GOVERNMENT COLLEGE OF ENGINEERING

SALEM - 636 011

(An Autonomous Institution Affiliated to

Anna University, Chennai)

REGULATIONS 2023

CURRICULAM AND SYLLABUS

(For Candidates admitted from 2023 - 2024 onwards)

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

(PART TIME PROGRAMME)

VISION OF THE DEPARTMENT

- To make ethically and emotionally strong Electrical Engineers of high caliber capable of meeting the national and global technological challenges for the well-being of the Society.

MISSION OF THE DEPARTMENT

- To Impart state of the art Knowledge in Electrical Science and Technology through under-graduate and graduate programmes.
- To develop the Electrical Engineering Department as a Centre of Excellence in Power Electronics and Industrial Drives.
- To provide Knowledge base and Consultancy services to the society at large and in particular for the upliftment and well-being of the rural and tribal communities.

VISION AND MISSION OF THE INSTITUTION

Vision

- We envision our students as excellent Engineers not only in the field of Science and Technology, but also in good citizenship and discipline.
- Our commitment lies in producing comprehensive knowledge seekers and humane individuals, capable of building a strong and developed nation.

Mission

- To impart update technical education and knowledge.
- To groom our young students to become professionally and morally sound engineers.
- To teach global standards in production and value-based living through honest and scientific approach.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Graduates will be employed electrical engineering profession as experts in solving electrical engineering problems by their depth of understanding in core electrical knowledge and/or completed/pursuing post graduate study or research.

PEO 2: Graduates will have awareness for lifelong learning and continued professional development

PEO 3: Graduates will demonstrate creativity in their engineering practices including entrepreneurial and collaborative ventures with strategic thinking, planning and execution.

PEO 4: Graduates will communicate effectively, recognize and incorporate societal needs and constraints in their professional endeavors and practice their profession with high regard to legal and ethical responsibilities.

PEO 5: Graduates will have necessary foundation on computational platforms and software applications related to the field of electrical and electronics engineering.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to

PO 1: **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: **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.

PO 3: **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.

PO 4: **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.

PO 5: **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.

PO 6: **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

PO 7: **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

PO 8: **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

PO 9: **Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: **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.

PO 11: **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 environment

PO 12: **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.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Electrical and Electronics Engineering Graduates will be able to

PSO 1: Apply knowledge of mathematics, engineering sciences and multidisciplinary knowledge to the solution of electrical and electronics engineering problems.

PSO 2: Apply research-based knowledge, appropriate techniques, IT tools to complex Electrical and Electronics Engineering problems including design, analysis, interpretation of data, and synthesis of the information to provide valid conclusions.

PSO 3: Apply ethical principles, management skills and lifelong learning for professional development and personnel growth.

B.E. (ELECTRICAL AND ELECTRONICS ENGINEERING) [PART TIME]
CURRICULUM AND SYLLABUS REGULATIONS – 2023

SEMESTER - I										
Sl No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	23PTMA101	Mathematics-I	BS	3	0	0	3	40	60	100
2.	23PTEE101	Electric Circuit Analysis	PC	2	1	0	3	40	60	100
3.	23PTEE102	DC Machines and Transformers	PC	2	1	0	3	40	60	100
4.	23PTEE103	Electron Devices and Circuits	PC	3	0	0	3	40	60	100
5.	23PTCS101	Fundamental of Problem Solving and C Programming	ES	3	0	0	3	40	60	100
		TOTAL					**15**			**500**

SEMESTER – II										
Sl No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	23PTMA201	Mathematics-II	BS	3	0	0	3	40	60	100
2.	23PTEE201	Electromagnetic Theory	PC	2	1	0	3	40	60	100
3.	23PTEE202	Synchronous and Induction Machines	PC	2	1	0	3	40	60	100
4.	23PTEE203	Analog and Digital Integrated Circuits	PC	3	0	0	3	40	60	100
PRACTICAL										
5.	23PTEE204	Electrical Machines Laboratory	PC	0	0	3	1.5	60	40	100
		TOTAL					**13.5**			**500**

