishers, Sixteenth Edition, 2011.
3. Bhag Sing Guru and Huseyin R. Hiziroglu, Electromagnetic Field Theory Fundamentals, Cambridge University Press, fourth Edition, 2010.
4. A.Joseph. Edminister and Vishnu Priye, Electromagnetics, Special Indian edition, Schaum'sOutlines, Tata McGraw Hill, 2009.
5. Sadiku, Elements of Electromagnetics, Third Edition, Oxford University Press, 2010.
6. Kraus and Fleish, Electromagnetics with Applications, McGraw Hill International Editions,Fifth Edition, 2008.

18EE305 POWER GENERATION SYSTEMS 3 0 0 3

Course Objectives

- To understand the various terminologies of power plants
- To understand the layout and working of steam power station
- To understand the layout and working of hydro power station
- To understand the layout and main parts of nuclear power station
- To understand the working of different types of alternative sources of electrical energy

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

f. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the performance parameters of power plants
2. Examine the characteristics of turbo alternators and analyze the layout and working of steamturbines and Cogeneration systems
3. Analyze the performance parameters and working of different hydro power station
4. Summarize the layout, working and site selection criteria of Nuclear power station
5. Outline the generation of electricity from alternative energy sources

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2					1						3	
2	2						2						2	1
3	2						2						2	1
4	2					2	2						2	1
5	2					2	3						2	1

UNIT I **9 Hours**

INTRODUCTION

Connected load, maximum load, maximum demand, demand factor, load factor, diversity factor, plant capacity factor, plant utilization factor, load curve , load duration curve and mass curve. Choice of Power station and units.

UNIT II **9 Hours**

STEAM POWER STATION

Steam station layout, Steam station auxiliaries and working of a steam station, characteristics of turbo alternators, super pressure steam stations and Cogeneration systems.

UNIT III **8 Hours**

HYDRO POWER STATION

Hydrology, Hydrographs, Flow duration curve, Hydroelectric power plants - classification, Layout, auxiliaries and working of a hydro station.

UNIT IV **9 Hours**

NUCLEAR POWER STATIONS

Basics of nuclear energy, Layout and main parts of nuclear power station, types of reactor, site selection criteria for nuclear power plant, safety measures.

UNIT V **10 Hours**

ALTERNATIVE SOURCES OF ENERGY

Solar power generation - Photo-voltaic and solar thermal generation, Wind power generation, Geo Thermal, Biomass, Fuel Cell power systems, micro-hydel power plants, tidal power generation and MHD generation.

FOR FURTHER READING

Types of power station, Types of dam,Types of power reactor, Conversion of solar energy into electric energy.

Total:45 Hours

Reference(s)

1. B.R. Gupta Generation of Electrical Energy, S.Chand Publishers, New Delhi,2015.
2. J.B.Gupta , A Course in Electrical Power, S.K. Kataria & Sons Publishers, New Delhi ,2014.
3. Gate Academy Publication, Electrical Power Generation, Third Edition, DURG, 2016.
4. M.V. Deshpande ,Elements of Electric Power Station Design, Tata McGraw Hill, New Delhi,2006.
5. Car, T.H., Electric Power Station, Chappman& Hall Publishers, 2006.
6. Soni Gupta Bhatnagar , A Course in Electrical Power, DhanpatRai Publishers, New Delhi ,2009.

18EE306 COMPUTER PROGRAMMING II 3 0 2 4

Course Objectives

- Understand the fundamental concepts of data structure
- Impart the different paradigms in linear and non-linear data structures to problem solutions
- Determine the problems to solve using sorting and searching algorithms

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Identify the basic concept of data structure and identify the list data structures and its operations
2. Develop applications using stack and queue data structures
3. Develop applications to retrieve records from database using hashing techniques
4. Compare efficiency of various searching techniques using different tree data structures
5. Compare efficiency of various sorting techniques using different data structures

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	3											1	
2	2	2	3										2	
3	2	3	3										3	
4	2	3	3										3	
5	2	3	3										3	

UNIT I **9 Hours**

INTRODUCTION

Basic Terminologies: Elementary Data Organizations, Data Structure Operations: Insertion, Deletion, Traversal, Analysis of an Algorithm: Asymptotic Notations, Time-Space Trade off, Abstract Data Types (ADTs): List ADT

UNIT II **9 Hours**

STACKS AND QUEUES

ADT Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and evaluation-corresponding algorithms and complexity analysis. ADT queue, Types of Queue: Simple Queue, Circular Queue, Priority Queue; Operations on each types of Queues: Algorithms and their analysis.

UNIT II **9 Hours**

LINKED LIST

Singly linked lists: Representation in memory, Algorithms of several operations: Traversing, Searching, Insertion into, Deletion from linked list; Linked representation of Stack and Queue, Header nodes,

Doubly linked list: operations on it and algorithmic analysis; Circular Linked Lists: all operations their algorithms and the complexity analysis.

UNIT IV **10 Hours**

TREES

Basic Tree Terminologies, Different types of Trees: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with Complexity analysis. Applications of Binary Trees. B Tree, B+ Tree: definitions, algorithms and analysis.

UNIT V **8 Hours**

SORTING AND HASHING

Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Performance and Comparison among all the methods, Hashing.

FOR FURTHER READING

Applications of list - Red-Black trees - Splay trees- Bucket hashing - Introduction to NP Completeness

1 **3 Hours**

EXPERIMENT 1

Implement the concepts of Stack, Simple Queue using Arrays

2 **3 Hours**

EXPERIMENT 2

Implement the concepts of Circular Queue and Priority Queue ADT using Arrays

3 **3 Hours**

EXPERIMENT 3

Implement Singly and Doubly Linked list.

4 **3 Hours**

EXPERIMENT 4

Implement Circular Linked list

5 **3 Hours**

EXPERIMENT 5

Implement Stack and Queue ADT using Linked list

6 **3 Hours**

EXPERIMENT 6

Create program to perform tree traversals and other operations in a Binary Search Tree

7 **3 Hours**

EXPERIMENT 7

Develop applications for Hashing.

8 **3 Hours**

EXPERIMENT 8

Implement Sorting and Searching algorithms based on a given scenario.

9 **3 Hours**

EXPERIMENT 9

Implement Quick sort and Merge sort based on a given scenario

10 **3 Hours**

EXPERIMENT 10

Implement Heap sort based on a given scenario

Total: 75 Hours

Reference(s)

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C, 2nd Edition, Pearson Education, 2016.
2. Ellis Horowitz, Sartaj Sahni, Fundamentals of Data Structures, Illustrated Edition, Computer Science Press.
3. Richard F. Gilberg, and Behrouz A. Forouzan, Data Structures - A Pseudocode Approach with C, Thomson 2011.
4. R. G. Dromey, how to Solve it by Computer, 2nd Impression, Pearson Education.

18EE307 ELECTRICAL MACHINES I LABORATORY 0 0 2 1

Course Objectives

- To understand the characteristics of DC motor under various loading conditions.
- To understand the open circuit and load characteristics of DC generator
- To perform the tests to determine the efficiency and regulation of the DC machines and transformers

Programme Outcomes (POs)

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the performance characteristics of PMDC Motors and Generators
2. Apply different methods to control the speed of the DC machine for different operating conditions.
3. Analyze the performance of special machines for different excitation.
4. Determine the performance of a single phase transformer by direct and indirect loading methods.
5. Evaluate the performance parameters of parallel operation of transformers

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1			2										3	
2			3										2	
3			3										2	2
4			3										3	2
5				1									1	3

1 **3 Hours**

EXPERIMENT 1

Performance Analysis of Permanent Magnet DC motor

2 **3 Hours**

EXPERIMENT 2

Performance Analysis of DC Generator coupled with DC motor

3 **3 Hours**

EXPERIMENT 3

Control of Permanent Magnet DC motor.

4 **3 Hours**

EXPERIMENT 4

Load test on DC shunt motor .

5 **3 Hours**

EXPERIMENT 5

Speed control of DC shunt Motor.

6 **3 Hours**

EXPERIMENT 6

Predetermination of Efficiency of DC machine using Swinburne's Test.

7 **3 Hours**

EXPERIMENT 7

Control of stepper motor for different excitations.

8 **3 Hours**

EXPERIMENT 8

Load test on single phase transformer.

9 **3 Hours**

EXPERIMENT 9

Open circuit and short circuit test on single phase transformer.

10 **3 Hours**

EXPERIMENT 9

Determination of performance parameters of transformer using Sumpner's test.

Total: 30 Hours

18EE308 ELECTRON DEVICES AND CIRCUITS LABORATORY

0 0 2 1

Course Objectives

- To obtain the VI characteristics of semiconductor devices.
- To construct a regulated DC power supply for various voltage level.
- To obtain the frequency response of amplifiers and oscillator circuits.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the Volt-Ampere characteristics of diodes, current controlled and voltage controlledpower switches.
2. Design and implement a gate driver circuit for Power Switches.
3. Design and implement the Power supply circuits using voltage regulators.
4. Design and analyse the performance of amplifiers and oscillators
5. Design and implementation of Monostable and Astable Multivibrator circuits.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	3						3	1			3	
2	1	2	3						3	1			3	2
3	3	2	3						3	1			3	2
4	3	2	3						3	1			3	2
5	1	2	3						3	1			3	3

1 **4 Hours**

EXPERIMENT 1

Volt-Ampere characteristics of PN diode and Zener diode.

2 **4 Hours**

EXPERIMENT 2

Volt-Ampere characteristics of Transistor and MOSFET.

3 **4 Hours**

EXPERIMENT 3
Design of Gate driver circuit for MOSFET

4 **2 Hours**

EXPERIMENT 4
Design of DC Power supply circuit.

5 **2 Hours**

EXPERIMENT 5
Design and verification of series voltage regulator.

6 **2 Hours**

EXPERIMENT 6
Design and implementation of CE amplifier.

7 **2 Hours**

EXPERIMENT 7
Design and implementation of class B push pull amplifier.

8 **4 Hours**

EXPERIMENT 8
Design and implementation of RC Phase shift and Wein bridge oscillator.

9 **4 Hours**

EXPERIMENT 9
Design and implementation of Monostable and Astable Multivibrator circuits.

10 **2 Hours**

EXPERIMENT 10
Design of audio amplifier using any one type of power amplifier.

Total: 30 Hours

18EE401 GRAPH THEORY AND PROBABILITY 3 1 0 4

Course Objectives

- Understand the basic concepts of probability and the distributions with characteristics of onedimensional random variables.
- Analyze the various data by different numerical and statistical sampling techniques.
- Develop enough confidence to identify and model mathematical patterns in real world and offer appropriate solutions, using the skills learned in their interactive and supporting environment.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Demonstrate and apply the basic probability axioms and concepts in their core areas of randomphenomena.
2. Analyze the various data by different numerical techniques.
3. Analyze the various collection of data in science / engineering problems using statistical inference techniques.
4. Verify the validity of an argument using propositional and predicate logic and apply graph theory models of data structures and state machines to solve problems of connectivity and constraint satisfaction.
5. Apply the concept of error analysis and finite element analysis techniques in their core area

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1										1	2	
2	3	1										1	3	
3	1	1										1	1	
4	1	1										1	1	
5	2	3										3	2	

UNIT I **10 Hours**

GRAPH THEORY

Introduction to Graphs-Graph operations- Graph and Matrices-Graph Isomorphism- Connected Graphs- Euler Graphs- Hamilton paths and circuits- planar Graph-Graph colouring-Trees- Shortest path problem.

UNIT II **9 Hours**

NUMERICAL SOLUTIONS OF DIFFERENTIAL EQUATION

Solution of first order ordinary differential equations: Euler and Modified Euler mthods-Fourth order Runge- Kutta method - Solution of partial differential equations: Elliptic equations: Laplace equationand Poisson's equation.

UNIT III **10 Hours**

PROBABILITY THEORY

Probability. Random variables, probability densities and distributions, mean and variance of a distribution. Conditional probability. Bayes theorem. Binomial, Poisson and normal distributions.

UNIT IV **9 Hours**

STATISTICS

Mean: Arithmetic mean ,Geometric mean and Harmonic mean ,Median, Mode, Variance, Standard Deviation, Time series Analysis: Moving average Techniques, Covariance, Correlation and Regression.

UNIT V **7 Hours**

ERROR ANALYSIS

Errors, Truncation and round off errors, measurement errors, Chebyshev's Polynomial and data filtering.

Total: 60 Hours

Reference(s)

1 Greenberg Michael D., Advanced Engineering Mathematics, Prentice-Hall International Inc,2nd Edition 2006.
2 James Glyn, Advanced Modern Engineering Mathematics, Addison-Wesley, 4th Edition 2011.
3 Kreyszig Erwin, Advanced Engineering Mathematics, 10th Edition, John Wiley, 2015.
4 Kenneth H Rosen, Discrete Mathematics and its Applications with Combinatorics and Graph Theory, Seventh Edition, Seventh Edition, Mc Graw Hill Education India Private Limited, New Delhi, 2013.
5 Milton J. S. and Arnold Jesse C., Introduction to Probability and Statistics: Principles and Applications for Engineering and The Computing Sciences, McGraw Hill Inc, 4th Edition, 2002.

18EE402 DIGITAL LOGIC CIRCUITS 3 1 0 4

Course Objectives

- To perform the numeric conversions and design of simple logic circuits.
- To understand the concepts of combinational circuits
- To construct synchronous and asynchronous sequential circuits
- To familiarize with programmable logic devices and logic families
- To understand the fundamental concepts of VHDL programming

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply Boolean algebra and number systems to design the digital circuits.
2. Design and realize the combinational circuits using logic gates
3. Analyze the synchronous and asynchronous sequential circuits and design the synchronous sequential circuits using basic flip flops
4. Examine the operation of various Programmable Logic Devices and logic families
5. Develop simple programs in VHDL

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	3	1									3	
2	3	2	3	1									3	1
3	3	2	3	1									3	1
4	3	2	3	1									2	1
5	3	2			3								2	1

UNIT I **10 Hours**

NUMBER SYSTEM AND BOOLEAN ALGEBRA

Review of number system; Types and conversion of codes-BCD, Gray code, Excess 3 code; Error detection and correction codes; Boolean algebra: De-Morgan's theorem, Simplification of functions using K-maps- Quine McCluskey method.

UNIT II **9 Hours**

COMBINATIONAL CIRCUITS

Design of functions using logic gates, Design of Adders, Subtractors, Comparators, Code converters, Encoders, Decoders, Multiplexers and Demultiplexers.

UNIT III **10 Hours**

SYNCHRONOUS AND ASYNCHRONOUS SEQUENTIAL CIRCUITS

Flip flops - SR, JK - MSJK , D and T, Analysis of synchronous and asynchronous sequential circuits, Design of synchronous sequential circuits-Counters, Moore and Melay model; state diagram; state reduction; state assignment.

UNIT IV **7 Hours**

PROGRAMMABLE LOGIC DEVICES AND LOGIC FAMILIES

Programmable Logic Devices: PLA, PAL, Logic families: TTL, ECL,IIL, CMOS.

UNIT V **9 Hours**

INTRODUCTION TO VHDL

Digital design process flow- Entities and Architecture-Concurrent Statements-Sequential statements -Behavioral, Dataflow, and structural modeling - simple VHDL codes.

FOR FURTHER READING

Shift registers: shift register operations, SISO, SIPO, PISO and PIPO, Design of asynchronous sequential circuits, Field Programmable Logic Array(FPLA)

Total: 60 Hours

Reference(s)

1. Malvino and Leach, Digital Principles and Applications, Tata McGraw Hill, New Delhi, 7th edition, 2011
2. A.Anand kumar, Fundamentals of digital circuits, 3rd Edition, PHI Learning Pvt Ltd, 2014
3. John M.Yarbrough, Digital Logic, Application & Design, Thomson, 2010.
4. Floyd, Digital Fundamentals, Pearson Education, 10 th edition, 2011.
5. M. Morris Mano, Digital Logic and Computer Design, Prentice Hall of India, 4th edition, 2013
6. A. K. Maini,Digital Electronics: Principles, Devices And Applications, Wiley, 2007

18EE403 TRANSMISSION, DISTRIBUTION AND UTILIZATION

3 0 0 3

Course Objectives

- To understand the various types of transmission system and develop the mathematical models for line parameters.
- To compute the voltage regulation and efficiency using line parameters.
- To analyze the voltage distribution in insulator strings and grading of cables in transmission lines.
- To understand the different types of distribution system and substations with its layout
- To understand the application of electrical energy in domestic and industrial loads.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the line parameters of overhead transmission lines.
2. Determine the voltage regulation and transmission efficiency of short, medium and long transmission lines.
3. Classify the different types of cables and insulators and estimate the string efficiency of insulators.
4. Classify the substations and analyze the performance of single and three phase distributionsystem.
5. Exemplify the utilization of electric energy in heating and welding applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2											3	
2	3	3											3	
3	3	2											1	
4	3													1
5	3													1

UNIT I **10 Hours**

LINE PARAMETERS

Resistance, Inductance and capacitance of single phase and three phase line - Stranded and bundled conductor configurations - Symmetrical and unsymmetrical spacing - Transposition of line conductors - Double circuit lines - Skin and proximity effects.

UNIT II **10 Hours**

PERFORMANCE OF TRANSMISSION LINES

Regulations and Efficiency of Short Lines, Medium transmission lines by nominal T & Ž methods- Long Transmission line by Rigorous Solutions - ABCD Constant - Ferranti Effect - Corona Effect - Corona loss.

UNIT III **8 Hours**

CABLES AND INSULATORS

Cables - Types - Capacitance - Grading of cables - Testing of cables - Insulators - Types and comparison Voltage distribution in insulator string - String efficiency - Methods of improving string efficiency.

UNIT IV **9 Hours**

DISTRIBUTION SYSTEM

AC distribution - single phase and three phase, 4-wire distribution- System comparison- Primary and Secondary distribution networks - Underground Distribution system - Laying, Terminal equipment - Substation equipment and layouts.

UNIT V **8 Hours**

UTILIZATION OF ELECTRICAL ENERGY

Electric Heating: Advantages and methods of electric heating, resistance heating, induction heating and dielectric heating Electric Welding: resistance and arc welding, electric welding equipment, comparison between A.C. and D.C. Welding.

Total: 45 Hours

Reference(s)

1. C.L .Wadhwa, Electrical Power Systems, New Age International Edition, New Delhi 2018
2. I.J.Nagrath, D.P.Kothari, Power System Engineering, Tata McGraw Hill Ltd, New Delhi, 2017
3. V. Kamaraju , Electrical Power Distribution Systems, Tata McGraw Hill Ltd, New Delhi, 2017
4. Turan Gonen, Electric Power Distribution system, Engineering, CRC Press 2017
5. H Partap Art and Science of Utilization of Electrical Energy, Dhanpat Rai & Sons 2017
6. E. Openshaw Taylor and V. V. L. Rao, Utilization of Electric Energy, University Press

18EE404 ELECTRICAL MACHINES I 3 1 0 4

Course Objectives

- To understand the construction, working and performance characteristics of alternator.
- To understand the construction and starting methods of Synchronous motor.
- To understand the construction working and performance characteristics of single phase and three phase induction motor.
- To select the appropriate machine from the knowledge of starting and speed control for variousapplications
- To understand the characteristics of fractional horse power motors.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the performance of alternator and compute EMF equation and voltage regulation by using different methods
2. Analyze the characteristics and assess the performance of synchronous motor.
3. Analyze the characteristics, equivalent circuit and circle diagram of three phase induction motor and induction generator.
4. Apply suitable starting and speed control methods for three phase induction motors.
5. Apply the double revolving field theory to develop equivalent circuit of fractional horse power motors and examine their performance.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2											2	-
2	2	2											2	1
3	3	2											3	-
4	2	2											-	2
5	2	3											1	2

UNIT I **10 Hours**

ALTERNATOR

Principle of Operation - Construction - Types of rotor - EMF equation - Armature reaction - Regulation of alternator: EMF, MMF and ZPF method - Capability curve of alternator - Permanent Magnet Synchronous Generator.

UNIT II **8 Hours**

SYNCHRONOUS MOTOR

Principle of operation - Methods of starting - Phasor diagram - V and Inverted V curve - Power angle characteristics - Hunting in synchronous motor - Application of Synchronous motor as synchronous condenser

UNIT III **10 Hours**

INDUCTION MOTOR

Concept of Rotating Magnetic Field - Construction - Types of rotor - Operation - torque equation - Torque - slip characteristics - Equivalent circuit model - Induction generator - Linear induction motor.

UNIT IV **8 Hours**

STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

Need for starters - Methods of starting - Fully automated starters: DOL, Autotransformer, star delta starter - rotor resistance starter - Methods of braking, Methods of Speed Control - V/f Control and Pole Changing Techniques

UNIT V **9 Hours**

FRACTIONAL HORSE POWER MOTOR

Double Revolving Field Theory - Methods of Starting : Capacitor start - Capacitor start capacitor run - Shaded pole Equivalent circuit model - Universal motor - Stepper motor

Total: 60 Hours

Reference(s)

1. M.G.Say, Performance and Design of Alternating Current Machines, 3rd Edition, CBS Publisher, 2017
2. D. P. Kothari and I. J. Nagrath, Electric Machines, Tata McGraw Hill Publishing Company Ltd,Fourth Edition 2018
3. Stephen J.Chapman, Electric Machinery Fundamentals, Tata McGraw Hill, New Delhi, 2018
4. E. Fitzgerald, Charles Kingsley, Stephen.D.Umans, Electric Machinery, Tata McGraw Hillpublishing Company Ltd, New Delhi ,2015
5. P. S. Bhimbhra, Electrical Machinery, Khanna Publishers, Seventh Edition 2018
6. Acarnley, P. P, Stepping motors: a guide to modern theory and practice, The Institution ofElectrical Engineers.