SEMESTER – III										
Sl No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	23PTEE301	Control Systems	PC	2	1	0	3	40	60	100
2.	23PTEE302	Power Electronics	PC	3	0	0	3	40	60	100
3.	23PTEE303	Electrical Machine Design	PC	2	1	0	3	40	60	100
4.	23PTEE304	Measurements and Instrumentation	PC	3	0	0	3	40	60	100
5.	23PTCY301	Environmental Science and Engineering	ES	3	0	0	3	40	60	100
		TOTAL					**15**			**500**

SEMESTER – IV										
Sl No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	23PTEE401	Power Generation, Transmission, and Distribution System	PC	2	1	0	3	40	60	100
2.	23PTEE402	Microprocessor and Microcontroller	PC	3	0	0	3	40	60	100
3.	23PTEE403	Biomedical Instrumentation	PC	3	0	0	3	40	60	100
4.	23PTHS401	Universal Human Values	HS	2	1	0	3	40	60	100
PRACTICAL										
5.	23PTEE404	Microprocessor and Microcontroller Laboratory	PC	0	0	2	1	60	40	100
		TOTAL					**13**			**500**
SEMESTER – V										
Sl No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	23PTEE501	Power System Analysis and Stability	PC	2	1	0	3	40	60	100
2.	23PTEE502	Protection and Switchgear	PC	3	0	0	3	40	60	100
3.	23PTEE503	Electrical Drives and Control	PC	3	0	0	3	40	60	100
4.	23PTEE504	Special Electrical Machines	PC	3	0	0	3	40	60	100
PRACTICAL										
5.	23PTEE505	Power Electronics and Drives Laboratory	PC	0	0	3	1.5	60	40	100
		TOTAL					**13.5**			**500**
SEMESTER – VI										
Sl No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	23PTEE601	Power System Operation and Control	PC	3	0	0	3	40	60	100
2.	23PTEE602	Utilization of Electrical Energy	PC	3	0	0	3	40	60	100
3.	23PTEE603	Solar and Wind Energy Conversion Systems	PC	3	0	0	3	40	60	100
4.	23PTEEE1X	Professional Elective-I	PE	3	0	0	3	40	60	100
5.	23PTEEE2X	Professional Elective-II	PE	3	0	0	3	50	60	100
		TOTAL					**15**			**500**

SEMESTER – VII										
Sl No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	23PTEE701	High Voltage Engineering	PC	3	0	0	3	40	60	100
2.	23PTEE702	Smart Grid Technologies	PC	3	0	0	3	40	60	100
3.	23PTHS701	Industrial Management and Economics	PC	3	0	0	3	40	60	100
4.	23PTEEE3X	Professional Elective-III	PE	3	0	0	3	40	60	100
5.	23PTEEE4X	Professional Elective-IV	PE	3	0	0	3	40	60	100
TOTAL							**15**			**500**
SEMESTER – VIII										
Sl No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	23PTEEE5X	Professional Elective-V	PE	3	0	0	3	40	60	100
2.	23PTEEE6X	Professional Elective-VI	PE	3	0	0	3	40	60	100
3.	23PTEEE7X	Professional Elective-VII	PE	3	0	0	3	40	60	100
PRACTICAL										
4.	23PTEE801	Project Work	EEC	0	0	6	3	120	80	200
TOTAL							**12**			**600**
GRAND TOTAL							**112**			

B.E. (Electrical and Electronics Engineering) [Part Time]
PROFESSIONAL ELECTIVES COURSES

Sl. No.	Course Code	Course Title	Category	Hours per Week			Credit	Maximum Marks		
				L	T	P	C	CA	FE	Total
ELECTIVE – I (VI SEMESTER)										
1.	23PTEEE11	Advanced Control Systems	PE	3	0	0	3	40	60	100
2.	23PTEEE12	Discrete Control Systems	PE	3	0	0	3	40	60	100
3.	23PTEEE13	Digital Controller in Power Electronics Applications	PE	3	0	0	3	40	60	100
4.	23PTEEE14	Robotics and Automation	PE	3	0	0	3	40	60	100
5.	23PTEEE15	Industrial Automation and Control	PE	3	0	0	3	40	60	100
ELECTIVE – II (VI SEMESTER)										
1.	23PTEEE21	HVDC Transmission Systems	PE	3	0	0	3	40	60	100
2.	23PTEEE22	EHVAC Transmission Systems	PE	3	0	0	3	40	60	100
3.	23PTEEE23	Flexible AC Transmission System	PE	3	0	0	3	40	60	100
4.	23PTEEE24	Substation Engineering and Automation	PE	3	0	0	3	40	60	100
5.	23PTEEE25	Power System Automation	PE	3	0	0	3	40	60	100
ELECTIVE – III (VII SEMESTER)										
1.	23PTEEE31	Power System Transients	PE	3	0	0	3	40	60	100
2.	23PTEEE32	Distributed Generation and Microgrid	PE	3	0	0	3	40	60	100
3.	23PTEEE33	Restructured Power System	PE	3	0	0	3	40	60	100
4.	23PTEEE34	Power Quality	PE	3	0	0	3	40	60	100
5.	23PTEEE35	Power Plant Engineering	PE	3	0	0	3	40	60	100
ELECTIVE – IV (VII SEMESTER)										
1.	23PTEEE41	Industrial Electrical System	PE	3	0	0	3	40	60	100
2.	23PTEEE42	Modern Electrical Drives	PE	3	0	0	3	40	60	100
3.	23PTEEE43	Multilevel Power Converters	PE	3	0	0	3	40	60	100
4.	23PTEEE44	Modelling and Control of Power Converters	PE	3	0	0	3	40	60	100
5.	23PTEEE45	Control and Integration of Renewable Energy Sources	PE	3	0	0	3	40	60	100

ELECTIVE – V (VIII SEMESTER)										
1.	23PTEEE51	Digital Signal Processing	PE	3	0	0	3	40	60	100
2.	23PTEEE52	Embedded System Design	PE	3	0	0	3	40	60	100
3.	23PTEEE53	Artificial Intelligence and Computer Vision	PE	3	0	0	3	40	60	100
4.	23PTEEE54	Soft Computing	PE	3	0	0	3	40	60	100
5.	23PTEEE55	Internet of Things for Electrical System	PE	3	0	0	3	40	60	100
ELECTIVE – VI (VIII SEMESTER)										
1.	23PTEEE61	Electrical Energy Conservation and Auditing	PE	3	0	0	3	40	60	100
2.	23PTEEE62	Electrical Wiring, Estimation and Costing	PE	3	0	0	3	40	60	100
3.	23PTEEE63	Energy Management System and SCADA	PE	3	0	0	3	40	60	100
4.	23PTEEE64	Digital Protection of Electrical System	PE	3	0	0	3	40	60	100
5.	23PTEEE65	Traction Engineering	PE	3	0	0	3	40	60	100
ELECTIVE – VII (VIII SEMESTER)										
1.	23PTEEE71	Electric Vehicles and Control	PE	3	0	0	3	40	60	100
2.	23PTEEE72	Testing of Electric Vehicles	PE	3	0	0	3	40	60	100
3.	23PTEEE73	Hybrid Electric Vehicles	PE	3	0	0	3	40	60	100
4.	23PTEEE74	Battery Management Systems	PE	3	0	0	3	40	60	100
5.	23PTEEE75	Energy Storage Systems and Applications	PE	3	0	0	3	40	60	100

SUMMARY OF CREDITS FOR PART-TIME STREAM

Sl. No	Course Components	Credits per Semester								Total Credits
		I	II	III	IV	V	VI	VII	VIII	
1.	Humanities and Social Science (HS)				3			3		**6**
2.	Basic Sciences (BS)	3	3							**6**
3.	Engineering Sciences (ES)	3		3						**6**
4.	Professional Core (PC)	9	10.5	12	10	13.5	9	6		**70**
5.	Professional Electives (PE)						6	6	9	**21**
6.	Open Electives (OE)									
7.	Employment Enhancement Course (EEC)								3	**3**
8.	Mandatory / Management / Non-Credit Course (MC/HSMC)									
Total Credits		**15**	**13.5**	**15**	**13**	**13.5**	**15**	**15**	**12**	**112**