18EE405 INTEGRATED CIRCUITS AND APPLICATIONS

3 0 0 3

Course Objectives

- To understand the fundamentals and characteristics of Op-amp.
- To understand the linear applications of Op-amp.
- To understand the Non-linear applications of Op-amp.
- To understand the operation of A/D and D/A converters using Op-amp.
- To familiarize the students with the application of Special IC's.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and thecultural, societal, and environmental considerations.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the DC and AC characteristics of the Op-amp.
2. Develop simple Op-amp based circuits for linear applications.
3. Design and analyze the Op-Amp for non linear applications.
4. Construct A/D and D/A converters for signal processing applications and analyse the effect ofsingle power supply Op-Amp.
5. Design and Analyze various application circuits using Special IC's

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	-										1	
2	3	3	3										3	2
3	3	3	3										3	2
4	2	2	2										3	2
5	2	3	3										3	3

UNIT I **10 Hours**

CHARACTERISTICS OF OPERATIONAL AMPLIFIER

Basic Parameters of Operational Amplifier - Block diagram of Operational Amplifier - Characteristics of Ideal and Practical Operational Amplifier, transfer characteristics - Inverting and Non-inverting Amplifiers, Voltage follower -DC characteristics-AC characteristics-Frequency Response, Stability - Frequency Compensation techniques.

UNIT II **8 Hours**

LINEAR APPLICATIONS OF OPERATIONAL AMPLIFIER

Summing amplifier- Differential amplifier - Instrumentation amplifier - Integrator and Differentiator - Voltage to Current and Current to Voltage converters, Oscillators-Sine Wave (RC Phase Shift and Wein Bridge), Triangular Wave and Saw tooth Wave Generation.

UNIT III **10 Hours**

NON-LINEAR APPLICATIONS OF OPERATIONAL AMPLIFIERS

Comparators-Zero crossing detector, Schmitt Trigger, Window detector -Clippers, Clampers, Peak Detector-Sample and Hold circuit- Astable and Monostbale Multivibrators - Active filters-Analysis and Design of first order low pass, high pass, band pass and Band stop Butterworth filters.

UNIT IV **9 Hours**

A-D AND D-A CONVERTERS

DAC/ADC performance characteristics -Digital to Analog Converters: Binary weighted and R-2R Ladder types - Analog to digital converters: Successive approximation and Flash Type. Single Power Supply Operational Amplifiers: Need for single power supply operational amplifiers, AC Inverting and Non-Inverting amplifiers.

UNIT V **8 Hours**

SPECIAL ICS

555 Timer circuit -Functional block, Astable and Monostable characteristics, applications; Voltage regulators - fixed voltage regulators, adjustable voltage regulators - switching regulators.

FOR FURTHER READING

566-voltage controlled oscillator circuit; 565- PLL Functional Block diagram -Principle of operation, Applications: Frequency synthesis, AM and FM detection, FSK demodulator.

Total: 45 Hours

Reference(s)

1. David A.Bell, 'Op-amp & Linear ICs', Oxford, 2013.
2. Ramakant A.Gayakward, 'Op-amps and Linear Integrated Circuits', IV edition, Pearson Education, 2015.
3. Jacob Millman, Christos C.Halkias, 'Integrated Electronics - Analog and Digital circuits system',Tata McGraw Hill, 2009.
4. Michael Jacob J, 'Applications and Design with Analog Integrated Circuits', Prentice Hall ofIndia, New Delhi, 2010.
5. Robert F.Coughlin, Fredrick F. Driscoll,Op-amp and Linear ICs, Pearson, 6th edition,2012

6. S. Salivahanan and V.S. Kanchana Bhaaskaran , Linear Integrated Circuits, First reprint, Tata McGraw Hill, 2015.

18EE406 PYTHON PROGRAMMING 2 0 2 3

Course Objectives

- Understand the history and basics of python.
- Gain knowledge about the different data types and control flow statements.
- Impart knowledge about the functions, files, list, set tuples and dictionaries.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Implement simple python programs using input output operations.
2. Develop python programs using expressions and statements.
3. Implement python programs using control flow statements and strings.
4. Apply the concepts of functions and files in python programming.
5. Design applications using list, sets, tuples and dictionaries in python.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3		3									1	
2	2	3		3									2	
3	2	3		3									1	
4	2	3		3									1	
5	2	3		3									3	

UNIT I **6 Hours**

INTRODUCTION

What is Python - History of Python - Features of Python - Simple Program in Python - Commenting in Python - Quotations in Python - Lines and Indentation - Multi-Line Statements - Input Operations - Output Operations.

UNIT II **4 Hours**

DATA, EXPRESSIONS, STATEMENTS

Python interpreter and interactive mode; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.

UNIT III **8 Hours**

CONTROL FLOW STATEMENTS AND STRINGS

if statement-if-else statement-if-elif-else statement- Nested if - While loop - for loop - else statement used with loops - break statement -continue - pass statement - Strings: string slices -immutability - stringfunctions and methods - In-built string methods - string formatting operations - string module.

UNIT IV **6 Hours**

FUNCTIONS AND FILES

Functions: return values -parameters - local and global scope - function composition - recursion; Files: Reading and Writing-Format Operators-Filenames and paths.

UNIT V **6 Hours**

LIST, SET, TUPLES AND DICTIONARIES

Lists as arrays - Lists: list operations - list slices -list methods - list loop - mutability - aliasing - cloning lists - list parameters; Set; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods.

1 **2 Hours**

EXPERIMENT 1

Program to implement basic operators.

2 **2 Hours**

EXPERIMENT 2

Program for Operator Precedence.

3 **2 Hours**

EXPERIMENT 3

Program to implement the concept of function.

4 **3 Hours**

EXPERIMENT 4

Develop the program for selection statements.

5 **3 Hours**

EXPERIMENT 5

Program to implement looping statements.

6 **3 Hours**

EXPERIMENT 6

Program to implement break and continue statements.

7 **3 Hours**

EXPERIMENT 7

Develop a program to implement the concept of Recursion.

8 **3 Hours**

EXPERIMENT 8

Program to implement string functions.

9 **3 Hours**

EXPERIMENT 9

Implement the concept of list.

10 **3 Hours**

EXPERIMENT 10

Develop a program to implement tuples.

11 **3 Hours**

EXPERIMENT 11

Program to implement set,dictionaries.

Total: 60 Hours

Reference(s)

1. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, 2nd edition,Updated for Python 3, Shroff Reilly Publishers, 2016 (http://greenteapress.com/wp/think- python/)
2. Guido van Rossum and Fred L. Drake Jr, An Introduction to Python -Revised and updated forPython 3.2, Network Theory Ltd., 2014.
3. Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem-Solving Focus, Wiley India Edition, 2015.
4. John V Guttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press , 2017.

18EE407 ELECTRICAL MACHINES II LABORATORY 0 0 2 1

Course Objectives

- To understand the performance of a three phase induction motor by direct loading method.
- To understand the performance characteristics of an induction generator with self-excitation.
- To analyze the performance parameters of special motors by conducting suitable test.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1.Analyze the load characteristics of three phase induction motor and the separation of losses.

2.Apply different speed control techniques and its performance evaluation for three phase induction motor.

3.Analyze the performance characteristics induction motor for braking techniques.

4.Evaluate the performance characteristics of self-excited induction generator and axial flux generator.

5.Analyze the load characteristics of special motors and its performance.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1		3		1					3				3	1
2		3		2					3				3	1
3	2	3		3					3				3	1
4		2		3					3				2	1
5		3		1					3				2	1

1 **3 Hours**

EXPERIMENT 1

Performance curves of three phase squirrel cage induction motor by direct loading method.

2 **3 Hours**

EXPERIMENT 2

Separation of no load losses in three phase squirrel cage induction motor.

3 **3 Hours**

EXPERIMENT 3

Speed control of three phase induction motor.

4 **4 Hours**

EXPERIMENT 4

Equivalent circuit and circle diagram for three phase induction motor

5 **3 Hours**

EXPERIMENT 5

Braking methods of three phase induction motor.

6 **4 Hours**

EXPERIMENT 6

Load test on self-excited induction generator.

7 **4 Hours**

EXPERIMENT 7

Performance analysis of three phase AC motor coupled Axial Flux Generator.

8 **3 Hours**

EXPERIMENT 8

Speed control of BLDC Motor.

9 **3 Hours**

EXPERIMENT 9

Load characteristics of BLDC motor**.**

Total: 30 Hours

Reference(s)

1.E. Fitzgerald, Charles Kingsley, Jr.Stephen D. Umans, Electric Machinery, Sixth Edition,Tata McGraw Hill Publishing Company Ltd., 2002.

2.M.G.Say, Performance and Design of Alternating Current Machines, 3rd Edition, CBS Publisher

3.D. P. Kothari and I. J. Nagrath, Electric Machines, Tata McGraw Hill Publishing Company Ltd,Fourth Edition 2010

4.Raj put R.K, Electric Machines, Lakshmi publication,fifth edition, reprinted at 2011

5.P. S. Bhimbhra, Electrical Machinery, Khanna Publishers, Seventh Edition 2011

6.Miller T.J.E. Brushless permanent Magnet and Reluctance Motor Drives, Clarendon Press

18EE408 DIGITAL AND INTEGRATED CIRCUITS

LABORATORY 0 0 2 1

Course Objectives

- To analyze the operation of combinational and Sequential digital circuits.
- To apply the principles of Op-amp in linear and non linear applications.
- To understand the applications of 555 timer IC.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural,societal, and environmental considerations.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Design and implementation of combinational and sequential logic circuits using logic gates.
2. Design and Implementation of digital circuits using VHDL.
3. Design wave shaping circuits, ADC and DAC using op amp.
4. Design and Implementation of real time applications using Op-Amp.
5. Design and construct astable and monostable multivibrators using IC555 timer.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2		3		3				3				3	1
2	2		3		3				3				3	1
3			3						3				2	1
4	3		3						3				3	1
5	2		3						3				3	2

1 **4 Hours**

EXPERIMENT 1

Simulation of logic gates and design Full adder and Full subtractor circuits by using VHDL.

2 **2 Hours**

EXPERIMENT 2

Experimental verification of logic gates and design adder, subtractor and three variable Boolean Functions

3 **4 Hours**

EXPERIMENT 3

Design and implementation of Multiplexer and Demultiplexer using logic gates

4 **4 Hours**

EXPERIMENT 4

Verification of RS and JK Flip-flop and design the bidirectional shift registers by VHDL.

5 **2 Hours**

EXPERIMENT 5

Design and implementation of counters by behavioural modeling of VHDL

6 **4 Hours**

EXPERIMENT 6

Design and implementation of differentiator and integrator circuits by using op-amp.

7 **2 Hours**

EXPERIMENT 7

Design and implementation of Instrumentation amplifier by using op-amp

8 **2 Hours**

EXPERIMENT 8

Design and implementation of simple Microphone to Speaker circuit by using op-amp

9 **2 Hours**

EXPERIMENT 9

Design and implementation of analog to digital converter and digital to analog converter using op-amp.

10 **4 Hours**

EXPERIMENT 10

Design and implementation of Astable and Monostable Multivibrators using IC 555 Timer.

Total: 30 Hours

18HS001 ENVIRONMENTAL SCIENCE 2 0 0 0

Course Objectives

- Understand the interdisciplinary and holistic nature of the environment
- Identify the significance of natural resources and environment on the quality of life and stimulate the quest for sustainable development
- Assess the socio-economic, political and ethical issues in environmental science

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Explain the importance of interdisciplinary nature of environment studies, uses andexploitation of natural resources
2. Analyze the different types of ecosystems and biodiversity, its values and also role of professionals in protecting the environment from degradation
3. Identify the existing environmental challenges related to pollution and its management
4. Select suitable strategies for sustainable management of components of environmentalscience
5. Correlate the impacts of population and human activities on environment

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2											2	
2	1	1											3	
3	2	2					1						2	
4	1												1	
5	2												2	

UNIT I **6 Hours**

NATURAL RESOURCES

Forest resources: Use - over exploitation - deforestation - case studies. Water resources: Use - over utilization of surface and ground water - conflicts over water. Mineral resources: Use - exploitation - environmental effects of extracting and using mineral resources - case studies. Food resources: Effects of modern agriculture - fertilizer-pesticide problems (eutrophication, blue baby syndrome, biomagnification) - water logging - salinity - case studies. Energy resources: renewable(solar, wind, tidal, geothermal and hydroelectric power) - non renewable energy sources

UNIT II **6 Hours**

ECOSYSTEMS AND BIODIVERSITY

Concept of an ecosystem: Structure and function of an ecosystem - producers - consumers - decomposers - food chains - food webs and ecological pyramids - Types of ecosystem: Introduction - characteristic features: forest ecosystem - desert ecosystem - ecological succession. Biodiversity - value of biodiversity - threats to biodiversity - endangered and endemic species - Conservation of biodiversity: In-situ and ex-situ conservation of biodiversity - field study

UNIT III **6 Hours**

ENVIRONMENTAL POLLUTION

Pollution: Definition - causes - effects - control measures of air pollution - water pollution : (Sewage water treatment by activated sludge and trickling filter process) - marine pollution - thermal pollution - noise pollution. Disaster management: causes - effects - control measures of floods - earthquake - cyclone – landslides

UNIT IV **7 Hours**

SOCIAL ISSUES AND ENVIRONMENT

Sustainable development : Definition - Unsustainable to sustainable development - urban problems related to energy. Environmental ethics - issues and possible solutions - solid waste management - causes - effects - 3R Principles (landfills, incineration, composting). Water conservation - rain water harvesting - watershed management. Climate change - global warming - acid rain - ozone layer depletion. Environment protection act: Air (Prevention and control of pollution) act - wildlife protection act.

UNIT V **5 Hours**

HUMAN POPULATION AND ENVIRONMENT

Human population: Population growth - characteristics - variation among nations - population explosion - women and child welfare programmes - value education - HIV / AIDS. Role of information technology in environment and human health - occupational safety and health administration (OSHA)

FOR FURTHER READING

Human rights: E - waste and biomedical waste -Identification of adulterants in food materials

Total: 30 Hours

Reference(s)

1. Anubha Kaushik, C.P. Kaushik, Environmental Science and Engineering , 4th MultiColour Edtion, New Age International Publishers, New Delhi, 2014
2. Raven, P.H., Hassenzahl, D.M. & Berg, L.R. 2012. Environment. 8th edition. John Wiley& Sons
3. T. G. Jr. Miller, S. Spoolman, New Environmental Science, 14th Edition, Wadsworth Publishing Co, New Delhi, 2014
4. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2011. Environmental and Pollution Science. Academic Press
5. A. K. De, Environmental Chemistry, 7th Edition , New age international publishers, NewDelhi, 2014

21EE501 POWER SYSTEM ANALYSIS

3 1 0 4

Course Objectives

- To apply the concept of per unit systems in power system computations.
- To develop algorithms for power system planning.
- To understand the application of power system matrices.
- To understand the concept of symmetrical components.
- To analyze the stability of given network.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Apply the concept of per unit systems to construct the reactance diagram of the givenpower system network.
2. Evaluate the power flow and losses in a power system network using non-lineariterative solution methods.
3. Apply the concepts of Bus impedance matrix, reactance diagrams to analyze the effects of balanced faults in power system.
4. Apply the concept of symmetrical components to analyze the effects of unbalanced faults in power system.
5. Evaluate the stability of the power system during transient operations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3											3	
2	3	3		1									3	
3	3	3		2									3	
4	3	3		2									3	
5	3	3		2									3	

UNIT I **9 Hours**

POWER SYSTEM MODELING

Single line diagrams -Per unit system -Per unit impedance/ reactance diagrams -Formation of network matrices - Y bus formation using inspection and singular transformation -Z bus formation using step- by-step building algorithm method.

UNIT II **8 Hours**

LOAD FLOW ANALYSIS

Load flow equations and methods of solution -Slack bus concept -Gauss Seidal, Newton Raphson, Fast decoupled methods for load flow studies.

UNIT III **8 Hours**

FAULT ANALYSIS - SYMMETRICAL FAULTS

Importance of short circuit analysis - assumptions in fault analysis - analysis using Thevenin's theorem - Z-bus building algorithm - fault analysis using Z-bus - computations of short circuit capacity, postfault voltage and currents.

UNIT IV **11 Hours**

FAULT ANALYSIS - UNSYMMETRICAL FAULTS

Introduction to symmetrical components - sequence impedances - sequence circuits of synchronous machine, transformer and transmission lines - sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenin's theorem and Z-bus matrix.

UNIT V **9 Hours**

POWER SYSTEM STABILITY

Steady state and transient stability -Swing equation and its solution method (step by step) -Equal areacriterion -Factors affecting stability and methods of improving stability.

FOR FURTHER READING

Overview of Indian power scenario- Electricity Deregulation-Captive Power Plants

Total: 60 Hours

Reference(s)

1. I.J. Nagarath, D.P. Kothari, Modern Power System Analysis, Tata McGraw Hill PublishingCompany, New Delhi,2013.
2. John Grainger, William Stevenson JR, Power System Analysis, Mcgraw-Hill Series in Electricaland Computer Engineering, New Delhi, 2014.
3. Hadi Saadat, Power System Analysis, PSA Publishers, New Delhi, 2013.
4. P.Kundur, Power System Stability and Control, Tata McGraw Hill Book Company, New Delhi,2013.
5. Charles A. Gross, Power System Analysis, Wiley India Pvt Ltd, Second edition, 2010.
6. P. Venkatesh, B.V. Manikandan, S. Charles Raja, A. Srinivasan, Electrical Power SystemsAnalysis, Security and Deregulation, PHI Learning Private Limited, New Delhi, 2012.

21EE502 CONTROL SYSTEMS 3 1 0 4

Course Objectives

- To understand the basic concepts of open loop and closed loop control systems.
- To analyze the given system in time domain.
- To understand the concept of frequency domain analysis
- To understand the concept of stability of system
- To design the compensator for different control systems

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural,societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Develop a mathematical model of a physical system and compute the transfer function usingBlock diagram reduction technique and Signal flow graph.
2. Analyze the performance of first and second order system and compute the steady state error fordifferent test signals.
3. Analyze the frequency response of a given system.
4. Examine the stability of a given system using various methods.
5. Design a lag, lead and lag lead compensator for open loop system and examine a system usingstate variable techniques.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3											3	
2	3	3											3	
3	3	3		1									3	
4	3	3		1									3	
5	3	3	1	1									3	3

UNIT I **10 Hours**

MATHEMATICAL MODEL OF PHYSICAL SYSTEMS

Introduction- Basic Elements of control systems-Open loop and closed loop system - Elements of Control system - Transfer function of mechanical translational and rotational system, electrical system - Electrical analogy of mechanical system - Block diagram reduction technique - Signal flow graph.

UNIT II **8 Hours**

TIME DOMAIN ANALYSIS

Standard test signals - Time response of first order and second order systems for unit step test signals - Time domain specifications-Steady state response - Static error constants - steady state error - Effects of proportional derivative, proportional integral systems.

UNIT III **9 Hours**

FREQUENCY DOMAIN ANALYSIS

Frequency response of systems - Frequency domain specifications - Correlation between frequency domain and time domain specifications - Bode plot, Polar plot

UNIT IV **10 Hours**

STABILITY ANALYSIS OF CONTROL SYSTEM

Concepts of stability - Necessary conditions for Stability-Characteristics equation - Location of roots inS plane for stability - Routh Hurwitz criterion-Nyquist stability criterion- Root Locus technique- Relative Stability

UNIT V **8 Hours**

COMPENSATOR DESIGN

Compensators, Deign of Lag compensator - Lead compensator - Lag-lead compensator (using Bode plot) - Concept of state, state variable, state model, Controllability and observability

Total: 60 Hours

Reference(s)

1. I.J.Nagrath and M.Gopal, Control System Engineering, NewAge International Publisher,2018
2. M.Gopal, Control System Principles and Design,TataMcGraw-Hill,2012.
3. K.Ogatta, Modern Control Engineering, Pearson Education, NewDelhi, 2015
4. BenjaminC. Kuo, Automatic Control Systems, Prentice-Hall of India Pvt. Ltd.2014
5. M.N.Bandyopadhyay, Control Engineering Theory and Practice, Prentice Hall of India,2009

21EE503 MEASUREMENT AND INSTRUMENTATION 3 0 2 4

Course Objectives

- To understand the fundamental concepts of measuring instruments.
- To understand the operation of various analog instruments.
- To understand the operation of various digital instruments.
- To measure R, L and C elements using DC and AC bridges.
- To learn the principle and working of various transducers.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the static and dynamic behavior of a measurement system and compare with standard system.
2. Apply the concept of Faradays Law in various types of Analog Instruments and determine thetypes of errors associated with them.
3. Analyze the characteristics and performance parameters of Digital instruments.
4. Design a suitable bridge for the measurement of unknown resistance, Inductance and Capacitance.
5. Analyze the various types of transducers to measure the physical quantities.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2											1	
2	2	1											2	
3	2	1											2	
4	3	3											2	1
5	2												1	

UNIT I **9 Hours**

INTRODUCTION

Units and dimensions, Functional elements of an instruments, Static and dynamic characteristics, Errors in measurement, Statistical evaluation of measurement data, Standards and calibration.

UNIT II **9 Hours**

ANALOG INSTRUMENTS

Moving coil instruments: Permanent magnet moving coil instruments, Moving iron: attraction and repulsion type instruments- Torque equations and errors, Single and Three phase watt meters and Energy meters.

UNIT III **10 Hours**

DIGITAL INSTRUMENTS

Introduction, Digital Multi-meter: Block diagram, principle of operation, Digital Voltmeter: Block diagram, principle of operation, Types-Integrating type voltmeter, Digital Phase meter, Power quality analyzer.

UNIT IV **9 Hours**

MEASUREMENT OF ELECTRICAL AND NON ELECTRICAL QUANTITIES

Measurement of Resistance:Kelvin double bridge,Wheatstone bridge, Measurement of inductance and capacitance: Maxwell and Schering bridge,Earth Resistance Tester, Measurement of Temperature: Thermocouples, Radiation and Optical pyrometer.

UNIT V **8 Hours**

TRANSDUCERS

Selection of transducer, Classification of transducers: Resistive ,capacitive & inductive transducers, Piezoelectric, Hall Effect Transducers.

FOR FURTHER READING

Calibration of Meters, Smart sensors.

1 **2 Hours**

EXPERIMENT 1

Displacement measurement using LVDT.

2 **4 Hours**

EXPERIMENT 2

Experimental verification of Wheatstone bridge.

3 **4 Hours**

EXPERIMENT 3

Experimental verification of Kelvin double bridge.

4 **4 Hours**

EXPERIMENT 4

Experimental verification of Maxwells inductance bridge.

5 **4 Hours**

EXPERIMENT 5

Experimental verification of Schering bridge

6 **2 Hours**

EXPERIMENT 6

Calibration of ammeter and voltmeter.

7 **2 Hours**

EXPERIMENT 7

Calibration of Wattmeter.

8 **2 Hours**

EXPERIMENT 8

Calibration of single phase energy meter.

9 **4 Hours**

EXPERIMENT 9

Temperature measurement using RTD, Thermistor and IC AD590.

10 **2 Hours**

EXPERIMENT 10

Measurements using cathode ray oscilloscope.

Total: 75 Hours

Reference(s)

1. A. K. Sawhney, A Course in Electrical & Electronic Measurements & Instrumentation, 19th edition Dhanpat Rai and Co, 2014.
2. E. O. Doebelin, Measurement Systems Application and Design, Tata McGraw Hill Publishing Company, 2007.
3. D. V. S. Murthy, Transducers and Instrumentation, Prentice Hall of India Pvt Ltd, 2004.
4. H. S. Kalsi, Electronic Instrumentation, Tata McGraw Hill, 3rd edition 2012.
5. J. B. Gupta, A Course in Electronic and Electrical Measurements, S. K. Kataria & Sons, Delhi, 2008.

21EE504 POWER ELECTRONICS 3 1 0 4

Course Objectives

- To analyze the static and switching characteristics of power semi-conductor devices.
- To understand the operation of controlled rectifiers.
- To understand and analyze the various types of choppers.
- To evaluate the operation, characteristics and performance parameters of Inverters.
- To understand the operation of ac-ac converters.

Programme Outcomes (POs)

a.Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural,societal, and environmental considerations.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Assess the static and dynamic characteristics of power semiconductor devices with the protection circuits.
2. Evaluate the input and output parameters of controlled rectifiers with R, RL and RLE Load.
3. Apply the various converter topologies to design and analyze the switched mode regulators
4. Examine the operation of inverter topologies with different PWM schemes.
5. Analyze the performance parameters of AC- AC converters.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1											1	
2	3	2	1										3	
3	3	2	1										3	1
4	3	2	1										3	1
5	3	2											3	1

UNIT I **9 Hours**

POWER SEMI-CONDUCTOR DEVICES

Construction Operation Static and Dynamics characteristics of Power Diode-Power BJT -SCR -DIAC - TRIAC- GTO -MOSFET - IGBT Ratings of Devices Protection of Devices.

UNIT II **10 Hours**

CONTROLLED RECTIFIERS

Single Phase and Three Phase Half and Fully controlled rectifier with R, RL, RLE Load - Effect of Freewheeling Diode -Continuous and Discontinuous Mode of operation - Performance Analysis - Dual converter.

UNIT III **8 Hours**

CHOPPERS

Classification -control strategies - Buck, Boost, and Buck-Boost - Performance analysis - PWM techniques for choppers- Switched mode regulators

UNIT IV **12 Hours**

INVERTERS

Single Phase H - Bridge and Cascaded H Bridge - Three Phase Voltage Source Inverters - Single phase and Three Phase Current Source Inverters - Performance analysis - PWM techniques. - Analysis of Harmonic Distortion.

UNIT V **6 Hours**

AC-AC CONVERTERS

Performance analysis of Single Phase and Three Phase AC Voltage Controllers - Single phase Matrix converters.

Total: 60 Hours

Reference(s)

1.Muhammad H.Rashid, Power Electronics Circuits, Devices & Applications 4th Edition, Pearson India, 2017.

2.NedMohan, Tore.M.Undeland, William.P.Robbins, Power Electronics: Converters, Applications and Design,3rd Edition WileyIndia, NewDelhi, 2007.

3.M.D.Singh & K.B Khanchandani. Power Electronics 2nd Edition Tata Mc Graw Hill Publishing Co.Ltd., New Delhi,2008.

4.D. Ronanki, S. Singh, S. Williamson, "Comprehensive Topological Overview of Rolling Stock Architectures and Recent Trends in Electric Railway Traction Systems", IEEE Trans. Transportation Electrification., vol. 3, no. 3, pp. 724-738, May 2017.

5.E. Babaei, S. Alilu, and S. Laali, "A new general topology for cascaded multilevel inverters with reduced number of components based on devel-oped H-bridge,-IEEE Trans. Ind. Electron., vol. 61, no. 8, pp. 3932-3939,Aug. 2014

21EE507 POWER SYSTEM SIMULATION

LABORATORY **0 0 2 1**

Course Objectives

- To acquire programming skills and experience in the usage of standard packages like Matlab and E-Tap necessary for power system analysis
- To acquire knowledge required for planning, operation and control of power system networks through simulation

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Apply the concepts of graph theory to determine the network incidence matrices
2. Evaluate the power flow and losses in a power system network using non-linear iterative solution methods
3. Analyse the short circuit current in a power system network following a fault, using simulationtools
4. Create a program to determine the economic loading point of synchronized generating units
5. Analyse rotor angle stability in a power system network using simulation tools.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1				3								3	
2	1				3								3	
3	1				3								3	
4	1				3								3	
5	1				3								3	

1 **4 Hours**

EXPERIMENT 1
Formation of Bus Admittance Matrix and Bus Impedance Matrix

2 **4 Hours**

EXPERIMENT 2
Formation of Bus incidence matrix and loop incidence matrix.

3 **4 Hours**

EXPERIMENT 3
Formation of Branch path incidence matrix and Basic cutest matrix.

4 **2 Hours**

EXPERIMENT 4
Solution of Power Flow and Related Problems Using Gauss-Seidel method

5 **4 Hours**

EXPERIMENT 5
Solution of Power Flow and Related Problems Using Newton-Raphson Method

6 **4 Hours**

EXPERIMENT 6
Solution of Power Flow and Related Problems Using Fast-Decoupled Load Flow

7 **2 Hours**

EXPERIMENT 7
Short Circuit analysis

8 **2 Hours**

EXPERIMENT 8
Economic Dispatch in Power Systems

9 **2 Hours**

EXPERIMENT 9
Transient Stability Analysis

10 **2 Hours**

EXPERIMENT 10
Contingency Analysis

Total: 30 Hours

21EE508 CONTROL SYSTEMS LABORATORY 0 0 2 1

Course Objectives

- To understand the basic concepts of open loop and closed loop control systems
- To analyze the given system in time domain
- To understand the concept of frequency domain analysis
- To understand the concept of stability of system

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural,societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Construct the transfer function of AC servo motor and analyze the performance of the system.
2. Analyze the time and frequency domain response of linear and nonlinear systems.
3. Apply the bode plot and root-locus technique to analyze the stability of the control system.
4. Analyze the performance of induction motor and PMDC motor with closed loop control system.
5. Design and verify the performance of different types of controllers for given applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3								3				3	2
2	3	3		1					3				2	
3	3		3						3				3	
4	3	3							3				3	2
5	1		3						3				3	1

1 **4 Hours**

EXPERIMENT 1

Determine the transfer function of AC servo motor.

2 **2 Hours**

EXPERIMENT 2

Design a servo mechanism for robotic arm control using PIC.

3 **4 Hours**

EXPERIMENT 3

Analyze the response of given first order system with step, ramp and impulse inputs

4 **4 Hours**

EXPERIMENT 4

Develop a state model for given system and analyze its stability using Bode plot and Root locus

5 **4 Hours**

EXPERIMENT 5

Realization of first order and second order system using op-amp.

6 **2 Hours**

EXPERIMENT 6

Design and analysis of lag and lead compensator.

7 **2 Hours**

EXPERIMENT 7

Design and verify the performance of P, PI and PID controllers

8 **4 Hours**

EXPERIMENT 8

Experimental verification of closed loop control system for 3 phase induction motor

9 **2 Hours**

EXPERIMENT 9

Design and implementation of closed loop control system for PMDC motor.

10 **2 Hours**

EXPERIMENT 10

Study and experimental verification of Programmable Logic Controller for given applications

Total: 30 Hours

Reference(s)

1. I.J.Nagrath and M.Gopal, Control System Engineering, NewAge International Publisher,2018
2. K.Ogatta, Modern Control Engineering, Pearson Education, NewDelhi, 2015
3. M.Gopal, "Control System Principles and Design",TataMcGraw-Hill,2012
4. S.Palani, Control System Engg, TataMcGraw-Hill, 2016.

21EE601 POWER SYSTEM PROTECTION AND SWITCH GEAR

3 1 0 4

Course Objectives

- To understand the different types of protection schemes in power system
- To understand the construction and operating principle of protective relays
- To gain knowledge on transmission line and apparatus protection schemes
- To understand the concept of arc phenomena, arc interruption and lightning arresters
- To illustrate the construction and operating principle of circuit breakers

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

f. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the causes of different types of faults and choose a suitable protection scheme
2. Analyze the operating principle of protective relays
3. Apply suitable protective schemes for electrical apparatus
4. Examine the circuit interruption schemes for power systems
5. Outline the performance of different types of circuit breakers

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3					1							2	
2	3					2							3	1
3	3					2							2	2
4	3	2				2							2	1
5	3					3							1	2

UNIT I **8 Hours**

INTRODUCTION TO PROTECTION SCHEMES

Principles and need for protective schemes, Nature and causes of faults, primary and backup protection, Electromagnetic relays, Comparison between static and electromagnetic relays, Step and Touch potential, Zones of protection, Power System Earthing.

UNIT II **10 Hours**

PROTECTIVE RELAY

Non directional and directional over current relays, Static and numerical over current relays, Distance relay - Impedance, reactance and mho relays, Differential and pilot relaying schemes, Auto reclosing and synchronizing.

UNIT III **9 Hours**

APPARATUS AND LINE PROTECTION

Alternator, transformer, induction motor, bus bar and feeder protection schemes, CTs and PTs and their applications in protection schemes, microprocessor based protective schemes

UNIT IV **8 Hours**

THEORY OF CIRCUIT INTERRUPTION

Physics of arc phenomena and arc interruption, Restriking voltage, Recovery voltage, rate of rise of restriking voltage, resistance switching, current chopping and interruption of capacitive current, lightning arresters and its types.

UNIT V

CIRCUIT BREAKERS **10 Hours**

Introduction- Rating of Circuit Breakers, Types of Circuit Breakers-Miniature, Earth leakage, Air blast, Air break, oil, SF6 and Vacuum circuit breakers with advantages and disadvantages, High voltage dc circuit breakers- Maintenance and Testing of circuit breakers-Recent developments in protective relays.

Total: 60 Hours

Reference(s)

1. Badri Ram, D.N.Viswakarma "Power system Protection and switchgear", Tata Mcgraw Hill, Private Limited, New Delhi, 2013.
2. Bhaveshbhalja, R.P. Maheshwari, Nilesh G. Chothani, "Protection and Swtichgear", Oxford University press, 2014.
3. Sunil S. Rao, "Switchgear Protection and Power Systems", Khanna publishers, New Delhi, 13th Edition, Reprint 2008.
4. V.K.Metha and Rohit Metha "Principles of power system", S. Chand company Ltd, 2011.

5. Wadhwa C L, "Electrical Power Systems", New age International (P) Ltd., Sixth Edition, 2010.
6. Bo, Z.Q., Lin, X.N., Wang, Q.P. et al. Developments of power system protection and control(2016)

21EE602 MICROCONTROLLERS BASED SYSTEM DESIGN

3 0 0 3

Course Objectives

- To understand RISC and CISC architecture, pipelining and evaluation.
- To understand the architectural features of the hardware and interfacing peripheral devices to PIC 16Fxx
- To acquire sound knowledge of PIC Microcontroller
- To gain knowledge of LPC2148 architecture.
- To understand the concepts of MSP430 Architecture

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Examine the architecture and addressing modes of PIC Microcontroller.
2. Execute a program using the interrupts and timer operations of PIC Microcontroller.
3. Analyze the peripheral interfacing used in PIC Microcontroller.
4. Outline the architectural features of LPC2148 microcontroller.
5. Analyze the functional blocks, addressing modes and development tools of MSP430.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3		2										3	1
2	3		2										3	
3	3		2										3	
4	3		2										3	1
5	2		2										3	1

UNIT I **9 Hours**

INTRODUCTION TO PIC MICROCONTROLLER

Introduction to PIC microcontrollers, PIC 16FXX architecture, comparison of PIC with other CISC and RISC based systems - Pipelining - Program Memory considerations - Register File Structure - Addressing modes - Simple Operations.

UNIT II **9 Hours**

INTERRUPTS AND TIMER

PIC micro controller Interrupts- External Interrupts-Interrupt Programming - Loop time subroutine - Timers-Timer Programming - Front panel I/O-Soft Keys - key switches- Display of Constant and Variable strings.

UNIT III **9 Hours**

PERIPHERALS AND INTERFACING

I2C Bus for Peripherals Chip Access - Bus operation-Bus subroutines - Serial EEPROM - analog to Digital Converter - UART-Baud rate selection - Data handling circuit - Initialization - LCD andkeyboard Interfacing -ADC, DAC, and Sensor Interfacing.

UNIT IV **9 Hours**

INTRODUCTION TO ARM

The ARM architecture -ARM assembly language program -ARM organization and implementation – The ARM instruction set-The thumb instruction set -ARM CPU cores - GPIO Programming, Timer Programming, Interrupt programming, Serial Port Programming, LCD and Keyboard interfacing

UNIT V **9 Hours**

INTRODUCTION TO MSP430

MSP430 Architecture: Introduction - Functional block diagram - Memory - Central Processing Unit - Memory Mapped Input and Output - - Instruction Set - Introduction to Code Composer Studio (CCS v4).Understanding how to use CCS for MSP430 microcontrollers-Interrupt programming-Digital I/O- I/O ports programming using C.

Total: 45 Hours

Reference(s)

1. Peatman,J.B., Design with PIC Micro Controllers PearsonEducation,3rdEdition, 2004.
2. Mazidi, M.A., Rollin Mckinlay, Danny causey PIC Microcontroller, Prentice Hall of India, 2007
3. Myke Predko , Programming and Customizing the PIC Microcontroller TAB electronics,Third Edition, 2009
4. Furber,S., ARM System on Chip Architecture, Addison Wesley trade Computer Publication, 2009.
5. Technical documents related to MSP-EXP430G2 and Tiva C Series TM4C123G

21EE603 DIGITAL SIGNAL PROCESSING

3 1 0 4

Course Objectives

- To understand the signals and systems and their mathematical representation in time/frequency domain
- To analyze the discrete time systems using Z-transform and Inverse Z-transform
- To implement the discrete time systems in Discrete Fourier Transform using Fast Fourier Transform algorithm
- To design FIR, IIR filters with its response and obtaining its realization structure
- To understand the architectural overview and addressing modes in DSP processors

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Classify the different types of Signals and Systems and analyze its performance
2. Design and analyze a discrete time systems using Z-transform
3. Compute a DFT for a discrete time systems using Fast Fourier Transform
4. Design FIR filter, analyze its response and construct its realization structure
5. Develop an algorithm using DSP Processor for signal processing applications

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2	3		1								2	1
2	1	2	3		1								2	1
3	1	2	3		1								2	1
4	1	2	3		1								2	1
5	1	2	3		1								2	1

UNIT I **10 Hours**

SIGNALS AND SYSTEMS

Classification of Systems: Continuous, Discrete, Linear, Causal, Stability, Dynamic, Recursive, Time Variance Systems; Classification of Signals: Continuous and Discrete, Energy and Power; Mathematical representation of Signals; Spectral Density; Sampling techniques, Quantization, Quantization error, Nyquist rate, Aliasing effect

UNIT II **9 Hours**

DISCRETE TIME SYSTEM ANALYSIS

Z-transform and its properties, Inverse Z-transforms; Difference equation - Solution by Z-transform, Application to Discrete Systems - Stability analysis, Frequency response - Convolution - Discrete Time Fourier transform, Magnitude and Phase representation

UNIT III **8 Hours**

DISCRETE FOURIER TRANSFORM

Discrete Fourier Transform- properties, magnitude and phase representation - Computation of DFT using FFT algorithm - DIT & DIF using radix 2 FFT - Butterfly structure

UNIT IV **10 Hours**

DESIGN OF DIGITAL FILTERS

FIR & IIR filter realization - Parallel & Cascade forms. FIR design: Windowing Techniques - Need and choice of windows - Linear phase characteristics. Analog filter design - Butterworth and Chebyshev approximations; IIR Filters, Digital design using impulse invariant and bilinear transformation Warping, prewarping

UNIT V **8 Hours**

DIGITAL SIGNAL PROCESSORS

Introduction - Architecture - Features - Addressing Formats - Functional modes - Dedicated MAC unit - Multiple ALUs, Pipelining - Introduction to Commercial DS Processors

FOR FURTHER READING

Lattice structure of IIR and FIR filters, Kaiser Window, Quantization error in FFT algorithm, Applications of Multirate systems, Architecture of TMS320C6X, C0ode composer studio

Total: 60 Hours

Reference(s)

1. J.G. Proakis and D.G. Manolakis, 'Digital Signal Processing Principles, Algorithms and Applications', Pearson Education, New Delhi, PHI, 2007
2. S.K. Mitra, 'Digital Signal Processing - A Computer Based Approach', McGraw Hill Edu, 2013
3. Tarun Kumar Rawat, Digital Signal Processing, Oxford University Press, 2015
4. Richard G. Lyons, Understanding Digital Signal Processing, Prentice Hall, 3rd Edition, 2012
5. S. Salivahanan, A.Vallavaraj, Gnanapriya, Digital Signal Processing, McGraw-Hill, 2nd Edition, 2011

21EE607 MICROCONTROLLERS BASED SYSTEM DESIGN LABORATORY

0 0 2 1

Course Objectives

- To understand the instruction sets of different microcontrollers.
- To gain hands-on experience on various microcontrollers.
- To interface the microcontroller for given applications.
- To develop an Integrated Development Environment (IDE) for embedded system.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Design and execute a simple program using PIC, ARM & MSP430 controllers.
2. Implement and analyze the interfacing of peripherals devices with PIC, ARM & MSP430 controllers.
3. Analyze the peripheral interfacing used in LM35 Temperature Sensor.
4. Execute analog to digital conversion using PIC16F877a and MSP430.
5. Implement and analyze the interfacing of stepper motor with PIC, ARM & MSP430 controllers.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3		3		2				-				3	
2	3		3		2				-				2	2
3	2		1		2								1	2
4	3				2				-				2	2
5	2		3										2	3

1 **4 Hours**

EXPERIMENT 1

Simple programming to design Flashing LED with PIC 16F877A.

2 **4 Hours**

EXPERIMENT 2

Implementation and interfacing of LCD with PIC16F877a.

3 **2 Hours**

EXPERIMENT 3

Implementation and interfacing of stepper motor

4 **2 Hours**

EXPERIMENT 4

Implementation and interfacing of LM35 Temperature Sensor.

5 **2 Hours**

EXPERIMENT 5

Generation of PWM pulse to control DC motor using PIC16F877a.

6 **4 Hours**

EXPERIMENT 6

Simple programming to design Flashing LED with PIC 18FXXX.

7 **4 Hours**

EXPERIMENT 7

Flashing of LEDs using ARM LPC2148.

8 **2 Hours**

EXPERIMENT 8

Interfacing of Relay with ARM LPC2148.

9 **4 Hours**

EXPERIMENT 9

Basic Input and Output Using MSP430.

10 **2 Hours**

EXPERIMENT 10

Analog to Digital Conversion and Interrupts Using MSP430.

Total: 30 Hours

21EE608 POWER ELECTRONICS LABORATORY

0 0 2 1

Course Objectives

- Students will be able to analyse the performance of DC- DC converters.
- Students will be able to analyze the performance of Inverters.
- Students will be able to analyse the performance of Permanent magnet synchronous motor.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. Use research-based knowledge and research methods including design of experiments, analysisand interpretation of data, and synthesis of the information to provide valid conclusions.

i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Design and analyze the performance characteristics of converter.
2. Design and analyze the performance characteristics of inverter.
3. Analyze the performance characteristics of AC voltage controller.
4. Analyze the performance characteristics of Switched reluctance motor drive.
5. Design, Simulate and analyze the Permanent magnet synchronous motor .

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2			1					3				1	1
2	3		1	1					3				3	3
3	3		1	2					3				3	3
4	2			3					3				2	3
5	1		3	2					3				3	1

1 **3 Hours**

EXPERIMENT 1

Verification of single phase half and fully controlled converters.

2 **3 Hours**

EXPERIMENT 2

Experimental verification of Boost regulator with TPS55340 and LM5122 ICs and Low-dropout Regulators with TPS7A4901 and TPS7A8300.

2 Hours

3

EXPERIMENT 3

Verification of TPS54160 buck regulator and LM3475 hysteretic buck regulator.

4 **2 Hours**

EXPERIMENT 4

Verification of single phase AC voltage controller.

5 **4 Hours**

EXPERIMENT 5
Experimental verification of multilevel inverter

6 **4 Hours**

EXPERIMENT 6
Verification of three phase voltage source inverter and V/f control of three phase VSI fed Induction motor drive.

7 **3 Hours**

EXPERIMENT 7
Four quadrant operation of DC motor using chopper.

8 **2 Hours**

EXPERIMENT 8
Switched reluctance motor drive.

9 **3 Hours**

EXPERIMENT 9
Simulation of Permanent magnet synchronous motor Using MATLAB Software for Electric Vehicle.

10 **4 Hours**

EXPERIMENT 10
Simulation of Permanent magnet synchronous motor Using MATLAB Software for Electric Vehicle.

Total: 30 Hours

21HS002 HUMAN VALUES AND ETHICS 2 0 0 2

Course Objectives

- Understand the concept of good values and comprehend the importance of value-based living.
- Recognize the culture of peace through education.
- Identify and apply the practices for value development and clarification.