23PTMA101	MATHEMATICS – I (Common to Part Time B.E. - CIVIL, ECE, EEE & MECH Branches)		SEMESTER			I
PREREQUISITES		**CATEGORY**	**BS**	**Credit**		**3**
Basic 12th level knowledge of ODE, PDE, Vector algebra and Complex Analysis.		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To make the student acquire sound knowledge of techniques in solving ordinary differential equations that model engineering problems.
2.	To make the student to understand the techniques in solving partial differential equations that model engineering problems.
3.	To acquaint the student with the concepts of vector calculus needed for solving engineering problems.
4.	To understand the concept of analytic functions.
5.	To obtain the knowledge of complex integration

UNIT I	**ORDINARY DIFFERENTIAL EQUATIONS**	**9**	**0**	**0**	**9**

Higher order linear differential equations with constant coefficients – Method of variation of parameters – Cauchy's and Legendre's linear equations.

UNIT II	**PARTIAL DIFFERENTIAL EQUATIONS**	**9**	**0**	**0**	**9**

Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions – Lagrange's linear equation – Homogeneous Linear partial differential equations of second order with constant coefficients.

UNIT III	**VECTOR CALCULUS**	**9**	**0**	**0**	**9**

Gradient, divergence and curl – Directional derivative – Irrotational and solenoidal vector fields – Vector integration – Statement of Gauss divergence theorem and Stokes theorem – Simple applications involving cubes and rectangular parallelopipeds.

UNIT IV	**ANALYTIC FUNCTIONS**	**9**	**0**	**0**	**9**

Functions of a complex variable – Analytic functions – Necessary conditions, Cauchy – Riemann equation and sufficient conditions (excluding proofs) – Properties of analytic function – Harmonic conjugate – construction of analytic functions – Conformal mapping: $w = z + c,\ cz,\ \frac{1}{z}$ and bilinear transformation.

UNIT V	**COMPLEX INTEGRATION**	**9**	**0**	**0**	**9**

Complex integration – Statement and applications of Cauchy's integral theorem and Cauchy's integral formula – Taylor's and Laurent's expansions – Singular points – residues – Residue theorem – Application of residue theorem to evaluate real integrals over semi-circular contours (excluding poles on boundaries).

Total (45L + 0T) = 45 Periods

Text Books:

1.	B.S. Grewal, "Higher Engineering Mathematics", 43rd Edition, Khanna Publications, Delhi, 2015.
2.	P. Kandasamy, K. Thilagavathy and K. Gunavathy, "Engineering Mathematics (For I year B. E, B. Tech)", Ninth Edition, S. Chand & Co. Ltd., New Delhi, 2010.

Reference Books:

1.	James Stewart, "Calculus with Early Transcendental Functions", Cengage Learning, New Delhi, 2008.
2.	T.Veerarajan, "Engineering Mathematics (For semester I and II)", 5th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
3.	Erwin Kreyszig, "Advanced Engineering Mathematics", 7th Edition, Wiley India, 2007.

4.	R.K. Jain and S.R.K. Iyengar, “Advanced Engineering Mathematics”, 3rd Edition, Narosa Publishing House Pvt. Ltd., 2007.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Find the techniques of solving ordinary differential equations that arise in engineering problems.	L3: Applying
CO2	:	Find the techniques of solving partial differential equations that arise in engineering problems.	L3: Applying
CO3	:	Apply the concept of vector calculus and vector integration.	L3: Applying
CO4	:	Understand analytic function and its properties.	L2: Understanding
CO5	:	Evaluate various integrals by using Cauchy’s residue theorem.	L5: Evaluating

23PTEE101	**ELECTRIC CIRCUIT ANALYSIS**		**SEMESTER**			**I**
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Mathematics		**Hours / Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

1.	To introduce electric circuits and its analysis.
2.	To impart knowledge on solving circuits using network theorems.
3.	To introduce the phenomenon of resonance in coupled circuits.
4.	To educate on obtaining the transient response of circuits.
5.	To learn phasor diagrams and analysis of three phase circuits.

UNIT I	**BASIC CIRCUITS ANALYSIS**	**6**	**3**	**0**	**9**

Ohm's Law – Kirchhoff's laws – DC and AC Circuits – Resistors in series and parallel circuits –Mesh current and node voltage method of analysis for DC and AC Circuits – Phasor diagram - power, power factor and energy.