Programme Outcomes (POs)

h.Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i.Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j.Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Understand the importance of human values and ethics in life.
2. Execute the importance of harmonious living in a diverse society.
3. Analyze the sensitivity to the crying needs of society such as ungodliness, corruption, poverty, and suffering, and play a vital role in eradicating them.
4. Plan intellectually mature, morally upright, ethically correct, and spiritually inspired decisions.
5. Execute a correct balance between professional excellence and social commitment.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1								3	2	2				
2								3	2	2				
3								3	2	2				
4								3	2	2				
5								3	2	2				

UNIT I **6 Hours**

COURSE INTRODUCTION - NEED, BASIC GUIDELINES AND ANALYSIS

1.Importance of Human Values & Ethics in 21st Century
2.Understanding the theory of basic human values and ethics
Openness to change
Self-enhancement
Conservation
Self-transcendence
3. Schwartz Value Survey: Self-Assessment

UNIT II **6 Hours**

EMBRACING THE COMMON ETIQUETTE

Altruism – Integrity -Freedom -Justice -Honesty -Truthfulness -Responsibility –Compassion

UNIT III **6 Hours**

CONTINUOUS HAPPINESS AND PROSPERITY

An overview on basic Human Aspirations - Understanding and living in harmony at various levels of life - Embracing self-love and wellness -Understanding harmony in the family and society

UNIT IV **6 Hours**

UNIVERSAL HUMAN VALUES AND PROFESSIONAL ETHICS

Reflection on growing global multifold problems: poverty, pollution, hunger, disease, unemployment, caste system, child labour, gender equality, politics and violence.
Understanding the challenges in cultural, personal, social, political, and economic environment

UNIT V **6 Hours**

UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE - WHOLE EXISTENCE AS CO-EXISTENCE

Understanding the harmony in the Nature - Holistic perception of harmony at all levels of existence - Practice Exercises and Case Studies will be taken up in Practice Sessions

Total: 30 Hours

Reference(s)

1. Martin, G. (2011). The Little Book of Ethics: A Human Values Approach. Australia: G.P. Martin.
2. Gupta, N. L. (2002). Human Values For The 21St Century. India: Anmol Publications Pvt. Limited.
3. Mishra, A. (2017). Happiness Is All We Want. India: Bloomsbury Publishing.
4. Universal Human Values. (2023). (n.p.): Booksclinic Publishing.
5. A Textbook On Professional Ethics And Human Values. (2007). India: New Age International (P) Limited

21EE702 SOLID STATE DRIVES 3 0 0 3

Course Objectives

- To analyze the motor and load dynamics also predict the steady state stability of drives for different loads.
- To Apply power electronic converters to control the speed of DC motors.
- To analyze various speed control techniques and converter topologies for induction motor drives
- To analyze the performance of synchronous motor drives.
- To select the special electrical machines and control schemes for various industrial applications

Programme Outcomes (POs)

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural,societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the motor and load dynamics and predict the steady state stability of drives for different loads.
2. Analyze the steady state and transient performances of DC drives for different DC to DC converters.
3. Analyze the various speed control techniques and converter topologies for induction motordrives
4. Analyze the performance of synchronous motor drives.
5. Select the special electrical machines and their control schemes for various industrial applications

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1	1										2	
2	3	3	1										2	1
3	3	3	1										2	1
4	3	1	1										2	
5	3	1	1										1	2

UNIT I **9 Hours**

FUNDAMENTALS OF ELECTRIC DRIVES

Development of Electric Drives - Drive classifications - Advantage of Electric Drives - Equations governing motor load dynamics - Equilibrium operating point and its steady state stability - Mathematical condition for steady state stability and problems - Nature and classification of load torque Multiquadrant operation.

UNIT II **8 Hours**

CONVERTER / CHOPPER FED DC MOTOR DRIVE

DC motor and their performance - Braking - Steady state and transient analysis of the single and three phase fully controlled converter fed separately excited D.C motor drive - Continuous and discontinuous conduction mode - Dynamic braking with DC chopper - Four Quadrant operation - Chopper fed regenerative braking.

UNIT III **11 Hours**

INDUCTION MOTOR DRIVES

Analysis and performance of three-phase induction motor - Stator voltage - stator frequency control - V/F control, controlled current and controlled slip operation - PWM inverter drives - Voltage Source Inverter, Current Source Inverter and cycloconverter fed induction motor drives - Harmonic behavior of induction motors - Rotor slip power recovery schemes.

UNIT IV **9 Hours**

SYNCHRONOUS MOTOR DRIVES

Principle of vector control - Open loop v/f control - self controlled synchronous motor drive using load commutated thyristor inverter - self-control of CSI and VSI fed synchronous motor - Margin angle control and power factor control - Permanent magnet (PM) synchronous motor.

UNIT V **8 Hours**

BLDC, STEPPER MOTOR DRIVES AND APPLICATIONS

Brushless DC motor drives and its applications - Variable reluctance and permanent magnet stepper motor Drives - Selection of drives and control schemes for steel rolling mills, paper mills, shipping - PLL, PID based control of drives –Closed loop control of BLDC Drives-Development of sensor less BLDC motor control scheme using PIC Controller .

Total: 45 Hours

Reference(s)

1. Krishan.R ,Permanent Magnet Synchronous and Brushless DC Motor Drives, CRC Press ,2017.
2. Vedam Subramanyam, Electric Drives: Concepts & Applications, Tata McGraw- Hill Education, 2017.
3. Soumitra Kumar Mandal, Microprocessor & Microcontroller Architecture, Programming & Interfacing using8085, 8086, 8051, McGraw Hill Education, 2013.
4. P.S.Bimbra Power Electronics, Khanna Publishers, third Edition, 2003.
5. Ned Mohan, Power Electronics, John Wiley and Sons, 2019.
6. Bimal K. Bose, Power Electronics and Motor Drives: Advances and Trends, Academic Press, 2017.

21EE707 SOLID STATE DRIVES LABORATORY 0 0 2 1

Course Objectives

- To analyse the performance of DC drives.
- To analyze the closed loop controller of BLDC motor .
- Tto analyze the speed control methods of AC drives.
- To apply power electronic converters to control the speed of DC motors.
- To analyze various speed control techniques for SRM drives.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural,societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Design and analyze the closed loop control of DC motor and BLDC motor.
2. Analyze the four quadrant operation of DC motor drive.
3. Analyze the speed control methods of induction motor and SRM motor drives.
4. Analyze the performance characteristics of cycloconverter and CSI fed AC drive.
5. Design, Simulate and analyze the seed control methods of SRM motor drive. .

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3								3				3	2
2	3	3		1					3				2	
3	3		3						3				3	
4	3	3							3				3	2
5	1		3						3				3	1

1 **2 Hours**

EXPERIMENT 1

Experimental Verification of Closed loop Control of Siemens 6RA80 DC Drive.

2 **4 Hours**

EXPERIMENT 2

Experimental verification of four quadrant operation of DC motor using Siemens 6RA80 Drive.

3 **4 Hours**

EXPERIMENT 3

Experimental Verification of Speed control of three phase induction motor using Siemens Sinamics G120 Drive.

4 **4 Hours**

EXPERIMENT 4

Design and Verification of three phase inverter fed drive using Siemens Sinamics G120 Drive

5 **4 Hours**

EXPERIMENT 5

Design and Simulation of cyclo-converter fed AC drive using MATLAB

6 **4 Hours**

EXPERIMENT 6

Experimental Verification of V/F control of Induction motor drive using Siemens Sinamics G120 Drive

7 **2 Hours**

EXPERIMENT 7

Design and Simulation of CSI fed Induction motor drive using MATLAB

8 **2 Hours**

EXPERIMENT 8

Design and Simulation of the BLDC controller using MATLAB.

9 **2 Hours**

EXPERIMENT 9

Design and Simulation of closed loop control for BLDC motor using sensor less control technique in MATLAB

10 **2 Hours**

EXPERIMENT 10

Design and Simulation of speed control of SRM motor drive using MATLAB

Total: 30 Hours

21EE708 PROJECT WORK I 0 0 6 3

Course Objectives

- Formulate a real world problem, identify the requirement and develop the design solutions.
- Identify technical ideas, strategies and methodologies
- Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project
- Test and validate through conformance of the developed prototype and analysis the cost effectiveness
- Prepare report and present oral demonstrations

Programme Outcomes (POs)

a. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
f. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team,to manage projects and in multidisciplinary environments.

l. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Formulate a real world problem, identify the requirement and develop the design solutions.
2. Identify technical ideas, strategies and methodologies.
3. Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis the cost effectiveness.
5. Prepare report and present oral demonstrations

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	-	3	2			2	1						3	1
2	2	2	1	3		2					2	2	2	
3			3	2	2			2			2	2	3	
4		1		2	3	1	2	2					1	3
5									3	3	-	2		3

21EE801 PROJECT WORK II **0 0 18 9**

Course Objectives

- Formulate a real world problem, identify the requirement and develop the design solutions.
- Identify technical ideas, strategies and methodologies
- Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project
- Test and validate through conformance of the developed prototype and analysis the cost effectiveness
- Prepare report and present oral demonstrations

Programme Outcomes (POs)

a.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern

engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

f. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

h. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

m.Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Formulate a real world problem, identify the requirement and develop the design solutions.
2. Identify technical ideas, strategies and methodologies.
3. Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis the cost effectiveness.
5. Prepare report and present oral demonstrations

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	-	3	2			2	1						3	1
2	2	2	1	3		2					2	2	2	
3			3	2	2			2			2	2	3	
4		1		2	3	1	2	2					1	3
5									3	3	-	2		3

21EE001/21EEH01/21EEMO1 POWER SYSTEM OPERATION AND CONTROL 3 0 0 3

Course Objectives

- Understand the application of load forecasting tools.
- Understand the real power-frequency relationship and the need for developing the mathematical model of
- Load Frequency Control Loop.
- Understand the reactive power-voltage relationship and the necessity of voltage compensation.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Apply the load forecasting tools to estimate the generation and reserve capacity
2. Apply the concept of Laplace transform to construct the transfer function model of isolated and interconnected systems.
3. Predict the transfer function model of excitation system and to classify system level voltage control methods
4. Apply the iterative techniques to determine economical operating point of generating units
5. Analyse the functions of load dispatch centers at National, Regional and State Levels.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3											3	
2	3	3											3	
3	3	2											3	
4	3	3											3	
5	3				2								3	

UNIT I **9 Hours**

INTRODUCTION

System load variation: System load characteristics, load curves, Load-duration curve, load factor and diversity factor. Reserve requirements: Installed reserves, spinning reserves, cold reserves and hot reserves. Overview of system operation: Load forecasting, unit commitment and load dispatching. Overview of system control, Need for voltage and frequency regulation in power system, Plant level and System level controls.

UNIT II **10 Hours**

REAL POWER - FREQUENCY CONTROL

Fundamentals of speed governing mechanism and modeling: Speed-load characteristics-Load sharing between two synchronous machines in parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis. Multi-area systems: Two-area system modeling; static analysis; tie line with frequency bias control of two-area system. State variable model.

UNIT III **9 Hours**

REACTIVE POWER VOLTAGE CONTROL

Typical excitation system, modeling, static and dynamic analysis, stability compensation; generation and absorption of reactive power: Relation between voltage, power and reactive power at a node – method of voltage control - tap-changing transformer - System level control using generator voltage magnitude setting - tap setting of OLTC transformer and MVAR injection of switched capacitors to maintain acceptable voltage profile and to minimize transmission loss.

UNIT IV **9 Hours**

POWER SYSTEM ECONOMICS

Incremental cost curve, Unit Commitment and its constraints, Solution to unit commitment problem using priority list method- Economic Dispatch - co-ordination equations without loss and with loss, solution by direct method and lambda iteration method. (No derivation of loss coefficients.) Base point and participation factors. Economic dispatch controller added to LFC control.

UNIT V **8 Hours**

COMPUTER CONTROL OF POWER SYSTEMS

Energy control centre: Functions, Monitoring, data acquisition and control. System hardware configuration - SCADA and EMS functions: Network topology determination, security analysis and control. Various operating states: Normal, alert, emergency, in extremis and restorative. State transition diagram showing various state transitions and control strategies.

Total: 45 Hours

Reference(s)

1. Olle. I. Elgerd, “Electric Energy Systems Theory”, Tata McGraw Hill Publishing Company Ltd,New Delhi, Second Edition, 2017.
2. Allen.J.Wood and Bruce F.Wollenberg, “Power Generation, Operation and Control”, John Wiley & Sons Inc., New York 2013.
3. P.Kundur, Om P. Malik, “Power System Stability and Control”, Tata McGraw Hill Book Company, New Delhi,2022.
4. I.J. Nagarath, D.P. Kothari, “Modern Power System Analysis”, Tata McGraw Hill Publishing Company, New Delhi, 2022.
5. P. Venkatesh, B.V. Manikandan, S. Charles Raja, A. Srinivasan, “Electrical Power Systems Analysis, Security and Deregulation”, PHI Learning Private Limited, New Delhi, 2017

21EE002 /21EEH02/21EEMO2 POWER QUALITY 3 0 0 3

Course Objectives

- To analysis the various power quality phenomenon, their origin and effects.
- To summarize the causes and impacts of various power quality issues.
- To understand the methods of power quality monitoring and standards.
- To analysis the performance of passive compensators for mitigating the power quality issues.
- To design the active compensators for load compensation.

Programme Outcomes (POs)

a. The Graduate will be able to apply the core knowledge to identify, formulate, and solve problems in power electronics and drives systems.
b. The Graduate will be able to apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic and controllers.
c. The Graduate will be able to design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analysis the different types of power quality problems like sag, swell, under voltage, overvoltage, inter harmonics and etc., with their source of generation.
2. Identify the various causes and impacts of power quality issues due to commercial, domestic and industrial loads.
3. Understand different methodologies for monitoring, detection and classification of power quality problems.
4. Analysis the behavioural performance of passive shunt and series filters for mitigating the power quality issues generated in power systems.
5. Design and analysis of FACTS controllers like distribution static compensator, dynamic voltage regulator and etc., for enhancing the quality of power.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO
1	2	1											1	1
2	1	2											1	1
3	2		2										3	1
4	2	1	2										3	1
5	2	1	3										2	1

UNIT I **9 Hours**

INTRODUCTION TO POWER QUALITY

Electric power quality phenomena. Classifications, characteristics and causes of short duration variation like sag, swell and interruption - Long duration variation like under voltage, over voltage and sustained interruption – Transients, voltage imbalance, power frequency variations and waveform distortion like harmonics and DC offset.

UNIT II **9 Hours**

CAUSES AND IMPACTS OF POWER QUALITY ISSUES

Voltage sag due to faults, induction motor starting and transformer energizing. Over voltages due to capacitor switching, lightning and Ferro resonance. Harmonic sources from commercial and industrial loads. Classification and analysis of nonlinear loads. Effects of various power quality issues.

UNIT III **9 Hours**

POWER QUALITY MONITORING AND

Monitoring considerations. Power Quality Measurement - wiring and grounding test devices, disturbance analyzers,

Harmonic / spectrum analyzers and flicker meters. Smart power quality monitors, Expert system for power quality monitoring - IEEE and IEC standards.

UNIT IV **9 Hours**

PASSIVE COMPENSATION

Passive power filters - classifications, operations, design, modelling and performance analysis of passive shunt and series filters.

UNIT V **9 Hours**

ACTIVE COMPENSATION

FACTS devices: Classifications, operation, control methods, design and performance analysis of DSTATCOMs, DVRs and UPQCs.

FOR FURTHER READING

Estimation of voltage sag performance – Protection of overhead line, underground cables and transformers – Sag and

harmonic indices – Harmonic distortion evaluation – Loads that causes the power quality problems.

Total: 45 Hours

Reference(s)

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, “Electrical Power Systems Quality”, McGraw Hill, 2017.
2. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality: Problems and Mitigation Techniques", John
Wiley & Sons, 2015.
3. Heydt, G.T., “Electric Power Quality”, Stars in a Circle Publications, Indiana, 2nd edition 1996.
4. Arrillaga, J, Watson, N.R., Chen, S., “Power System Quality Assessment”, Wiley, New York, 2011.
5. M.H.J Bollen,"Understanding Power Quality Problems: Voltage Sags and Interruptions", (New York: IEEE Press,
2011.

21EE003/21EEH03/21EEMO3 HIGH VOLATGE TRANSMISSION 3 0 03

Course Objectives

- To understand the concept of HVAC and HVDC transmission systems
- To understand the concept of conductor and insulator design
- To explore the methods to convert high-voltage AC to high-voltage DC
- To predict the fault and provide proper protection to HVAC & HVDC transmission systems
- To classify the various filters used to mitigate the harmonics

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the performance of HVAC system components.
2. Analyze the power transfer capabilities and power flow control in HVAC.
3. Analyze the characteristics of high voltage power converters in HVDC.
4. Apply suitable methods to measure and predict the faults in HVDC.
5. Analyze the harmonics mitigation technique using filters.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	2	2									3	3
2	3	3	2	3									3	3
3	3	2	2	2									3	3
4	3	2	2	3									3	3
5	3	2	2	3									3	3

UNIT I

HVAC CABLE DESIGN **9 Hours**

Design aspects of HVAC – conductor, tower, insulator and substation structure, design of EHVAC lines bas steady state limits and transient over voltages - design of extra HV cables - XLPE cables and gas insulated cable.

UNIT II

HVAC POWER FLOW CONTROL **9 Hours**

Real and reactive power flows in HVAC systems – reactive power compensation, short circuit level & real power transfer capacity. Stability- voltage stability and control. Theory of travelling and stationary waves.

UNIT III **9 Hours**

HVDC TRANSMISSION SYSTEM

Introduction to HVDC transmission - Bridge representation, power reversal, desired features of control and actual control characteristics.

UNIT IV

9 Hours

HVDC PROTECTION AND CONTROL

Basic HVDC controllers, converter faults, commutation failure, bypass action in bridges, protection issues in HVDC - DC reactors, voltage and current oscillations, DC circuit breakers and over-voltage protection.

9 Hours

UNIT V

HARMONICS MITIGATION AND HYBRID HVDC

Harmonics in HVDC - characteristics and uncharacteristic harmonics, troubles due to harmonics, harmonic filters – active and passive filters. Introduction to Hybrid HVDC-Design aspects of Hybrid HVDC system.

Total: 45 Hours

Reference(s)

1. S.Rao, “EHV-AC, HVDC Transmission and Distribution Engineering”, Khanna Publishers, 3rd Edition, 2018.
2. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, New Age International Publishers, 3rd Edition, 2019.
3. Padiyar K.R., “HVDC Transmission Systems”, New Age International Publishers, 2nd Revised Edition, 2018.
4. C.L. Wadhwa, “High Voltage Engineering”, Wiley Eastern Limited, 2019.
5. E.Kuffel and M. Abdullah, “High Voltage Engineering”, Pergamon Press, 2019.
6. Alston, “High Voltage Technology” BS Publications, 2017.

21EE004//21EEH04/21EEMO4 DEMAND SIDE MANAGEMENT 3 0 0 3

Course Objectives

- To understand the energy scenario.
- To understand fundamentals of smart grid.
- To understand the concept of demand side management.
- To understand the economics of demand side management programs.
- To apply the cost effectiveness of demand side management.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyse the Energy Conservation Schemes through interpretation of energy audit results
2. Apply the concept of current and voltage flow to perform distribution load flow analysis.
3. Apply the concept of load forecasting to monitor the energy scenario.
4. Analyze the distribution system by performing demand side management
5. Analyze the economics effectiveness of demand side management.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	2									2	2
2	3	2	2	2									2	2
3	3	2	2	2									2	2
4	3	2	2	2									2	2
5	3	3	3	3									2	3

UNIT I **9 Hours**

ENERGY SCENARIO

Energy Audit- Concept, Energy Index, Cost Index, Pie Charts, Sankey Diagrams, Load Profiles, Energy Conservation Schemes; Measurements in Energy Audits, Presentation of Energy Audit Results

UNIT II **9 Hours**

LOAD FLOW ANALYSIS

Radial Distribution Network - Distribution load flow – Load flow analysis of balanced radial distribution system - Load flow analysis of unbalanced radial distribution system - Load flow analysis of balanced weakly meshed distribution system

UNIT III **9 Hours**

LOAD FORECASTING

Power Loads, Connected Load - Load Forecasting; Regression Analysis, Correlation Theory - Factors in Power System Loading - Unloading the System - Forecast of System Peak, Strategic Forecasting, Spatial Load Forecasting - Scenario Planning - Sources of Error: Regulating the Model.

UNIT IV **9 Hours**

DEMAND SIDE MANAGEMENT

Demand Side Management – Concept, Techniques, Benefits; Time of Day Pricing, Multi-Utility Power Exchange Model, Time of Day Models for Planning; Load Management, Load Priority Technique, Peak Clipping, Peak Shifting, Valley Filling, Strategic Conservation, Energy Efficient Equipment. Management and Organization of Energy Conservation Awareness Programs

UNIT V **9 Hours**

ECONOMICS OF DSM

The time value of Money Concept, Cash flow model, Pay back analysis, Depreciation, Net present value calculations; Taxes and Tax Credit –Numerical Problems; Importance of evaluation, measurement and verification of demand side management programs

Total: 45 Hours

Reference(s)

1. A S. Pabla, Electric Power Distribution, Tata McGraw-Hill Education, 2019.
2. B. Das, Power Distribution Automation, IET Power and Energy Series, 75, London, 2016.
3. Albert Thumann, ‘Fundamentals of Energy Engineering’, CRC Press, 2015
4. W.R. Murphy & G. Mckay Butter worth, Energy management, Heinemann publications, 2003.
5. Ashok V. Desai, Energy Demand – Analysis, Management and Conservation, Wiley Eastern, 2005.