UNIT II	**NETWORK REDUCTION AND NETWORK THEOREMS FOR DC AND AC CIRCUITS**	**6**	**3**	**0**	**9**

Network reduction: voltage and current division, source transformation- star and delta transformation, superposition Theorem - Thevenin's and Norton's Theorem — Maximum power transfer theorem – Reciprocity Theorem - substitution theorem.

UNIT III	**RESONANCE AND COUPLED CIRCUITS**	**6**	**3**	**0**	**9**

Series and parallel resonance –frequency response – Quality factor and Bandwidth - Self and mutual inductance – Coefficient of coupling- dot rule – analysis of coupled circuits –coupled circuits in series and parallel – Tuned circuits – analysis of Single and double tuned circuits.

UNIT IV	**TRANSIENT ANALYSIS**	**6**	**3**	**0**	**9**

Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and AC sinusoidal input.

UNIT V	**THREE PHASE CIRCUITS**	**6**	**3**	**0**	**9**

Three phase balanced/ unbalanced voltage sources – analysis of three phase three wire and four wire circuits with star and delta connected with balanced and unbalanced loads – phasor diagrams of voltages and currents –power and power factor measurements in three phase circuits

Total (30L + 15T) = 45 Periods

Text Books:

1.	William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits Analysis", TMH publishers, 6th edition, New Delhi, 2002.
2.	Joseph A. Edminister, and Mahmood Nahri, "Electric circuits", Schaum‟s series, Tata McGraw-Hill, New Delhi, 2001.

Course Outcomes:

Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basic concept of circuit elements, circuit laws and network reduction technique	L2: Understanding
CO2	:	Solve the electrical network using mesh and nodal analysis by applying network theorems.	L3: Applying
CO3	:	Analysis of AC and Dc circuits using various network theorems.	L4: Analyzing
CO4	:	Understand the resonance in series and parallel circuits and basic concepts of coupled circuits.	L4: Understanding
CO5	:	Analyse the transient response of series and parallel A.C. circuits and to solve problems in time domain using Laplace Transform.	L4: Analyzing

23PTEE102	**DC MACHINES AND TRANSFORMERS**			**SEMESTER**			**I**
PREREQUISITES			**CATEGORY**	**PC**	**Credit**		**3**
Nil			**Hours / Week**	**L**	**T**	**P**	**TH**
				2	**1**	**0**	**3**

Course Objectives:

1. To understand the concepts of electromechanical energy conversion and to gain the knowledge on single and multiply excited magnetic systems.
2. To gain the knowledge on construction and principles of operation of DC machines and transformers.
3. To analyse the performance characteristics of different types of DC machines and transformers.
4. To appreciate the applications of DC machines and transformers.
5. To analyse the performance of DC machines and transformers by conducting various tests.

UNIT I	**ELECTROMECHANICAL ENERGY CONVERSION**	**6**	**3**	**0**	**9**

Magnetic circuits – Magnetically induced EMF and force – AC operation of magnetic circuits – Energy in magnetic systems – Field energy & mechanical force – Single and Multiply-excited magnetic field systems.

UNIT II	**DC GENERATORS**	**6**	**3**	**0**	**9**

Constructional features of DC machine – Principle of operation of DC generator – EMF equation – Types of excitation – No load and load characteristics of DC generators – Commutation - Armature reaction – Parallel operation of DC generators - Applications.

UNIT III	**DC MOTORS**	**6**	**3**	**0**	**9**

Principle of operation of DC motors – Back EMF – Torque equation – Types of DC motors - Speed – Torque characteristics of DC motors – Starting of DC motors: 3- point starter, 4- point starter – Speed control of shunt and series motor: Field current control and Armature voltage control – Applications.

UNIT IV	**TRANSFORMERS**	**6**	**3**	**0**	**9**

Constructional features of single-phase transformers–Principle of operation - EMF equation –ideal transformer characteristics - Practical Transformer working on No- load and Load with phasor diagram – Equivalent circuit – Regulation – Parallel operation - Autotransformers - Three phase transformer connections.

UNIT V	**TESTING OF DC MACHINES AND TRANSFORMERS**	**6**	**3**	**0**	**9**

Losses and efficiency – Condition for maximum efficiency – Testing of DC machines: Swinburne's test and Hopkinson's test - Testing of transformers: open circuit and short circuit tests, Sumpner's test – All day efficiency.

Total (30L + 15T) = 45 Periods

Text Books:

1. D.P. Kothari, and I.J. Nagrath, "Electric Machines", Third Edition, Tata McGraw-Hill Company Ltd., New Delhi, 2010.
2. Dr. P.S. Bimbhra, "Electrical Machinery", Khanna Publishers, New Delhi, 2006.

Reference Books:

1. B.L. Theraja, and A.K. Theraja, "Electrical Technology", Vol.II, S.Chand & Company Ltd., New Delhi, 2006.
2. A.E. Fitzgerald, Charles Kingsley, and Stephen. D.Umans, "Electric Machinery", Tata McGraw Hill Publishing Company Ltd, 2003.
3. Dr. K. Murugesh Kumar, "DC Machines & Transformers", Vikas Publishing House Pvt. Ltd., Second Edition, 2003.

E-References:

1. www.onlinecourses.nptel.ac.in
2. www.class-central.com
3. www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recite the concepts of electromechanical energy conversion principles.	L1: Remembering
CO2	:	Understand the basic concepts of DC machines and transformers.	L2: Understanding
CO3	:	Evaluate the performance characteristics of DC machines and transformers.	L5: Evaluating
CO4	:	Conduct various tests on DC machines.	L3: Applying
CO5	:	Conduct various test on Transformers	L3: Applying

23PTEE103	ELECTRON DEVICES AND CIRCUITS		SEMESTER			I
PREREQUISITES		CATEGORY	PC	Credit		3
		Hours / Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To understand the characteristics of diodes.
2.	To understand the characteristics of transistors.
3.	To design amplifier circuits
4.	To design the oscillator circuits.

UNIT I	DIODES	9	0	0	9

Structure – Equilibrium conditions – Energy Band Concepts – Zero bias – Forward Bias – Reverse bias – Junction capacitances – one sided and non-uniformly doped junctions – Ideal PN junction current, P-N junction diode, V-I characteristics of a diode, review of half-wave and full-wave rectifiers, Zener diodes, voltage regulator using Zener diode, clamping and clipping circuits.

UNIT II	TRANSISTORS	9	0	0	9

Physical behaviour of a BJT – Ebers - Moll model, large signal current gains. Modes of transistor operation - Common base, common emitter and common collector configurations, Input and output characteristics, Early effect, regions of operation. AC and DC load lines - Need for stability of Q-Point. Bias stability – fixed bias, collector to base bias, self bias. Transistor switching times-Transistor as a switch and an amplifier, small signal ac model, high frequency effects, hybrid –π model-BJT ratings, Junction field effect transistor – structure, JFET structure and characteristics -UJT- structure and characteristics.

UNIT III	SMALL SIGNAL AMPLIFIER CIRCUITS	9	0	0	9

Single stage BJT and FET amplifiers, Analysis at low, medium and high frequencies – BJT and FET Differential amplifier, Differential and Common mode gain with resistive load and active load, CMRR - Cascade and Darlington Amplifiers.

UNIT IV	LARGE SIGNAL AMPLIFIER CIRCUITS	9	0	0	9

Power amplifiers– Classification, Single ended and Push-pull Configuration, Power dissipation, Output power and Conversion efficiency, Complementary symmetry power amplifiers, Class AB operation, Class C and Class D amplifiers, thermal considerations.

UNIT V	FEEDBACK AMPLIFIERS AND OSCILLATORS	9	0	0	9

Advantages of negative feedback – voltage / current, series, Shunt feedback –positive feedback – Condition for oscillations, phase shift – Wien bridge, Hartley, Colpitts and Crystal oscillators.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Millman J, Halkias C, and Satya Brata JIT, "Electronic Devices & Circuits", Tata McGraw-Hill, New Delhi, 2010.
2.	David A. Bell, "Electronic Devices and Circuits", New Delhi: Oxford University Press, 5th Edition, 2008.
3.	Boylestead L R, and Nashelsky L, "Electronic Devices and Circuit Theory", Pearson Education, New Delhi, 2009.