21EE005/21EEH05/21EEMO5 SMART GRID TECHNOLOGIES 3 0 0 3

Course Objectives

- To summarize the components used in smart grid and technologies involved in smart grid.
- To understand the concept of smart metering and implementation of demand side integration.
- To analyze the concepts in automated distribution systems in smart grid.
- To analyze the concepts in automated transmission systems in smart grid.
- To analyze the significance of power electronics in smart grid.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization tothe solution of complex engineering problems.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

Course Outcomes (COs)

1. Examine the operating principles and models of Smart Grid components.
2. Classify the protocols of smart metering used in demand Side Integration.
3. Outline the distribution system automation in Smart Grid.
4. Outline the transmission system automation in Smart Grid.
5. Analyze the power quality improvement concepts in Smart Grid.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2				3								3	
2	2				3								3	
3	2				3								3	
4	2				3								3	
5	2				3								3	

UNIT I **9 Hours**

INTRODUCTION

Electrical Grid - Definition of Smart Grid - Opportunities, Challenges and Benefits of Smart Grid - Inventory of Smart Grid Technologies - Operating Principles and Models of Smart Grid Components, Implementation of Smart Grid- Early Smart Grid initiatives - Overview of the technologies required for the Smart Grid.

UNIT II **9 Hours**

SMART METERING AND DEMAND-SIDE INTEGRATION

Introduction - Smart metering - Smart meters- An overview of the hardware used-Communications infrastructure and protocols for smart metering, Demand-side integration- Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations, Flexibility delivered by prosumers from the demand side, System support from DSI.

UNIT III **9 Hours**

DISTRIBUTION AUTOMATION

Distribution automation, automated meter reading (AMR), automated metering infrastructure (AMI), fault location isolation and service restoration (FLISR), Outage Management Systems (OMS), High Efficiency Distribution Transformers, Phase Shifting Transformers.

UNIT IV **9 Hours**

TRANSMISSION SYSTEM AUTOMATION

Substation automation, Feeder Automation, Supervisory control and data acquisition (SCADA), energy management system (EMS), phasor measurement units (PMU), Wide area monitoring systems (WAMS).

UNIT V **9 Hours**

POWER ELECTRONICS IN THE SMART GRID

Fault current limiting Shunt compensation, D-STATCOM, Active filtering, Shunt compensator with energy storage, FACTS- Reactive power compensation, Series compensation, Unified power flow controller.

FOR FURTHER READING

Smart appliance Technology - Pricing for Smart Appliances on demand. Security issues in DG, Distribution Automation, AMI, Electric Vehicle Management Systems - Approach to assessment of smart grid cyber security risks - Methodologies.

Total: 45 Hours

References:

1. Bimal K Bose, "Power electronics in renewable energy systems and smart grid: technology and applications", IEEE Press, 2019.
2. B. Vinoth Kumar, P. Sivakumar, M.M. Rajan Singaravel, K. Vijayakumar, "Intelligent Paradigms for Smart Grid and Renewable Energy Systems",Springer, 2021.
3. Omar Ellabban, Shady S Refaat, Sertac Bayhan, Haitham Abu-Rub, Frede Blaabjerg, Miroslav Begovic, " Smart Grid and Enabling Technologies",Wiley - IEEE, 2021.
4. M. Kathiresh , A. Mahaboob Subahani , G. R. Kanagachidambaresan , "Integration of Renewable Energy Sources with Smart Grid", Wiley-Scrivener, 2021.
5. Ali Keyhani, " Design of smart power grid renewable energy systems", Wiley,2020.

21EE006/21EEH06/21EEM06 POWER SYSTEM DEREGULATION 3 0 0 3

Course Objectives

- To Understand the need for restructuring of Power Systems, different market models and market power.
- To Understand the market model, operations and challenges faced in a deregulation environment.
- To Understand the transmission open access and congestion management methods.
- To apply the concepts and terminologies in pricing methodology and available transfer capability.
- To Understand the reforms in the Indian Power Sector and for future expansion.

Programme Outcomes (POs)

a. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and anengineering specialization to the solution of complex engineering problems.

b. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problemsreaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

e. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

m. Modeling, design and Analysis of Electrical and Electronic Systems using design principles and software tools

n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and Ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the restructuring process, new entities in power market and benefits.
2. Explain the challenges faced in a deregulation environment with their market model and operations.
3. Analyze the transmission open access and congestion management methods.
4. Compute the pricing of power transactions and available transfer capability in a deregulation environment.
5. Elaborate the reforms in Indian Power Sector and in future.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2											3	
2	3	2		2									3	1
3	2			2	3								3	2
4	2				3								3	2
5	3	2		3									3	

UNIT I **9 Hours**

POWER SYSTEM DEREGULATION: AN OVERVIEW

Introduction- Motivation for Restructuring of Power System- Electricity Market Entities and Model- Milestones of Deregulation-International Scenario - Benefits of deregulation- Basic Terminologies.

UNIT II **9 Hours**

COMPETITIVE WHOLESALE ELECTRICITY MARKET

Introduction - Restructuring models - Role of Independent system operator - Power exchange (PX) - Market Clearing Price (MCP) - Market operations - Whole sale electricity market characteristics - Challenges in wholesale electricity market.

UNIT III **9 Hours**

TRANSMISSION OPEN ACCESS

Introduction - Transmission open access- Types of Transmission services in open access - FERC order 889 - Structure of OASIS: Functionality and Architecture of OASIS - Congestion management - congestion management methods: An overview: Rescheduling of generation-Power World Simulation model.

UNIT IV **10 Hours**

PRICING AND AVAILABLE TRANSFER CAPABILITY

Introduction - Transmission cost components - Transmission pricing methods - Postage stamp method - contract path method-MW Mile method - Marginal participation method - Available Transfer Characteristics (ATC): Introduction -Definition - Methods of Static ATC Determination - Method based on multiple load flow and continuation power flow - method based on linear sensitivity factors - Power World Simulation model.

UNIT V **8 Hours**

INTERNATIONAL AND INDIAN POWER MARKET

Introduction - California Markets - New York Markets - PJM interconnection - Indian power sector past and present status-growth of power sector in India - overview - Time line of Indian power sector- Players in the Indian power sector.

FOR FURTHER READING

Electric Energy Trading, Electricity Price Forecasting, Demand Side Management

Reference(s)

1. M.Shahidepour, Hatim Tamin and Zuyi Li, "Market operations in electric power system forecasting,scheduling and risk management", John Wiley sons, 2002.
2. M.Shahidepour and M. Alomoush, "Restructured Electrical Power Systems: Operation: Trading, and Volatility", Marcel Dekker, Inc., 2001.
3. P.Venkatesh, B.V.Manikandan, S.Charles Raja and A.Srinivasan, "Electrical power systems analysis,Security and Deregulation", PHI 2012.
4. Loi Lei Lai, "Power system Restructuring and Deregulation" John Wiley sons, 2001.
5. Kankar Bhattacharya Maath H.J. Bollen and Jaap E.Daalder, "Operation of restructured power systems",Kluwer academic publishers, USA, first edition, 2001.

21EE007 ADVANCED POWER SEMICONDUCTOR DEVICES 3 0 0 3

Course Objectives

- To learn the characteristics of different types of semiconductor devices.
- To analyze the characteristics of power transistor
- To understand the construction and working principle of Thyristor
- To understand the operation and analyze the characteristics of power controlled devices
- To explore the need for isolation circuits and protection circuits

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an Engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n. Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Examine the performance characteristics of ideal and practical switches
2. Assess the performance characteristics of power transistor
3. Analyze the static and dynamic characteristics of thyristor
4. Analyze the static and switching characteristics of power controlled devices
5. Design a snubber and driver circuits for power controlled devices

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1											3	
2	3	1											3	
3	3	1											3	1
4	3	1											2	1
5	2	1	3										3	2

NIT I **9 Hours**

INTRODUCTION

Power switching devices -Attributes of an ideal switch, application requirements- circuit symbols -Power handling capability (SOA); Device selection strategy - On-state and switching losses - EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics - Rating.Introduction to wide band gap semiconductors such as silicon carbide and gallium nitride.

UNIT II **9 Hours**

POWER TRANSISTOR

BJTs - Construction, static characteristics, switching characteristics - Negative temperature coefficient and Secondary breakdown - Power Darlington - Thermal protection-dynamic models of BJT

UNIT III **9 Hours**

THYRISTOR

Thyristors - working principle and its operating modes- Two transistor analogy- concept of latching - Gate and switching characteristics - Converter grade and inverter grade and other types; series and parallel Operation -Comparison of BJT and Thyristor- Steady state and dynamic models of BJT and Thyristor - thermal protection

UNIT IV **9 Hours**

POWER CONTROLLED DEVICES

Principle, construction, types of Power MOSFETs and IGBTs- static and switching characteristics -Steady state and dynamic models of MOSFET and IGBTs; Basics of GTO, MCT, and IGCT

UNIT V **9 Hours**

FIRING AND PROTECTING CIRCUITS

Necessity of isolation circuit- Pulse transformer- Opto-coupler; Gate drive circuit for SCR,MOSFET, IGBTs and base driving for power BJT - Overvoltage, over current and gate protections, Design of snubbers.

Total: 45 Hours

Reference(s)

1. Timothy L. Skvarenina, “The power electronics handbook”, CRC press, New Delhi, 2012.
2. M. H. Rashid, “Power Electronics circuits, Devices and Applications”, Prentice Hall of India, New Delhi, 2011.
3. Shen, Shyh-Chiang, “Wide-bandgap device research and development at SRL”, Georgia Instituteof Technology Semiconductor Research Laboratory, retrieved 2014-09-03.
4. Baliga, B. Jayant, “Fundamentals of Power Semiconductor Devices”, springer, 2008.
5. Ned Mohan, Undeland and Robins, “ Power Electronics Concepts, applications and design”, John Wiley and sons, Singapore, 2000.
6. D. Singh and K. B. Khanchandani, “Power Electronics”, Tata McGraw Hill book Co,New Delhi, 2003.

21EE008 ADVANCED POWER CONVERTERS

3 0 0 3

Course Objectives

- To analyze the closed loop operation of switched mode power supplies.
- To understand the operation of switched mode rectifiers.
- To understand and analyze the various types of multilevel inverters.
- To evaluate the operation, and performance parameters of matrix converters .
- To understand the operation of soft switched power converters.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply the various converter topologies to design and analyze the switched mode power supplies.
2. Evaluate the input and output parameters of controlled rectifiers with PWM techniques.
3. Analyze the operation of advanced multilevel inverters with different modulation schemes.
4. Analyze the performance parameters of AC- AC converters with and without DC link.
5. Apply the soft switching techniques and analyze the performance of hard switched and soft switched converters.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	3									2	2
2	3	2	2	3									3	2
3	3	2	2	3									3	2
4	3	2	2	3									3	2
5	3	2	2	3									3	2

UNIT I **9 Hours**

SWITCHED MODE POWER SUPPLIES (SMPS)

DC Power supplies and Classification; Switched mode dc power supplies - with and without isolation, single and multiple outputs- Closed loop control and regulation- Design examples on converter and closed loop performance.

UNIT II

AC-DC CONVERTERS

Switched mode AC-DC converters-synchronous rectification - single and three phase topologies - switching techniques - Power Factor: power factor improvement techniques- reduced input current harmonic distortion -with and without input-output isolation.

UNIT III **9 Hours**

DC-AC CONVERTERS

Multi-level Inverter-operation with equal and unequal DC voltages, - Inverters for open ended load configurations - Carrier modulation schemes of multilevel inverter, SVPWM of Multilevel inverter, Neutral Point Balancing schemes.

UNIT IV **9 Hours**

AC-AC CONVERTERS WITH AND WITHOUT DC LINK

Matrix Converters-Modulation techniques - scalar modulation, indirect modulation-Matrix converter as only AC-DC converter-AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter.

UNIT V **9 Hours**

SOFT-SWITCHING POWER CONVERTERS

Soft switching techniques-ZVS, ZCS, quasi resonance operation-Performance comparison hard switched and soft switched converters-AC-DC converter, DC-DC converter, DC-AC converter- Resonant DC power supplies.

Total: 45 Hours

FURTHER READING(s)

Dual active bridge, resonant inverters-High frequency magnetics-Emerging power semi-conductor devices.

Reference(s)

1. Muhammad H.Rashid, "Power Electronics Circuits, Devices & Applications", 4th Edition, Pearson India, 2018.
2. Ned Mohan, Tore. M. Undeland, William. P. Robbins, "Power Electronics: Converters, Applications and Design", 3rd Edition Wiley India, NewDelhi, 2012.
3. M.D.Singh & K.B Khanchandani, "Power Electronics", 2nd Edition, Tata Mc Graw Hill Publishing Co.Ltd., New Delhi, 2017.
4. Robert W.Erickson, Dragan Maksimovic, "Fundamentals of Power Electronics", Soringer Nature Switzerland AG 2020.
5. Marian P.Kazmierkowski, R.Krishnan and Frede Blaabjerg, "Control in Power Electronics- Selected Problem",Academic Press (Elsevier Science), 2002.
6. José Rodríguez, , Jih-Sheng Lai, and Fang Zheng Peng, "Multilevel Inverters: A Survey of Topologies, Controls, and Applications", IEEE Trans. Ind. Electron., Vol. 49, No. 4, August 2002.

21EE009 MODERN RECTIFIERS AND RESONANT CONVERTERS

3 0 0 3

Course Objectives

- To understand the importance of harmonics standards and operation of rectifiers in CCM & DCM.
- To analyze and design power factor correction rectifiers for UPS applications.
- To understand the source current shaping methods for rectifiers.
- To understand the resonant converters for SMPS applications.
- To analyze the performance of DC- DC Converters.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Understand the types of modern rectifiers and its applications.
2. Analyze the performance of PWM inverters for specific applications.
3. Analyze the characteristics of resonant converters for different loads.
4. Apply the working linear system, state space model, PI controller.
5. Design a DC power supplies using advanced controller logic.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				1						2	3
2	3	2	3										3	3
3	2	3	3										3	3
4	3	2	3										3	3
5	2	3	2				1						3	3

UNIT I **9 Hours**

LINE COMMUTATED RECTIFIERS

AC line current harmonic standards IEC1000-IEEE 519-CCM and DCM operation of single phase full wave rectifier- Behaviour of full wave rectifier for large and small values of capacitance - CCM and DCM operation of three phase full wave rectifier- 12 pulse converters- Multi Pulse converters - Harmonic trap filters

UNIT II **9 Hours**

PULSE WIDTH MODULATED RECTIFIERS

Properties of Ideal single phase rectifiers-Realization of nearly ideal rectifier-. Single-phase converter systems incorporating ideal rectifiers - Losses and efficiency in CCM high quality rectifiers -Single-phase PWM rectifier - device selection for rectifiers - Three phase PWM rectifier - applications of rectifiers

UNIT III **9 Hours**

DYNAMIC ANALYSIS OF SWITCHING CONVERTERS

Review of linear system analysis-State Space Averaging-Basic State Space Average Model State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter. Pulse Width modulation - Voltage Mode PWM Scheme - Current Mode PWM Scheme - Design of PI controller.

UNIT IV **9 Hours**

RESONANT CONVERTERS

Soft Switching - classification of resonant converters - Quasi resonant converters- basics of ZVS and ZCS- half wave and full wave operation (qualitative treatment) - multi resonant converters - operation and analysis of ZVS and ZCS multi resonant converter - zero voltage transition PWM converters - zero current transition PWM converters

UNIT V **9 Hours**

SOURCE CURRENT SHAPING OF RECTIFIERS

Need for current shaping - power factor - functions of current shaper - input current shaping methods - passive shaping methods -input inductor filter - resonant input filter - active methods - boost rectifier employing peak current control - average current control - Hysteresis control Nonlinear carrier control.

FOR FURTHER READING

Zeta Converter, Push Pull converter, Space vector modulation

Total: 45 Hours

Reference(s)

1. Robert W. Erickson and Dragon Maksimovic, “Fundamentals of Power Electronics”, Second Edition, Springer science and Business media,2001.
2. William Shepherd and Li Zhang, “Power Converters Circuits”, Marceld Ekkerin C,2005.
3. Simon Ang and Alejandro Oliva, “Power Switching Converters”, Taylor & Francis Group, 2010.
4. Andrzej M. Trzynadlowski, " Introduction To Modern Power Electronics", John Wiley & Sons, 2016.
5. Marian.K.Kazimierczuk and Dariusz Czarkowski, “Resonant Power Converters”, John Wiley & Sons limited, 2011.
6. D. Grahame Holmes; Thomas A. Lipo, “Pulse Width Modulation for Power Converters: Principles and Practice”, Wiley-IEEE Press, 2003.

21EE010 **ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY** **3 0 0 3**

Course Objectives

- Acquire knowledge on electromagnetic interference and electromagnetic compatibility.
- To understand the EMI and EMC standards
- To understand the EMI in electric circuits.
- To interpret the Noise suppression techniques.
- To select the appropriate EMI filtering methods.

Programme Outcomes (POs)

PO1:. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4 Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyse the types and sources of EMI.
2. Apply the suitable measurement techniques and standards for EMI problems
3. Evaluate the EMI in electrical circuits
4. Apply appropriate techniques to control EMI .
5. Design a filter to suppress the EMI.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	3									2	2
2	3	2	2	3									3	2
3	3	2	2	3									3	2
4	3	2	2	3									3	2
5	3	2	2	3									3	2

UNIT I **9 Hours**

INTRODUCTION

Sources of EMI- Inter systems and Intra systems EMI- Conducted and radiated interference- Characteristics -EMI predictions and modeling, - Methods of eliminating interferences- Design of electromagnetic compatibility (EMC)- EMC regulation typical noise path.

9 Hours

UNIT II

EMI MEASUREMENT AND STANDARDS

EMI Measuring Instruments, Test Equipment, Measurement of Interference Voltage and Current- Spectrum Analysers - EMI Measurements for Consumer Appliances, Standards: Basic Standards, Product Standards, IEC, ANSI, FCC,CISPR, BSI,CENELEC, ACEC and MIL61E standards.

UNIT III **9 Hours**

EMI IN ELEMENTS AND CIRCUITS

Electromagnetic emissions, noise from relays and switches, non-linearity in circuits, passive intermodulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT IV **9 Hours**

NOISE SUPPRESSION TECHNIQUES

Noise Suppression in Relay Systems, Application of ACS switching Relays, Application of RC – Snubbers to Power Semiconductors, Shielded Transformers, Capacitor Filters, EMI Generation and Reduction at Its Source, Influence of Layout and Control of Parasitic.

UNIT V **9 Hours**

EMI FILTER CIRCUITS

Selection and Measurement, Test Methods, EMI Filter Design,-Insertion Loss, Design Method for Mismatched Impedance Condition, Design of EMI Filters with Common- Mode Choke Coils, Damped EMI Filters and Lossy Filter Elements.

Total: 45 Hours

Reference(s)

1. L. Tihanyi, "Electromagnetic compatibility in Power Electronics", IEEE press, 2020.

2. Bruce Archambeault, Colin Brench, Omar M. Ramahi, "EMI/EMC computational modelling handbook", Kluwer press, second edition, 2018.

3. D. Morgan, "A Handbook for EMC Testing and Measurement", IET Electrical Measurement Series, Band 8, 2018

4. Tim Williams, "EMC for product designers", Newnes press, fifth edition, 2016.

5. Henry W.Ott, “Noise reduction techniques in electronic systems”, John Wiley & Sons, 1989.

6. José Rodríguez, , Jih-Sheng Lai, and Fang Zheng Peng, ‘Multilevel Inverters: A Survey of Topologies, Controls, and Applications’, IEEE Trans. Ind. Electron., Vol. 49, No. 4, August 2015.

21EE011 ELECTRIC DRIVES AND CONTROL 3 0 0 3

Course Objectives

- To understand the motor, load dynamics, their nature and classification.
- To Apply power electronic converters to control the speed of DC motors.
- To analyze the speed control techniques for induction motor drives
- To analyze the performance of synchronous motor drives.
- To select the special electrical machines and control schemes for various industrial applications

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Understand the dynamics of electrical drives, their nature and classification
2. Analyze the chopper fed DC drive.
3. Analyze the speed control techniques of induction motor drives
4. Analyze the performance of synchronous motor drives.
5. Select the special electrical machines and apply control schemes for various industrial applications

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1	1										2	
2	3	3	1										2	1
3	3	3	1										2	1
4	3	1	1										2	
5	3	1	1										1	2

UNIT I **9 Hours**

INTRODUCTION

Concepts, and classification of Electric drives. Selection of motors. Dynamics of Electric drives: Types of loads, Multi quadrant operations, motor dynamics steady state stability and transient stability. Rating and Heating of motors: Heating effects, heating and cooling curves, classes of duty, load equalization, environmental factors.

UNIT II **9 Hours**

DC MOTOR DRIVE

Basic characteristics, Operating modes, 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 schemes.

UNIT III **9 Hours**

INDUCTION MOTOR DRIVES

Induction motor drives, stator voltage control, stator impedance control, rotor voltage control – Slip power recovery schemes, V/f control, Current control method. Need for harmonic filter, Closed loop control. Introduction to vector control scheme.

UNIT IV **9 Hours**

SYNCHRONOUS MOTOR DRIVES

Speed torque characteristics and torque angle characteristics. Fixed and variable frequency operation modes, Self-control modes.

UNIT V **9 Hours**

SPECIAL MACHINES

Brushless DC motor, Switched Reluctance Motor, introduction to the relevant converter circuits.

Total: 45 Hours

Reference(s)

1. G. K. Dubey, et.al., “Thyristorised Power Controllers,” New Age International, 2002.
2. Vedam Subramanyan, Electric Drives: Concepts and Applications, Tata McGraw Hill Publishing Company, New Delhi, 2011.
3. Krishan. R,'Permanent Magnet Synchronous and Brushless DC Motor Drives', CRC Press, 2010
4. Soumitra Kumar Mandal, Microprocessor & Microcontroller Architecture, Programming & Interfacing using 8085, 8086, 8051, McGraw Hill Education, 2013.
5. P. S. Bimbra Power Electronics, Khanna Publishers, third Edition, 2003.