Reference Books:

1.	Rashid, "Micro Electronic Circuits", Thomson publications, 1999.
2.	Donald L. Schilling, and Charles Belove, "Electronic Circuits", 3 Edition, Tata McGraw Hill, 2010.
3.	Adel Sedra, and Kenneth. C Smith, "Microelectronics Circuits", Oxford University Press, New Delhi, 2010.

E-References:

1.	https://electronicsforu.com/resources/electronic-devices-and-circuit-theory
2.	https://nptel.ac.in/courses/117103063/

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO1	:	Understand overview of semiconductor devices.	L2: Understanding
CO2	:	Recognize the fundamentals and characteristics of BJT	L1: Remembering
CO3	:	Analyze the fundamentals and characteristics of FET and UJT	L2: Understanding
CO4	:	Design and analyze the amplifiers	L4: Analysing
CO5	:	Design and analyze the differential amplifiers	L4: Analysing

23PTCS101	FUNDAMENTAL OF PROBLEM SOLVING AND C PROGRAMMING			SEMESTER			I
PREREQUISITES			**CATEGORY**	**ES**	**Credit**		**3**
NIL			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**
Course Objectives:							
1.	To introduce the problem-solving methodologies.						
2.	To learn the basic concepts of developing an algorithm and pseudo code.						
3.	To understand the concepts of C Programming.						
UNIT I	**INTRODUCTION**			**9**	**0**	**0**	**9**
Characteristics of Computers – Evolution of Computers – Computer Generations – Classification of Computers – Basic Computer organization –Number System – Binary – Decimal – Conversion – Problems.							
UNIT II	**PROBLEM SOLVING**			**9**	**0**	**0**	**9**
Problem formulation, Problem Solving methods, Need for logical analysis and thinking – Algorithm – Pseudo code – Flow Chart. C Character set, Identifies and Keywords, Data Types, Declarations, Expressions, Statements and Symbolic constants.							
UNIT III	**C PROGRAMMING BASICS**			**9**	**0**	**0**	**9**
Operators – Arithmetic Operators – Unary operators – Relational and Logical Operators – Assignment operators – Conditional operators. Managing Input and Output operations, pre-processor directives and storage classes.							
UNIT IV	**CONTROL STATEMENTS, ARRAYS AND STRINGS**			**9**	**0**	**0**	**9**
Conditional statements-branching and looping statements. Arrays – Initialization – Declaration – one dimensional and two-dimensional arrays. Strings - String operations – String handling functions.							
UNIT V	**FUNCTIONS, POINTERS STRUCTURES AND UNIONS**			**9**	**0**	**0**	**9**
Function – Library functions and user-defined functions – Function prototypes and function definitions – Call by value – Call by reference – Recursion – Pointers definition - Structure definition and Examples – Union.							
							Total (45L + 0T) = 45 Periods
Text Books:							
1.	R. Anita Goel and Ajay Mittal, "Computer Fundamentals and Programming in C", Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia, 2011.						
2.	E Balagurusamy, "Programming in ANSI C", fourth Edition, Tata McGraw-Hill, 2008.						
Reference Books:							
1.	Byron S Gottfried, "Programming with C", Schaum"s Outlines, Second Edition, Tata McGraw-Hill, 1996.						
E-Reference:							
1.	https://nptel.ac.in/courses/106106210						

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To Understand the basic terminology used in computer programming.	L2: Understanding
CO2	:	To write, compile and debug programs in C language.	L1: Applying
CO3	:	To Use different data types in a computer program	L1: Remembering
CO4	:	To Understand, analyze and implement software development tools like algorithm, pseudocodes and programming structure	L2: Understanding
CO5	:	To write programs related to simple/ moderate mathematical and logical problems in "C".	L1: Applying

23PTMA201	MATHEMATICS – II (Common to Part-Time B.E - CIVIL, ECE, EEE & MECH branches)		SEMESTER			II
PREREQUISITES		**CATEGORY**	**BS**	**Credit**		**3**
Basic 12^{th} level knowledge of Differential Calculus, Integral Calculus and ODE.		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the concept of Fourier series.
2.	To understand the application of Fourier analysis in solving boundary value problems.
3.	To obtain the knowledge of solving second order ODE using Laplace transform techniques and inverse Laplace transform using convolution theorem.
4.	To familiarize with Fourier, transform of a function and its sine and cosine transforms.
5.	To gain the skills to form difference equations and find its solution by using Z-transform method.