21EE012 POWER ELECTRONIC INTERFACES FOR RENEWABLE ENERGY SOURCES

3 0 0 3

Course Objectives

- To analyse the current scenario of the implementation of renewable energy system.
- To understand the modern power converters for solar thermal systems.
- To understand the interfacing of power converters with wind energy systems
- To understand the operations of various generators used in WECS.
- To analyse the distributed power generation systems.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply the rules and regulations for development of new energy technologies
2. Analyse the power converters for standalone solar power conversion system
3. Analyse the different configurations of wind energy conversion system
4. Analyze the converters for grid connected WECS and SECS
5. Apply the concepts of solar PV and wind energy conversion system to develop the distributed power generation system.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				1						2	3
2	3	2	3										3	3
3	2	3	3										3	3
4	3	2	3										3	3
5	2	3	2				1						3	3

UNIT I **9 Hours**

INTRODUCTION

Trends in energy consumption - World energy scenario - Energy sources and their availability - Conventional and renewable energy resources - Need to develop new energy technologies - Current status of renewable energy sources - Government Bodies and its function - MNRE & TEDA.

UNIT II **9 Hours**

SOLAR PV SYSTEMS

Solar radiation and measurements - Solar cells - Panels and their characteristics -Influence of insolation, temperature and parasitic capacitance PV arrays - power Converters-Maximum power point tracking - Applications.

UNIT III **9 Hours**

WIND ENERGY SYSTEMS

Principle of Wind Energy Conversion System- Nature of Wind - Components of Wind Energy Conversion System- Modern generators for WECS - Power conditioning schemes.

UNIT IV **9 Hours**

GRID CONNECTED WECS AND SECS

Grid codes- grid connectors -Grid related problems and standards-conventional and new grid synchronisation Methods-Generator control - Power converters for Grid connected WECS - Power converters for Grid connected SECS.

UNIT V **9 Hours**

DISTRIBUTED POWER GENERATION SYSTEMS

Hybrid Systems - Selection of power conversion ratio -Optimization of System components - Micro Hydro, wind, solar, and fuel cell systems - Converters and controllers for integration of renewable energy sources- types of energy storage systems

FOR FURTHER READING

Need for Hybrid Systems- Range and types of hybrid PV systems -SPV-Wind-Battery- fuel Cell-Diesel generator & grid interacted hybrid system - Micro hydro power - Co-generation

Total: 45 Hours

Reference(s)

1. S. Rao and Parulekar, Energy Technology Non Conventional, Renewable and Conventional, New Delhi, Khanna Publishers, 1999.
2. Rai G.D, Non conventional energy sources, Khanna Publishers, 1993.
3. Mukund R. Patel, Wind and Solar Power System, New York, CRC Press LLC, 1999.
4. Ned Mohan, Tore M. Undeland and William P.Robbins, Power Electronics: Converters, Applications and Design, New Jersey, John Wiley and Sons, 2003.
5. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley and Sons, Ltd., 2011.

21EE013 ELECTRIC VEHICLE ARCHITECTURE 3 0 0 3

Course Objectives

- To understand the sizing and architecture of Electric vehicles.
- To apply the propulsion mechanics for Electric Vehicles.
- To analyse the power components and braking system for Electric Vehicles.
- To apply the various control strategies for Electric Vehicles.
- To apply the concepts of Plug-in Hybrid Electric Vehicle.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyse, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Illustrate the sizing of various components of Electric Vehicle.
2. Design a propulsion system for Electric Vehicle.
3. Analyse the power components and braking system for Electric Vehicles.
4. Apply the various control strategies for Electric Vehicles.
5. Implement the concept of plug-in hybrid electric vehicle.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	3	3									3	3
2	3	3	3	3									3	3
3	3	3	3	3									3	3
4	3	3	3	3									3	3
5	3	3	3	3									3	3

9 Hours

UNIT I
VEHICLE ARCHITECTURE AND SIZING

Electric Vehicle History, and Evolution of Electric Vehicles - Series, Parallel and Series Parallel Architecture, Micro and Mild architectures - Mountain Bike - Motorcycle- Electric Cars and Heavy Duty EVs. -Details and Specifications.

UNIT II **9 Hours**

VEHICLE MECHANICS

Vehicle mechanics- Roadway fundamentals, Laws of motion, Vehicle Kinetics, Dynamics of vehicle motion, propulsion power, velocity and acceleration, Tire –Road mechanics, Propulsion System Design.

UNIT III **9 Hours**

POWER COMPONENTS AND BRAKES

Power train Component sizing- Gears, Clutches, Differential, Transmission and Vehicle Brakes. EV power train sizing, HEV Powertrain sizing, Example.

UNIT IV **9 Hours**

HYBRID VEHICLE CONTROL STRATEGY

Classification of control strategies: series, parallel, and power split-Different operating modes of hybrid vehicles: electric-only, engine-only, hybrid, regenerative braking-Control strategies for optimizing energy management and efficiency.

UNIT V **9 Hours**

PLUG-IN HYBRID ELECTRIC VEHICLE

Introduction-History-Comparison with electrical and hybrid electrical vehicle-Construction and working of PHEV-Block diagram and components-Charging mechanisms-Advantages of PHEVs.

Total: 45 Hours

Reference(s)

1. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.
2. Build Your Own Electric Vehicle,Seth Leitman , Bob Brant, McGraw Hill, Third Edition 2013.
3. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, First edition 2017.
4. The Electric Vehicle Conversion Handbook: How to Convert Cars, Trucks, Motorcycles, and Bicycles -- Includes EV Components, Kits, and Project Vehicles Mark Warner, HP Books, 2011.
5. Heavy-duty Electric Vehicles from Concept to Reality, Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, Kari Tammi, Elsevier Science, 2021
6. Electric Vehicles Modern Technologies and Trends, Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen Springer, 2020
7. Hybrid Electric Vehicles: A Review of Existing Configurations and Thermodynamic Cycles, Rogelio León , Christian Montaleza , José Luis Maldonado , Marcos Tostado-Véliz and Francisco Jurado, Thermo, 2021, 1, 134–150. https://doi.org/10.3390/thermo1020010.

21EE014 DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES **3 0 0 3**

Course Objectives

- To familiarize with power electronic components configuration to review the drive cycles and requirements of EVs
- To expose the utilization of different motors used in Electric Vehicle
- To learn the methods for analysing the behaviour of nonlinear control systems.
- To inculcate the knowledge to design and analyse power converters suitable for EV
- To design and analyse the transfer function of DC-DC converter used in EV

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Explain the various parameters in dynamics of electric vehicles.
2. Apply controls of different motors for drive system efficiency.
3. Derive linear quadratic optimal controllers for scalar systems, and evaluate design parameters influence the closed-loop system properties.
4. Design and analyse closed loop Power converters for EV.
5. Analyse power electronics circuits and losses occurring in practice.

Articulation Matrx

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3		3	-	-	-	-	1	-	3	-	3	3	-
2	3	3	3	3	3	-	-	1	-	3	-	3	3	3
3	3	3		3	3	-	-	1	-	3	-	3	3	3
4	3	3	3	3	3	-	-	1	-	3	-	3	3	3
5	3		3	3	3	-	-	1	-	3	-	3	3	3

UNIT I **9 Hours**

ELECTRIC VEHICLE DYNAMICS

Standard drive cycles-Dynamics of Electric Vehicles-Tractive force-Maximum speed, torque, power, energy requirements of EVs.

UNIT II **9 Hours**

MOTORS FOR ELECTRIC VEHICLES

Introduction – Speed And Torque control of above and below rated speed-Speed control of EV in the constant power region of electric motors. DC Motors, Induction Motor, Permanent Magnet Synchronous Motors (PMSM), Brushless DC Motors, Switched Reluctance Motors (SRMs). Synchronous Reluctance Machines-Choice of electric machines for EVs.

UNIT III **9 Hours**

BASICS OF SIMULATION IN CONTROL SYSTEMS

Transfer Function-How to build transfer function, identify Poles, zeros, draw time response plots, bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions, RHP Pole and RHP Zero Functions), state space modelling-transfer function from state space Model

UNIT IV **9 Hours**

MODELING OF DC-DC CONVERTERS

Overview of PWM Converter Modelling -Power Stage Modelling - PWM Block Modelling - Voltage Feedback Circuit and Small-Signal Model of PWM Converter - Averaging Power Stage Dynamics - Average Models for buck/boost Converter - Small-Signal Model of Converter Power Stage - Frequency Response of Converter

UNIT V **9 Hours**

POWER STAGE TRANSFER FUNCTIONS OF DC – DC CONVERTERS

Power Stage Transfer Functions of buck-boost Converter in CCM Operation, Input-to-Output Transfer Function, Duty Ratio-to-Output Transfer Function, Load Current-to-Output Transfer Function.

Total: 45 Hours

Reference(s)

1. Electronic Converters, Teuvo Suntio, Tuomas Messo, Joonas Puukko, First Edition 2017.
2. Fundamentals of Power Electronics with MATLAB, Randall Shaffer, Lakshmi publications . 2nd Edition, 2013,
3. Feedback Control problems using MATLAB and the Control system tool box, Dean Frederick and Joe Cho, 2000, 1st Edition, Cengage learning.
4. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis,
5. 2005,1st Edition.
6. Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley,2021, 1st Edition.
7. Emerging Power Converters for Renewable Energy and Electric Vehicles Modeling, Design,
8. and Control, Md. Rabiul Islam,Md. Rakibuzzaman Shah, Mohd. Hasan Ali, CRC Press,2021, 1st Edition.
9. Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Second Edition” CRC
10. Press, Taylor & Francis Group, Third Edition 2021.

21EE015 ELECTRIC VEHICLE DESGN, MECHANICS AND CONTROL 3 0 0 3

Course Objectives

- To understand the basics of EV and vehicle mechanics
- To identify the EV architecture and its types
- To find out the various types of energy storage system concepts
- To derive model for batteries and to know the different types of batteries and its charging methods
- To comprehend the control preliminaries for DC-DC converters.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyse the internal combustion engine based on vehicle fuel economy, emission control systems
2. Interpret the vehicle mechanics of EV and HEV
3. Analyse the battery pack and battery charging methods for different types of battery
4. Assess the stability of boost converter using bode plot
5. Evaluate the performance of AC motor with vector control and direct torque control.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	-	-	-	-	-	-	1	2	-	2	3	-
2	3	-	3	-	-	-	-	-	1	3	-	2	3	-
3	3	2	-	-	-	-	3	-	1	2	-	2	3	-
4	3	3	2	-	-	-	3	-	1	2	-	2	3	-
5	3	1	-	-	-	-	3	-	1	2	-	2	3	2

UNIT I **9 Hours**

INTERNAL COMBUSTION ENGINES

IC Engines, BMEP and BSFC, Vehicle Fuel Economy, Emission Control Systems, Treatment of Diesel Exhaust Emissions.

UNIT II **9 Hours**

ELECTRIC VEHICLES AND VEHICLE MECHANICS

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings- Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics.

UNIT III **9 Hours**

BATTERY MODELING, TYPES AND CHARGING

Batteries in Electric & Hybrid Vehicles – Battery Parameters. Types- Lead Acid Battery - Nickel-Cadmium & Nickel-Metal-Hydride (NiMH) Battery - Li-Ion & Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur & Sodium-Metal-Chloride, R&D for Advanced Batteries. Battery- Modelling, Pack Management & Charging, Electric Circuit Models.

UNIT IV **9 Hours**

CONTROL PRELIMINARIES

Control Design Preliminaries - Transfer Functions – Bode plot analysis for First order and second order systems - Stability - Transient Performance- Power transfer function for boost converter - Gain margin and Phase margin study-open loop mode.

UNIT V **9 Hours**

CONTROL OF AC MACHINES

Introduction- Reference frame theory, basics-modeling of induction and synchronous machine in various frames-Vector control- Direct torque control.

Total: 45 Hours

Reference(s)

1. Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
2. Power Electronic Converters,: Dynamics and Control in Conventional and Renewable Energy Applications, Teuvo Suntio, Tuomas Messo, Joonas Puukko, 1st Edition, Wiley - VCH.
3. Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2003, 1st Edition.
4. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001, 1st Edition.
5. Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, John Wiley & Sons, 2017, 2nd Edition.
6. Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall,1997, 1st Edition.
7. Electrical Machine Fundamentals with Numerical Simulation using MATLAB/ SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley, 2021, 1st Edition.

21EE016 DESIN OF ELECTRIC VEHICLE CHARGING SYSTEM 3 0 0 3

Course Objectives

- To understand the fundamental concept of charging stations and their standards.
- To learn about the working of power converters in electric vehicle charging stations.
- To find the various electric vehicle charging schemes using renewable energies and storage systems.
- To demonstrate the wireless power transfer technique for electric vehicle charging systems.
- To understand the necessity of PF improvement and design power factor correction circuits.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Understand the various charging techniques, charging standards and regulations.
2. Analyze the working of DC-DC converters used in the EV charging systems.
3. Analyze the performance of renewable energy-based charging systems.
4. Evaluate the working principle of wireless power transfer in EV charging systems.
5. Evaluate the performance of power converters by boosting the power factor.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	3	3	-	-	2	2	-	3	-	3	3	--
2	3	3	3	3	-	-	2	2	-	3	-	3	3	3
3	3				-	-			-		-		3	3
4	3	3	3	3	-	-	2	2	-	2	-	1	3	3
5	3	-	-	-	-	-	-	-	-	-	-	-	3	3

UNIT I **9 Hours**

CHARGING STATIONS AND STANDARDS

Introduction-Charging technologies- Conductive charging, EV charging infrastructure, International standards and regulations - Inductive charging, need for inductive charging of EV, Modes and operating principle, Static and dynamic charging, Bidirectional power flow, International standards and regulations

UNIT II **9 Hours**

POWER ELECTRONICS FOR EV CHARGING

Layouts of EV Battery Charging Systems-AC charging-DC charging systems- Power Electronic Converters for EV Battery Charging- AC–DC converter with boost PFC circuit, with bridge and without bridge circuit - Bidirectional DC–DC Converters- Non-isolated DC–DC bidirectional converter topologies- Half-bridge bidirectional converter.

UNIT III **9 Hours**

EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS

Introduction- - EV charger topologies , EV charging/discharging strategies - Integration of EV charging-home solar PV system , Operation modes of EVC-HSP system , Control strategy of EVC- HSP system - fast-charging infrastructure with solar PV and energy storage.

UNIT IV **9 Hours**

WIRELESS POWER TRANSFER

Introduction - Inductive, Magnetic Resonance, Capacitive types. Wireless Chargers for Electric Vehicles - Types of Electric Vehicles - Battery Technology in EVs -Charging Modes in EVs - Benefits of WPT. - WPT Operation Modes - Standards for EV Wireless Chargers, SAE J2954, IEC 61980. ISO 19363

UNIT V **9 Hours**

POWER FACTOR CORRECTION IN CHARGING SYSTEM

Need for power factor correction- Boost Converter for Power Factor Correction, Sizing the Boost Inductor, Average Currents in the Rectifier and calculation of power losses-

Total: 45 Hours

Reference(s)

1. Mobile Electric Vehicles Online Charging and Discharging, Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016, 1st Edition.
2. Alicia Triviño-Cabrera, José M. González-González, José A. Aguado, Wireless Power Transferor Electric Vehicles: Foundations and Design Approach, Springer Publisher 1st Edition. 2020.
3. Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Electric Vehicles Modern Technologies and Trends. Springer Publisher 1st Edition, 2021.
4. Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration, Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, IET 2021, 1st Edition.

5. Electric and Hybrid Electric Vehicles, James D Halderman, Pearson, 2022, 1st Edition.
6. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005.

21EE017 GRID INTEGRATION OF ELECTRIC VEHICLES 3 0 0 3

Course Objectives

- To understand the Vehicle-to-Grid (V2G) technology in the context of electric vehicle integration with the power grid.
- To understand the grid stability, energy efficiency, and economic advantages of V2G
- To identify and examine the challenges and barriers faced in the successful implementation of V2G.
- To Understand the impact of Electric Vehicles (EVs) and V2G technology on the smart grid and renewable energy systems.
- To comprehend the principles and strategies for effectively integrating and managing Electric Vehicles (EVs) within the existing power grid infrastructure.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Assess V2G potential impact on the power grid and energy management.
2. Analyse the benefits of V2G integration, propose strategies for enhancing sustainable energy systems
3. Analyse the key challenges hindering V2G adoption, propose potential solutions for effective grid integration
4. Assess the influence of EVs and V2G on grid stability for optimizing their synergistic effects.
5. Design and implement grid integration solutions of EVs while maintaining grid stability and efficiency.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	-	-	-	-	-	2	1	-	2	-	-	3	3
2	3	3	-	-	3	-	2	1	-	2	-	-	3	-
3	3	-	-	-	-	-	2	1	-	2	-	-	3	-
4	3	-	-	-	-	-	2	1	-	2	-	-	3	-
5	3	-	-	-	-	-	2	1	-	2	-	-	3	-

UNIT I **9 Hours**

DEFINITION, And STATUS Of V2G

Defining Vehicle to Grid (V2G) - History and Development of V2G. Incorporating V2G to the EV, Auditing and Metering, V2G in Practice, V2G - Power Markets and Applications . Electricity Markets and V2G Suitability , Long-Term Storage, Renewable Energy, and Other Grid Applications , Beyond the Grid: Other Concepts Related to V2G

UNIT II **9 Hours**

BENEFITS OF V2G

Benefits of V2G, Technical Benefits: Storage Superiority and Grid Efficiency, Economic Benefits: EV Owners and Societal Savings, Environment and Health Benefits: Sustainability in Electricity and Transport, Other Benefits.

UNIT III **9 Hours**

CHALLENGES TO V2G

Battery Limitations and Vehicle Considerations- Policy and Regulatory Hurdles for V2G Adoption- Ensuring Data Security and Privacy in V2G- Overcoming User Resistance to V2G Participation- Planning for V2G Integration in the Power Grid- Assessing Environmental Impacts of V2G Deployment

UNIT IV **9 Hours**

IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS

EV Charging Infrastructure and Grid Integration - Types of Electric Vehicles - Motor Vehicle Ownership and EV Migration - Impact of Estimated EVs on Electrical Network - Impact on Drivers and the Smart Grid - Standardization and Plug-and-Play - IEC 61850 Communication Standard and IEC 61850-7-420 Extension.

UNIT V **9 Hours**

GRID INTEGRATION AND MANAGEMENT OF EVS

Importance of Grid Integration - Machine to Machine (M2M) in distributed energy management systems - M2M communication for EVs - M2M communication architecture (3GPP) - Electric vehicle data logging - Scalability of electric vehicles -M2M communication with scheduling.

Total: 45 Hours

Reference(s)

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017, 1st Edition.
2. Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna , Farhad Shahnia and Arindam Ghosh,Springer,2015, 1st Edition.
3. ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor 1; Jesus Fraile-Ardanuy, IET 2020, 1st Edition.
4. Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015, 1st Edition.
5. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle- to-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019, 1st Edition.

21EE018 INTELLIGENT CONTROL OF ELECTRIC VEHICLES 3 0 0 3

Course Objectives

- To understand the mathematical model of a BLDC motor and its characteristics
- To understand the different control schemes for BLDC motor
- To understand the need of fuzzy in control of electric vehicles
- To understand the fundamentals of FPGA and VHDL
- To understand the fuzzy logic control of BLDC motor .

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Interpret the mathematical model of a BLDC motor and to discuss about its characteristics.
2. Represent the various speed control methods for controlling the speed of BLDC motor.
3. Infer the concept of fuzzy system
4. Understand the basics of VHDL & FPGA applied to control of EVs.
5. Design and implement of fuzzy logic control scheme for BLDC motor using FPGA in real time.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1											1	1
2	1	2											1	1
3	2		2										3	1
4	2	1	2										3	1
5	2	1	3										2	1

UNIT I **9 Hours**

MATHEMATICAL MODEL AND CHARACTERISTICS ANALYSIS OF THE BLDC MOTOR

Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Differential Equations, Transfer Functions, State-Space Equations., Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients

UNIT II **9 Hours**

SPEED CONTROL FOR ELECTRIC DRIVES

Introduction -PID Control Principle, Anti windup Controller, Intelligent Controller. Vector Control. Control applied to BLDC motor.

UNIT III **9 Hours**

FUZZY LOGIC

Membership functions, Fuzzification, Defuzzification, Fuzzy Arithmetic and Fuzzy Measures, Fuzzy Rule Base and Approximate Reasoning, Fuzzy Propositions, Rule Formation and Decomposition, Aggregation, Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert System, Fuzzy Decision Making.

UNIT IV **9 Hours**

FPGA AND VHDL BASICS

Introduction – FPGA Architecture-Advantages-Review of FPGA family processors- Spartan 3, Spartan 6 and Spartan 7. VHDL Basics- Fundamentals-Instruction set-data type-conditional statements- programs like arithmetic, sorting, PWM generation, Speed detection.

UNIT V **9 Hours**

REAL TIME IMPLEMENTATION

Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of 48 V BLDC motor using FPGA.

Total: 45 Hours

Reference(s)

1. John G. Hayes, G. Abas Goodarzi, 'Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles' Wiley 1st Edition 2018.
2. Jayaram Bhasker, 'VHDL Primer', A (3rd Edition), Prentice Hall, 1st Edition 2015.
3. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Third Edition" CRC Press, Taylor & Francis Group, 2021, 1st Edition.
4. Chang-liang, Permanent Magnet Brushless DC Motor Drives and Controls, Xia Wiley 2012, 1st Edition.
5. M.N. Cirstea, A. Dinu, J.G. Khor, M. McCormick, Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes publications, 1st Edition, 2002.
6. Wei Liu, 'Hybrid Electric Vehicle System Modelling and Control', Wiley 2017, 2nd Edition.

21EE019 SOLAR ENERGY CONVERSION SYSTEMS 3 0 0 3

Course Objectives

- To provide solar radiation and its measurement techniques
- To understand the overview of solar pv cell and its mathematical model.
- To attain a broad comprehension on solar photovoltaic standalone and grid connected system
- To understand the operations of solar thermal energy conversion system.
- To understand the applications of solar pv and solar thermal systems

Programme Outcomes (POs)

a. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply the various instruments for measuring solar radiation.
2. Analyse the I-V characteristics of Solar PV System and conversion efficiency
3. Design a converter control topology for standalone and grid connected PV systems.
4. Analyse the different types of solar thermal energy collectors.
5. Apply a suitable Solar PV or thermal systems for various domestic and industrial applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1											1	
2	2	2		3	1								3	
3	2	2	3	1	1								3	
4	2		2		1								2	
5	3		2		1									2

UNIT I **7 Hours**

SOLAR RADIATION AND MEASUREMENT

Electromagnetic spectrum-Solar angles-Sun path diagrams-Solar insolation- -Radiation absorption, scattering -Measurement of radiation-Pyranometer-Pyrheliometer-Sunshine recorder.

UNIT II **10 Hours**

SOLAR PV CELL

Formation of a PN – junction - Space charge and internal field - Quasi - Fermi levels - The Shockley diode equation - Structure of a solar cell - The solar cell equation - I-V characteristics - Fill factor - Crystalline silicon solar cells - Thin film solar cells - PV Cell Interconnection and Module Fabrication - PV Modules and arrays -Conditions for maximum power Transfer-Conversion efficiency- Basics of Load Estimation.

UNIT III **8 Hours**

STAND-ALONE AND GRID CONNECTED PV SYSTEMS

Grid interconnection standards- - Inverter control topologies for standalone and grid connected systems-Feasible operating region of inverter for grid connected system -Real time issues in grid connected systems- Maximum Power Point Tracking algorithms.

UNIT IV **10 Hours**

SOLAR THERMAL ENERGY CONVERSION

Solar thermal energy- Solar flat plate collector, solar evacuated tube collector -Pool and Air Collectors Construction -Function - Solar heating and cooling system - Real time issues in solar thermal systems-Comparison of solar thermal and Solar PV systems.

UNIT V **10 Hours**

APPLICATIONS OF SOLAR PV AND SOLAR THERMAL SYSTEMS

Solar PV power plant - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping -Solar thermal electric power plant -solar thermal applications: heating, cooling, desalination, drying, cooking, Solar Ponds.

FOR FURTHER READING

Indian and International Energy Policies-Recent trends in solar thermal and Solar PV systems - Limitations of solar thermal and PV systems.

Total: 45 Hours

Reference(s)

1. CS Solanki, Solar Photovotaics,Fundamentals, Technologies and Applications, 3rd edition, PHI Learning Pvt. Ltd., 2015.
2. Martin A. Green, Solar Cells Operating Principles, Technology, and System Applications PrenticeHall, 2008.
3. H.P. Garg and J. Prakash., Solar Energy,Fundamentals & Applications, Tata McGraw Hill book Co, New Delhi, 2017.
4. S.P. Sukhatme, J.K. Nayak, Solar Energy-Principle of thermal storage and collection, Tata McGraw Hill book Co, 3rd edition New Delhi, 2011.
5. G.N.Tiwari, Solar Energy-Fundamentals, Design,Modeling and Applications,Narosha Publishing House Ltd.,2013.
6. Amine Allouhi et al. Up-to-date literature review on Solar PV systems: Technology progress, market status and R&D, Journal of Cleaner Production (2022)

21EE020 WIND POWER TECHNOLOGY 3 0 0 3

Course Objectives

- To understand the wind power scenario, characteristics and classifications of WECS.
- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To understand the operations of various generators used in WECS.
- To analyze the grid integration issues.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the performance of WECS and select a suitable site.
2. Analyze the control mechanism for wind turbine.
3. Analyze the different types of generator for fixed speed wind turbine systems.
4. Apply the characteristics of generators for variable speed constant frequency systems.
5. Analyze the interconnection requirements of grid connected systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				1						2	3
2	3	2	3										3	3
3	2	3	3										3	3
4	3	2	3										3	3
5	2	3	2				1						3	3

UNIT I **9 Hours**

INTRODUCTION

Wind source -Characteristics of Wind Energy-Wind Energy Conversion System (WECS) siting - Classification- Types of Towers -Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Aerodynamics of Wind turbine- offshore Wind Turbine.

UNIT II **9 Hours**

WIND TURBINES

Terminologies-Types of Wind Power Plants-HAWT and VAWT -Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-Number of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction.

UNIT III **9 Hours**

FIXED SPEED SYSTEMS

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model of wind turbine rotor - Drive Train model.

UNIT IV **9 Hours**

VARIABLE SPEED SYSTEMS

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

UNIT V **9 Hours**

GRID CONNECTED SYSTEMS

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, Harmonics and Power Quality-Wind Turbine as a Discrete Generator-Islanding.

FOR FURTHER READING

Hybrid Energy systems- wind - photovoltaic systems-wind- diesel hybrid systems-diesel generator and photovoltaic systems.

Total: 45 Hours

Reference(s)

1. Earnest Joshua, “Wind Power Technology”, PHI Learning, New Delhi, 2019, ISBN: 978-8120351660.
2. S.N.Bhadra, D.Kastha, S.Banerjee, “ Wind Electrical Systems”, Oxford University Press,2010.
3. Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2015.
4. Ahmad Hemami, “Wind Power Technology”, Cengage Learning Series in Renewable Energy, 2012.
5. N. Jenkins, “Wind Energy Technology”, John Wiley & Sons,2021.
6. Siegfried Heier, “Grid Integration of WECS”, John Wiley & Sons Ltd, 2014.

21EE021 FUEL CELL SYSTEMS 3 0 0 3

Course Objectives

- To Understand the principles of fuel cell technology
- To understand the concept of fuel cell system components
- To differentiate and apply the working of different fuels cells.
- To analyse fuel cell system design and integration.
- To analyse the applications of fuel cell systems.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply the concepts of fuel cell basic components.
2. Analyse the working of fuel cell under different parameter constraints.
3. Analyse the benefits of fuel cells applications.
4. Analyse the role of Safety and Environmental Considerations.
5. Design solutions for optimised fuel cell systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	2										2
2	3	2	2	2										2
3	3	2	2	2										2
4	3	2	2	2										2
5	3	2	2	2										2

UNIT I 9 Hours

INTRODUCTION

Types of fuel cells: proton exchange membrane (PEM), solid oxide (SOFC), molten carbonate (MCFC), and phosphoric acid (PAFC) fuel cells-Working principles of fuel cells-Electrochemical reactions in fuel cells-Advantages and challenges of fuel cell technology

UNIT II 9 Hours

FUEL CELL COMPONENTS AND MATERIALS

Electrodes and catalysts: types, characteristics, and selection criteria-Membranes and electrolytes: properties and considerations-Bipolar plates and current collectors-Gas diffusion layers and flow fields-Materials selection for fuel cell components-Durability and performance considerations

UNIT III **9 Hours**

FUEL CELL SYSTEMS AND DESIGN

System configurations: standalone, grid-connected, and hybrid systems-Balance of plant (BOP) components: compressors, humidifiers, heat exchangers, pumps, and control systems-System efficiency and optimization strategies-System integration and control-Safety considerations in fuel cell system design

UNIT IV **9 Hours**

FUEL CELL APPLICATIONS

Transportation applications: automotive, buses, and trains-Portable and off-grid power applications-Residential and commercial stationary power generation-Industrial and remote power systems-Emerging applications and market trends

UNIT V **9 Hours**

FUEL CELL PERFORMANCE, TESTING, AND CHARACTERIZATION

Fuel cell performance metrics: voltage-current characteristics, power density, and efficiency-Testing methodologies and protocols-Diagnosis and troubleshooting of fuel cell systems-Performance modelling and simulation-Lifetime and degradation analysis

FOR FURTHER READING

Fuel Cell Materials, Fuel Cell Stack Design, Fuel Cell Electrochemistry - Fuel Cell Degradation and Durability

Total: 45 Hours

Reference(s)

1. Ryan O'Hayre, Suk-Won Cha, Whitney Colella, and Fritz B. Prinz, “Fuel Cell Fundamentals”, PHI Learning, New Delhi, 2016

2. James Larminie and Andrew Dicks, “ Fuel Cell Systems Explained”, Latest edition: 2003.

3. Nigel Sammes and Ruud van Berkel, “Fuel Cell Technology: Reaching Towards Commercialization"”, (Latest edition: 2006).

4. Matthew M. Mench and Kwang J. Kim, “Fuel Cell Engines”, (Latest edition: 2008).

5. Ludwig Jörissen and Detlef Stolten, “Fuel Cells: Principles, Design, and Analysis”, (Latest edition: 2013)

21EE022 RENEWABLE ENERGY SYSTEMS INSTALLATIONS AND MAINTENANCE **3 0 0 3**

Course Objectives

- To Understand the fundamental principles and components of solar energy systems
- To understand site assessment and design considerations
- To understand the electrical wiring and commissioning of solar energy systems
- To apply the concepts and methods for maintenance and troubleshooting
- To apply the principles and applications of off-grid and grid-tied solar energy systems.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply the fundamental principles and components of solar energy systems
2. Assess the Design and plan for the solar energy systems
3. Design, installation and commissioning solar energy systems.
4. Analyse performance and troubleshooting techniques of solar energy systems.
5. Analyse performance of an off grid and grid tied solar energy systems

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				2							2
2	3	2	3				2							2
3	2	3	3				2							2
4	3	2	3				2							2
5	2	3	2				2							2

UNIT I **9 Hours**

INTRODUCTION

Overview of solar energy and its importance Basic principles of solar energy conversions - Types of solar energy systems: photovoltaic (PV) systems and solar thermal systems - Components of a solar energy system: solar panels, inverters, batteries, charge controllers

UNIT II **9 Hours**

DESIGNING SOLAR ENERGY SYSTEMS

Site assessment and analysis for solar energy systems - Load estimation and energy consumption analysis - Sizing of solar energy systems based on energy needs - Placement and orientation of solar panels for optimal performance - Electrical design considerations: wiring, grounding, and safety.

UNIT III **9 Hours**

SOLAR ENERGY SYSTEM INSTALLATION

Preparing the site for installation: permits, regulations, and safety measures - Mounting and securing solar panels - Electrical wiring and connections - Installation of inverters, batteries, charge controllers, and other system components - Testing and commissioning the solar energy system

UNIT IV **9 Hours**

MAINTENANCE AND TROUBLESHOOTING

Regular maintenance practices for solar energy systems - Cleaning and inspection of solar panels - Monitoring and performance analysis - Identifying and addressing common issues and troubleshooting techniques - Safety precautions during maintenance activities.

UNIT V **9 Hours**

OFF-GRID AND GRID-TIED SYSTEMS

Off-grid solar energy systems: design and installation considerations - Battery storage systems: types, sizing, and maintenance - Grid-tied solar energy systems: connecting to the electrical grid - Net metering and feed-in tariffs - Backup power options and emergency preparedness

FOR FURTHER READING

Photovoltaic systems- Solar PV Engineering and Installation- Solar Power Plant Design

Total: 45 Hours

Reference(s)

1. Muhammad H., “Photovoltaic Systems: Analysis and Design”, Year: 2018
2. Michael Boxwell, “Solar Electricity Handbook: A Simple, Practical Guide to Solar Energy”,2020
3. Sean White "Solar PV Engineering and Installation: Preparation for the NABCEP PV Installation Professional Certification",2015.
4. Chetan Singh Solanki "Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers, and Engineers",2012
5. Majid Ghassemi & Robert Foster, "Solar Energy: Renewable Energy and the Environment",2018.

21EE023 ENERGY STORAGE SYSTEMS 3 0 0 3

Course Objectives

- Understand the significance of energy storage schemes.
- Understand the working of two types of mechanical energy storage systems
- Understand the concepts of various models of batteries
- Understand the performance of passive energy storage elements.
- Understand the principles of different methods of thermal energy storage schemes

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Justify the significance of energy storage in current scenario.
2. Apply the concepts of mechanical energy in storage schemes
3. Compare the working methods of various electrochemical batteries.
4. Apply the principle of Electromagnetism for energy storage.
5. Analyze the various methods of thermal energy storage systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				1						2	3
2	3	2	3										3	3
3	2	3	3										3	3
4	3	2	3										3	3
5	2	3	2				1						3	3

UNIT I **8 Hours**

MODES OF STORAGE

Need and importance of Energy storage, Periodic Storage, Modes of Storage: Thermo-chemical energy storage, Energy Storage in Organic Fuels, Hydrogen Storage.

UNIT II **9 Hours**

MECHANICAL ENERGY STORAGE

Introduction - Potential Energy Storage - Energy Storage in Pressurized Gas - Pumped-Hydro Storage - Kinetic Energy in Mechanical Systems - Linear and Rotational Kinetic Energy - Internal Structural Energy Storage, Applications

UNIT III **10 Hours**

ELECTROCHEMICAL ENERGY STORAGE SYSTEMS

Fundamental concepts - Reaction Mechanisms in Electrochemical Cells - Practical Parameters, Equivalent Circuit, Types of batteries: Primary, Secondary, Lithium, Solid-state and molten solvent, lead acid, Nickel Cadmium Batteries; Zinc Manganese dioxide, Applications.

UNIT IV **9 Hours**

ELECTROMAGNETIC ENERGY STORAGE SYSTEMS

Superconducting Magnet Energy Storage (SMES) systems, Energy in a Material in a Magnetic Field, Superconductive Materials, Super capacitor: Electrochemical Double Layer Capacitor (EDLC): principle of working, structure, performance and applications

UNIT V **9 Hours**

THERMAL ENERGY STORAGE

Basic Principles - Benefits - Methods - Sensible Thermal Energy Storage (TES)- Latent TES - Cold TES - Seasonal TES - Thermal Energy Savings - Environmental Impacts - Applications.

FURTHER READING

Ocean wave energy - conversion, principle, power plants, tidal energy conversion, Scope and development

Total: 45 Hours

Reference(s)

1. S.R. Khalid, " Energy Storage Systems: Operation and Control", CRC Press, 1st Edition, 2020.
2. Bengt Sunden and Mohammad Reza Ghalambor, "Handbook of Energy Storage: Types, Technologies and Applications", Springer, 1st Edition, 2019.
3. Huggins, Robert A., Energy Storage: Fundamentals, Materials and Applications, Second Edition, Springer US, 2015.
4. Ibrahim Dincer,Mark A. Rosen, Thermal Energy Storage Systems and Applications, 2nd Edition, Wiley, 2011.
5. Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion, First, Wiley publications, 2012.

21EE024 GRID INTEGRATION OF RENEWABLE SOURCES 3 0 0 3

Course Objectives

- To understand the operation of grid interconnected renewable energy systems.
- To identify the grid integration issues.
- To understand the grid integration of PV system.
- To understand the grid integration of wind system.
- To understand the Integration of alternate sources of energy.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Understand the challenges and opportunities for renewable generation in both large interconnected grid and micro grid settings.
2. Identify the requirements for grid interconnection and its impact with NCE sources.
3. Analysis the current techniques of PV interconnections with power system.
4. Analysis the current techniques of wind interconnections with power system.
5. Analysis the principles, power and limitations of complex power networks incorporating distributed generation and storage.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	3											2	2
2	2	3											2	2
3	2	2	2	3									3	2
4	2	2	3	3									3	3
5	2	3	3	3									3	3

UNIT I 9 Hours

INTRODUCTION

Introduction to renewable energy systems, environmental aspects of electric energy conversion, impacts of renewable energy penetration to grid. Grid Codes in India and other countries. Basic power electronic converters for renewable energy integration to grid - Qualitative analysis - Grid Interactive Inverters-matrix converters.

UNIT II **9 Hours**

IMPACT OF GRID INTEGRATION

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT III **9 Hours**

GRID INTEGRATION OF PV SYSTEMS

Grid-Connected PV Power Systems - Inverter Control Algorithms - Synchronous Reference Frame–Based Current Controller - Digital PI-Based Current Controller - Adaptive Notch Filter-Based Grid Synchronization - Modeling, Simulation, and Hardware Implementation of Controllers

UNIT IV **9 Hours**

GRID INTEGRATION OF WIND SYSTEMS

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

UNIT V **9 Hours**

INTEGRATION OF ALTERNATE SOURCES OF ENERGY

Introduction, principles of power injection: converting technologies, power flow; instantaneous active and reactive power control approach; integrating multiple renewable energy sources; DC link integration; AC link integration; HFAC link integration; islanding and interconnection

Total: 45 Hours

Reference(s)

1. Marco H. Balderas, 'Renewable Energy Grid Integration, Nova Science Publishers, New York, 2009.
2. Majid Jamil, M. Rizwan, D.P.Kothari, 'Grid integration of solar photovoltaic systems', CRC Press, NewYork, 2017.
3. B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O Malley, R. Watson and D. Milborrow, 'Wind Power Integration connection and system operational aspect, 1st Edition, IET Power and Energy Series 50, 2007.
4. H. Siegfried and R. Waddington, "Grid integration of wind energy conversion systems" John Wiley and Sons Ltd., 2006.
5. Felix A. Farret and M. Godoy Simoes, 'Integration of Alternative sources of Energy', 1st Edition, IEEE Press – Wiley-Interscience publication, 2006.

21EE031 UTILISATION OF ELECTRICAL ENERGY

3 0 0 3

Course Objectives

- To understand the definitions for illumination and types of lamps.
- To Maintain different types of electrical utilities and systems.
- To look over the Electric drives for traction.
- To understand the Electric drives for elevators.
- To analyze the tariff and power factor improvement for all types of supplies.

Programme Outcomes (POs)

a. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
g. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
l. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the functioning of different types of lamps, laws and fittings.
2. Analyze different electric heating methods and different welding equipment.
3. Analyze About different types of electric drives and elevators.
4. Apply the different electric traction systems and speed calculations.
5. Apply the tariffs for various schemes and analyze equipment for power factor improvement.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	2			2				1		3	2	
2	3	3	3	2			2				1		3	1	
3	3	3	3	2			3				1		3	3	
4	3	3	3	2			3				1		3	3	
5	3	3	3	2			1				1		2	1	

Unit-I

Illumination **9 Hours** Illumination terminologies - Laws of Illumination – Inverse square law and Lambert's cosine law-Various types of lamps - LED lamps - Various lighting schemes: features and application - Domestic and industrial lamp fittings, Electronic ballast.

Unit— II

Electric Heating and welding systems **9 hours**

Concept of electrical heating - classification of electric heating - Induction heating - Dielectric heating - Types of welding systems - Arc welding - Supply requirements; AC welding machines - welding transformer, safety precautions

.

Unit – III

Electric Drives and Elevators **9 Hours** Electric Drives -Transmission of mechanical power - Bearing - Size and rating of motor, Definition of standard rating as per IS - Load cycles - Load Equalization - Braking - Elevators - Factors on which shape and size of car depends - Bombay Lift Act 1939. (Latest Amendment).

Unit – IV

Electric Traction

9 Hours

Requirements of an ideal traction system - different types of traction system used in India - Traction mechanics - Traction motors - Definition of average and schedule speed, factors affecting schedule speed - Speed-time curve - Current collecting System: - Pantographs.

Unit-V

Tariff and Power Factor Improvement **9 Hours** Tariff: Desirable characteristics, types - Power factor - Power factor improvement using; static capacitor- most economical power factor, location of power factor improvement - Devices from consumer and electrical supply company point of view.

Reference Book(s)

1. Pratap H, "Art and Science of Utilization of Electrical Energy" ,Dhanpat Rai &Sons, New Delhi, 2017.
2. Gupta J B "Utilization of Electric Power and Electric Traction", S. K. Kataria & Sons, New Delhi, 2016.
3. Garg "Utilization of Electric Power and Electric Traction", G. C. Khanna Publishers, New Delhi, 2016,
4. Upadhyay J, Mahendra S N, "Electric Traction", Allied Publisher Ltd., New Delhi, Latest edition .
5. Dubey G, "Fundamentals of Electrical Drives",G. K. Narosa Publishing House. New Delhi, Latest edition.
6. Mehta V K, "Principles of Power system, S.Chand, New Delhi, Latest edition
7. Sivanagaraju S, Balasubba Reddy M ,Srilatha B "Generation and Utilization of Electrical Energy", Pearson Education, New Delhi, 2016.
8. Partab H "Modern Electric Traction", Dhanpat Rai & Sons, New Delhi, 2016,

21EE032 INDUSTRIAL ELECTRONICS 3 0 0 3

Course Objective

- To study about the physical phenomena of different types of sensors.
- To understand about the measuring principal of MEMS devices and technologies.
- To understand about the MEMS devices and technologies and applications.
- To study about the role of FPGA in industrial applications.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Explain the various Fundamental physical phenomena of sensors.
2. Explain the various technological advancement of sensors.
3. Understand the fundamentals of MEMS technologies and its application in industrial devices.
4. Explain and analyse the types and working principles of micro sensors
5. Analyse the role of FPGA in reconfigurable systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2
1	2	2	2	2									1	2
2	2	3	2	2									2	2
3	2	3	2	2									2	2
4	2	2	3	2									1	2
5	2	2	2	3									2	2

UNIT I 9 Hours

FUNDAMENTALS OF SENSORS AND TRANSDUCERS

Performance terminology, static and dynamic characteristics of transducers, classification of sensors and transducers, signal processing and signal conditioning. Operational amplifiers, filters, protection devices, analog to digital converter, digital to analog converter.

UNIT II 9 Hours

ADVANCED SENSOR TECHNOLOGIES

Laser production, characteristics of lasers, types of laser sensors, bar code sensors, benefits of bar coding,

transponder, RFID (Radio Frequency Identification), electro-magnetic identifier, optical encoders, colour sensors, sensing principles, colour theory, unit colour measurement, colour comparator, colour sensing algorithm, fuzzy logic colour sensor. fuzzy logic for opt-electronic colour sensor in manufacturing.

UNIT III **9 Hours**

MEMS TECHNOLOGIES AND APPLICATIONS

Introduction to Microsystems and microelectronics - Applications of micro system in automotive - bio medical - aerospace - telecommunication industries. Trimmer's scaling vector and scaling laws, Materials for MEMS-Deposition - Etching-Molding.

UNIT IV **9 Hours**

MICRO SENSORS

Microsensors - Types of micro sensors - Micro accelerometer, Pressure sensors and thermal sensors. Micro actuation techniques - piezoelectric crystals - Shape memory alloys - bimetallics - conductive polymers. Micro motors - micro grippers - Microfluidic devices - Micro pumps - micro valves - valve less micro pumps.

UNIT V **9 Hours**

FPGAS AND RECONFIGURABLE SYSTEMS

Introduction-advanced Hardware resources in FPGAs-Software tools for FPGAs-role of FPGAs in reconfigurable Systems-applications.

FOR FURTHER READING

Continuous time Signals-Time Domain analysis of Continuous time signals-Frequency Domain analysis of Continuous time signals-Signal Processors-Discrete time (Digital) Filters.

Total: 45 Hours

Reference(s)

1. Maloney, Timothy, "Modern Industrial Electronics", Upper Saddle River: Prentice Hall. 2015.
2. A.K.Sawhney and P.Sawhney, "A Course on Mechanical Measurement Instrumentation and Control", Dhanpat Rai and Co, New Delhi, 2011
3. Tai Ran Hsu, "MEMS and Micro Systems Design and Manufacture", Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2008.
4. Rehg, James, A., Sartori, Glenn," Industrial Electronics", Upper Saddle River: Prentice Hall. 2016.
5. G.K.Mithal,"IndustrialElectronics",Khanna Publishers,Delhi, 2016.

2EE033 ILLUMINATION ENGINEERING 3 0 0 3

Course Objectives

- To impart basic knowledge on Illumination.
- To understand the types of sources and accessories used in lighting.
- To understand the measurement techniques of illumination and its parameters.
- To illustrate the design procedures applicable for interior lighting.
- To illustrate the design procedures applicable for exterior lighting.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. PSO1: Modeling, design and Analysis of Electrical and Electronic Systems using design principles and software tools

n. PSO2: Develop electrical machineries/Appliances for various Domestic and industrialneeds

Course Outcomes (COs)

1. Explain the basic concepts of lighting.
2. Select the lighting source and its control technique based on the requirement.
3. Analyse the various parameters of illumination and their measuring techniques.
4. Apply the lighting procedure for designing exterior environments.
5. Apply the lighting procedure for designing interior environments.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2
1	3												1	
2	3													3
3	2	3											1	
4	2		3										3	2
5	2		3										3	2

UNIT I **7 Hours**

INTRODUCTION

Light and Lighting, Basic Concepts and Units, Photometry and Measurement, Quantity and Quality of Lighting. Factors affecting lighting, artificial lighting, Lighting scheme.

UNIT II **8 Hours**

ACCESSORIES

Light sources: Daylight, Incandescent, Electric Discharge, Fluorescent, Arc lamps, Lasers, Neon signs,Energy Efficiency, LED - LCD displays, Luminaries, Wiring, Switching, Control circuits.

UNIT III **10 Hours**

CALCULATION AND MEASUREMENT

Luminance measurement, Effect of voltage variation, Lighting calculations and characteristic curves, Solid angle, Inverse square and cosine laws, Illumination from point, line and surface sources, Photometry and Spectro - photometry, photocells.

UNIT IV **10 Hours**

INTERIOR LIGHTING

Lighting design procedure for Industrial, Residential, Office, Departmental stores, Indoor stadium, Theatres and Hospitals-Energy Efficient Lighting.

UNIT V **10 Hours**

EXTERIOR LIGHTING

Environment and glare, Lighting Design procedure for Flood, Street, Sport, Aviation and Transportlighting, Lighting for Displays and Signalling-Energy Efficient Lighting.

FURTHER READING

Special Features of Aesthetic Lighting : Monument and statue lighting, Auditorium lighting

Total: 45 Hours

Reference(s)

1. Joseph B. Murdoch, Illumination Engineering from Edisons Lamp to the Laser, Visions Communications, Washington DC, USA, 1994
2. Jack L. Lindsey, Applied Illumination Engineering, Prentice Hall of India, New Delhi, 2008.
3. Marc Schiler, Simplified Design of Building Lighting, John Wiley and Sons, 1997.
4. IES Lighting Handbook, 1993.
5. D.C. Pritchard, Lighting, Routledge, 6th Edition, 2016

21EE034 ELECTRICAL SAFETY 3 0 0 3

Course Objectives

- To provide knowledge on basics of electrical fire and statutory requirements for electrical safety.
- To understand the causes of accidents due to electrical hazards.
- To know the various protection systems in Industries from electrical hazards.
- To know the importance of earthing.
- To distinguish the various hazardous zones and applicable fire proof electrical devices.

Programme Outcomes (POs)

f. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the basic concepts in electrical circuit and hazards involved in it.
2. Analyze the electrical hazards in the workplace and its impacts.
3. Examine the operation of various protection systems from electrical hazards.
4. Analyze the various safety procedures involved in the industries.
5. Explore the different hazardous zones in Industries and their safety measures.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1						2	1						2	
2						1	2						1	2
3						2							2	1
4						2	1						1	
5						2	1						2	1

UNIT I 9 Hours

CONCEPTS AND STATUTORY REQUIREMENTS

Review of Electrical concept - electrostatics, electro magnetism, stored energy - working principles of major electrical equipment - Indian electricity act and rules - statutory requirements from electrical inspectorate- international standards on electrical safety.

UNIT II 9 Hours

ELECTRICAL HAZARDS

Primary and secondary hazards - Energy leakage - clearances and insulation - current surges - electrical causes of fire and explosion - national electrical safety code ANSI- Lightning hazards.

UNIT II **9 Hours**

PROTECTION SYSTEMS

Fuse, circuit breakers and types - protection against over voltage and under voltage - safe limits of amperage - safe distance from lines - overload and short circuit protection - earth fault protection. - system grounding - equipment grounding - earth leakage circuit breaker (ELCB) - ground fault circuit interrupter - electrical guards - Personal protective equipment.

UNIT IV **9 Hours**

SELECTION, INSTALLATION, OPERATION AND MAINTENANCE

Role of environment in selection - protection and interlock - discharge rod and earthing devices - safety in the use of portable tools - preventive maintenance.

UNIT V **9 Hours**

HAZARDOUS AREAS

Hazardous area classification and classification of electrical equipment for hazardous areas (IS, API and OSHA standards)- classification of equipment/enclosure for hazardous locations.

Total: 45 Hours

Reference(s)

1. Fordham Cooper, W., "Electrical Safety Engineering, Butterworth and Company", London, Third Edition,2013.
2. "Indian Electricity Act and Rules", Government of India.
3. "Power Engineers", Handbook of TNEB, Chennai, 2010.
4. "Accident prevention manual for industrial operations", N.S.C., Chicago, 1982.
5. John Cadick, P.E., Mary Capelli-Schellpfeffer, Dennis K. Neitzel, Al Winfield, "Electrical Safety Handbook", Fourth Edition, Tata Mcgraw Hill, 2014.

21EE035 ENERGY AUDITING AND MANAGEMENT

Course Objectives

3 0 0 3

- To understand the Indian energy scenario and international energy policies.
- To study the energy utilization of electrical systems.
- To analyse the energy audit techniques by using suitable tools and energy balance.
- To study the energy management features and audit procedure.
- To gain the knowledge on financial management in energy audit.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.

n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the importance of energy policies, energy conservation act features and energy security.
2. Apply the different energy conservation technique involved in electrical and electromechanical devices.
3. Apply the suitable energy audit technique using appropriate tools to improve the system efficiency with mass and energy balance concept.
4. Analyze the suitable energy audit technique, procedure and bench marking in energy audit.
5. Analyze the energy conservation opportunities and the various financial technique adopted in energy management.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2					2						3	
2	2	2											2	3
3	1	2											2	1
4	2	2											3	
5	1	2											2	1

UNIT I **10 Hours**

ENERGY SCENARIO AND ENERGY POLICY

Role of energy in economic development and social transformation- Indian energy scenario- Energy statistics 2021-international energy policies-G20 and OPEC countries - Need for use of new and non-renewable Energy-Energy conservation act-2001 & its features - Energy Security.

UNIT II **8 Hours**

ELECTRICAL ENERGY UTILITY SYSTEM

Transmission and Distribution Losses-Transformer losses - Electricity Tariff- Load management and maximum demand control- Electric motor-losses in induction motor- efficiency calculation-factors affecting motor performance-power factor - energy efficient motors.

UNIT III **7 Hours**

ENERGY AUDIT INSTRUMENTS AND ENERGY BALANCE

Electrical measurements- Instruments used in energy audit: Wattmeter - flue gas analysers- PQ analyzers- infrared Thermography-Energy efficiency calculation in lighting, pump Applications-Material balance- energy balance - features

UNIT IV **10 Hours**

ENERGY MANAGEMENT AND AUDIT

Definition and objective of energy management - Principle of energy management - Key elements of energy management -Roles and responsibilities of energy manager - energy audit definition -types- Detailed energy audit procedure- understanding energy cost -Bench marking.

UNIT V **10 Hours**

EVALUATION OF SAVING OPPORTUNITIES AND FINANCIAL MANAGEMENT

Determination of cost saving -conservation opportunities - Estimating cost of implementation -Financial analysis techniques-plant energy audit report - Simple payback period, Return on investment, Net present value, Internal rate of return.

FOR FURTHER READING

Energy conservation and management -case studies - BEE rules and regulations.

Total: 45 Hours

Reference(s)

1. Jose Golden Berg, Thomas Johansson, A K N Reddy, Robert Williams “Energy for a sustainable world”, WileyEastern, 1988.
2. BEE reference book 1/2/3/4
3. Albert Thumann,Terry Niehus “A Handbook of Energy Audits”, Ninth Edition, 2012.
4. Charles E Brown, “World Energy Resources”, Springer, 2012.

21EE036 PLC and SCADA 3 0 0 3

Course Objectives

- To understand the architecture of PLC
- To understand the PLC programming using ladder logic and instructions
- To develop a real time models using PLC for required applications.
- To understand the architecture and types of SCADA
- To interface the PLC with SCADA

Programme Outcomes (POs)

a. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
f. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Understand the network and communication devices for interfacing computer with PLC.
2. Analyse the different programming languages used in PLC.
3. Create and execute a ladder logic for the particular industrial application.
4. Understand the architecture of SCADA and its types.
5. Apply the Supervisory Control and Data Acquisition for the particular industrial application.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2			-							2	1
2	2	3	3			-							2	2
3	2	2	3			3							2	3
4	3	3	2			-							2	2
5	2	3	2			3							2	3

UNIT I **8 Hours**

ARCHITECTURE OF PLC

Components of PLC - sink and source I/O cards - Processor - Memory: Types of memory, Input and Output modules: Discrete, Analog -Scan time of PLC -Interfacing computer and PLC: RS232, RS485, Ethernet - Selection criteria for PLC

UNIT II **10 Hours**

PLC PROGRAMMING

Programming languages - Ladder logic components: User, bit, branch and internal relay instruction -Boolean logic - Latching –Timers and Counters.

Instructions in PLC: Program Control, Math, Data Manipulation – Sequencer, Shift register and Analog Instructions.

UNIT III **9 Hours**

APPLICATIONS OF PLC

Case Studies: Motor control- Bottle filling system - Pick and place robot - Car Parking - Traffic light control-Elevators - Pneumatic stamping system - alarm control system

UNIT IV **8 Hours**

INTRODUCTION SCADA

Supervisory Control and Data Acquisition-Architecture/block diagram, Benefits of SCADA Types of SCADA- SCADA System Hardware -Remote terminal unit-Master terminal unit-Data Storage- Application area of SCADA.

UNIT V **10 Hours**

SCADA INTERFACING AND APPLICATIONS

Connection Diagram - Object Linking and Embedding for Process controlarchitecture – Steps in creating SCADA- Steps for Linking SCADA Object with PLC using OPC- Concept of Tag, Applications of SCADA: On-off Control Lamp, Traffic Light Control– Elevator system – conveyor system

FOR FURTHER READING

Distributed control System

Total: 45 Hours

Reference(s)

1. F.D. Petruzella, “Programmable Logic Controllers”, Tata Mc-Graw Hill, Third edition, 2015
2. John W Webb and Ronald A Resis, “Programmable Logic Controller”, Prentice Hall of India Pvt. Ltd., New Delhi, 2013
3. Hackworth, John Hackworth, “Federic Programmable logic controllers”, Prentice Hall of India Pvt. Ltd., New Delhi, 2013
4. Katariya Sanjay B, **“**Industrial Automation Solutions for PLC, SCADA, Drive and Field Instruments”, Notion Press; 1st edition, 2020.
5. Bailey David, Wright Edwin, “Practical SCADA for Industry”, Elsevier Publication 2003.

21EE037 ARTIFICIAL INTELLIGENCE IN ELECTRICAL ENGINEERING **3 0 0 3**

Course Objectives

- To understand the models of artificial neural networks.
- To understand the deep learning methodologies
- To understand the concept of fuzzy logic principles.
- To understand the Genetic Algorithm and Particle Swarm Optimization.
- To apply the machine learning and deep learning techniques for practical applications

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Analyze the various artificial neural network algorithms.
2. Analyze the different methodologies used in deep learning
3. Apply the concept of fuzzy logic in Electrical systems.
4. Analyze the Genetic and Particle Swarm Optimization algorithms.
5. Apply the various artificial intelligence techniques in electrical systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	2									2	2
2	3	2	2	2									2	2
3	3	2	2	2									2	2
4	3	2	2	2									2	2
5	3	3	3	3									2	3

UNIT I **9 Hours**

ARTIFICIAL NEURAL NETWORK

Artificial neuron, activation function, supervised, unsupervised learning, Single layer perceptron – Limitation – Multi layer perceptron – Back Propagation Algorithm (BPA) – Recurrent Neural Network (RNN) – Adaptive Resonance Theory (ART) based network – Radial basis function network –Reinforcement learning.

UNIT II **9 Hours**

DEEP NEURAL NETWORKS

Convolutional Neural networks- LeNet- AlexNet – GoogLeNet – ResNet - Long Short-Term Memory- Gate Recurrent Unit- Deep Belief Network - Ensemble methods: Bagging, boosting, Evaluating and debugging learning algorithms

UNIT III **9 Hours**

FUZZY SET THEORY

Fuzzy Sets – Set-theoretic operations – Member Function Formulation and parameterization – Fuzzy Rules and Fuzzy Reasoning - Extension principle and Fuzzy Relations – Fuzzy If-Then Rules – Fuzzy Reasoning – Fuzzy Inference Systems – Mamdani Fuzzy Models-Sugeno Fuzzy Models – Tsukamoto Fuzzy Models – Input Space Partitioning and Fuzzy Modeling.

UNIT IV **9 Hours**

GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION

Genetic Algorithms-Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators – Particle Swarm Optimization- Topologies – Control parameters.

UNIT V **9 Hours**

AI APPLICATIONS

Load forecasting - Fault Identification in transmission lines - Energy management in Micro Grid - Duty ratio optimization in power converters.

Total: 45 Hours

Reference(s)

1. Ethem Alpaydin, Introduction to Machine Learning, Fourth Edition,MIT Press, 2020.
2. Andrew Glassner, Deep Learning: From Basics to Practice , First Edition, The Imaginary Institute, Seattle, 2018.
3. H J Zimmermann, Fuzzy set theory and its application, Second Edition, Allied Publishers, 2014.
4. Xin-She Yang , Nature – Inspired Optimization Algorithms, Second Edition , Elsevier , 2020.
5. Gheisarnejad, Meysam, Hamed Farsizadeh, and Mohammad Hassan Khooban. "A novel nonlinear deep reinforcement learning controller for DC–DC power buck converters." IEEE Transactions on Industrial Electronics 68.8 (2020): 6849-6858.
6. Asbery, Chris, and Yuan Liao. "Fault identification on electrical transmission lines using artificial neural networks." Electric Power Components and Systems 49.13-14 (2022): 1118-1129.
7. Aguila-Leon, Jesus, Vargas-Salgado, C., Chiñas-Palacios, C., & Díaz-Bello, D. "Energy management model for a standalone hybrid microgrid through a particle Swarm optimization and artificial neural networks approach." Energy Conversion and Management 267 (2022): 115920.

21EE038 BIG DATA ANALYTICS FOR SMART GRID 3 0 0 3

Course Objectives

- To understand the fundamental concepts of big data analytics.
- To understand the fundamentals of various big data analytics techniques
- To apply concept of cloud computing techniques for smart grid.
- To apply the big data analytics for smart grid data management.
- To analyse the smart metering data set in the power system.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
n. PSO2: Apply the core knowledge and technical skills to develop reliable and sustainable solutions to real world problems.

Course Outcomes (COs)

1. Apply the concepts of big data applications for smart grid.
2. Analyse the big data tools and its analysis techniques.
3. Analyse the benefits of cloud computing in smart grid technology.
4. Analyse the role of big data in smart grid data management system.
5. Design solutions for smart grid system using big data analytics.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	2										2
2	3	2	2	2										2
3	3	2	2	2										2
4	3	2	2	2										2
5	3	2	2	2										2

UNIT I **9 Hours**

INTRODUCTION

Introduction to Big Data Analytics - Fundamental Mathematical Prerequisites, Big Data Era, General Security Challenges - Challenges of conventional systems - Modern data analytic tools. History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System.

UNIT II **9 Hours**

DATA ANALYSIS

Regression modeling, Multivariate analysis, Bayesian modeling, inference and Bayesian networks, Support vector and kernel methods, Analysis of time series: linear systems analysis, nonlinear dynamics - Rule induction. Sampling and large sample tests, chi- square test, theory of estimation, linear and polynomial fitting by the methods, correlation of bivariate frequency distribution.

UNIT III **9 Hours**

CLOUD COMPUTING APPLICATIONS FOR SMART GRID

Cloud computing in smart grid, Cloud computing architecture, Demand Response - Geographical Load- Balancing - Dynamic Pricing - Virtual Power Plant - Advanced Metering Infrastructure - Cloud-Based Security and Privacy.

UNIT IV **9 Hours**

SMART GRID DATA MANAGEMENT AND APPLICATIONS

Pricing and energy forecasting in Demand Response, case study on Energy Forecast, Smart Meter Data Management -PHEVs: Internet of Vehicles - Smart Buildings.

UNIT V **9 Hours**

SMART GRID DESIGN AND DEPLOYMENT

Attack detection, current problem and techniques, Secure Data Learning Scheme, Logical Security Architecture, Smart Metering Data Set Analysis—A Case Study, Security Schemes for AMI Private Networks, Simulation Tools- Worldwide Initiatives - Use of data analytics for renewable energy integration and grid resilience

FOR FURTHER READING

Legal Protection of Personal Data in Smart Grid and Smart Metering Systems, Phases of smart grid system development cycle, Smart Grid Security and Privacy of Customer-Side Networks

Total: 45 Hours

Reference(s)

1. Smart Grid Technology: A Cloud Computing and Data Management Approach, S. Misra and S. Bera, Cambridge University Press, 2018, 1st Edition.
2. Smart Grid Communication Infrastructure: Big Data, Cloud Computing and Security, F. Ye, Y. Qian and R.Q. Hu, Wiley IEEE Press, 2018, 1st Edition.
3. Smart Grid: Fundamentals of Design and Analysis, James A. Momoh, Wiley India, 2015, 1st Edition.
4. Big Data and Analytics, Seema Acharya, Subhashini Chellapan,, Wiley, 2015.
5. Big data analytics in future power systems, Ahmed F. Zobaa, Trevor J. Bihl, 1st Edition, CRC press 2018.

21EE039 INDUSTRY 4.0 **3 0 0 3**

Course Objectives

- To expose the various stages of industrial revolutions.
- To introduce and familiarize the industry 4.0 and its physical structure and interconnectivity.
- To understand the different Automation Systems concepts for various sectors from the Industry 4.0 perspective.
- To outline the cloud computing and cyber security in the robotics industry.
- To understand the concepts VR systems, work and list the applications of VR.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
m.PSO1: Design, analyze, and evaluate the performance of Electrical & Electronics systems using contemporary tools

to provide effective solutions for real-world problems.
n.PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply the concept of Industry 4.0 transformation in industries.
2. Analyse the various systems used in a manufacturing plant and their role in an Industry 4.0 world.
3. Apply the concept Understand the smartness in Smart Factories, Smart cities, smart products and smart Services.
4. Analyze the types of Cloud computing and cyber security in a networked industrial System.
5. Analyze the Virtual reality requirements in the industries .

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2	3									3	3
2	2	2	2	3									3	3
3	2	2	2	3	2								2	2
4	2	2	2	3	3				2				2	2
5	2	2	2	3	3				2				2	2

UNIT I **9 Hours**

INTRODUCTION

Introduction, core idea of Industry 4.0, origin concept of industry 4.0, Industry 4.0 production system, current state of industry 4.0, Technologies, how is India preparing for Industry 4.0.

UNIT II **9 Hours**

CONCEPTUAL FRAMEWORK

Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0, Obstacles and Framework Conditions for Industry 4.0.

UNIT III **9 Hours**

TECHNOLOGY ROADMAP

Proposed Framework for Technology Roadmap, Strategy Phase, New Product and Process Development Phase ,Case Study: Smart Manufacturing, Smart Devices and Products.

UNIT IV **9 Hours**

ADVANCES IN ROBOTICS

Recent Technological Components of Robots- Advanced Sensor Technologies, Internet of Robotic Things, Cloud Robotics, and Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic Applications- Manufacturing, Maintenance and Assembly.

UNIT V **9 Hours**

VIRTUAL REALITY

Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output-Visual, Aural & Haptic Displays, VR Hardware and Software Technology, Industrial Applications of VR.

Total: 45 Hours

Reference(s)

1. Alp Ustundag, Emre Cevikcan, “Industry 4.0: Managing the Digital Transformation”, springer, 2017.
2. Lane Thames, Dirk Schaefe, “Cybersecurity for Industry 4.0: Analysis for Design and Manufacturing”, springer, 2017.
3. Diego Galar Pascual, Pasquale Daponte, Uday Kumar, “Handbook of Industry 4.0 and SMART Systems”, Taylor and Francis,2020.
4. Steven M. LaValle, “Virtual Reality”, Cambridge University Press, 2016.
5. William R Sherman and Jeffrey D Will, Morgan Kaufmann, Alan B Craig, “Developing Virtual Reality Applications: Foundations of Effective Design”, 2009.
   2011.