UNIT I	**FOURIER SERIES**	**9**	**0**	**0**	**9**

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Parseval's Identity.

UNIT II	**BOUNDARY VALUE PROBLEMS**	**9**	**0**	**0**	**9**

Classification of second order quasi linear partial differential equations – Solutions of one-dimensional wave equation – One dimensional heat equation – Steady state solution of two-dimensional heat equation for infinite plates (Insulated edges excluded) – Fourier series solutions in Cartesian coordinates.

UNIT III	**LAPLACE TRANSFORM**	**9**	**0**	**0**	**9**

Laplace Transform- Conditions for existence – Transform of elementary functions – Basic Properties – Transform of derivatives and integrals – Initial and Final value theorems- Transform of periodic Functions – Inverse Laplace Transform- statement and application of convolution theorem.

UNIT IV	**FOURIER TRANSFORM**	**9**	**0**	**0**	**9**

Statement of Fourier integral theorem – Fourier transforms pair – Sine and Cosine transforms Properties – Transforms of simple functions – Parseval's Identity.

UNIT V	**Z -TRANSFORM AND DIFFERENCE EQUATIONS**	**9**	**0**	**0**	**9**

Z-transform of simple functions and properties – Inverse Z – transform –initial and final value theorems- Convolution theorem - Solution of difference equations using Z – transform technique.

Total (45L + 0T) = 45 Periods

Text Books:

1.	T. Veerarajan, "Engineering Mathematics (For Semester III)", 3^{rd} Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
2.	P. Kandasamy, K. Thilagavathy and K. Gunavathy, "Engineering Mathematics, Volume III", S. Chand & Company Ltd., New Delhi, 1996.

Reference Books:

1.	B.S. Grewal, "Higher Engineering Mathematics", 43^{rd} Edition, Khanna Publishers, Delhi, 2014.
2.	Wylie C. Ray and C.Barrett Louis, "Advanced Engineering Mathematics", Sixth Edition, McGraw-Hill, Inc., New York, 1995.
3.	L.A. Andrews and B.K Shivamoggi, "Integral Transforms for Engineers and Applied Mathematicians", MacMillan, New York, 1988.
4.	S. Narayanan, T.K. Manicavachagom Pillai, and G. Ramaniah, "Advanced Mathematics for Engineering Students", Volumes II and III, S. Viswanathan (Printers and Publishers) Pvt. Ltd. Chennai, 2002.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Acquire the knowledge about Fourier series.	L2: Understanding
CO2	:	Appreciate the physical significance of Fourier series techniques in solving one- and two-dimensional heat flow problems and one-dimensional wave equations.	L3: Applying
CO3	:	Apply the knowledge of Laplace transforms method to solve second order differential equations.	L3: Applying
CO4	:	Apply the knowledge of Fourier transform in engineering problems.	L3: Applying
CO5	:	Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems.	L3: Applying

<table>
<tr><td>23PTEE201</td><td colspan="2">ELECTROMAGNETIC THEORY</td><td colspan="3">SEMESTER</td><td>II</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Basic Electrical and Electronics Engineering</td><td rowspan="2">Hours / Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>2</td><td>1</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td colspan="7">To impart knowledge on the basic concepts of vectors, coordinate systems, static and dynamic electric and magnetic fields and apply Maxwell’s equations for various engineering applications involving electromagnetic waves.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT I</td><td colspan="2">ELECTROSTATICS – I</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Vector fields: Components of a vector and Classification of vector fields - Coordinate Systems and transformation – Gradient, Divergence, Curl – theorems and applications - Coulomb’s Law – Electric field intensity – Field due to discrete and continuous charges – Gauss’s law and applications.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT II</td><td colspan="2">ELECTROSTATICS – II</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Electric flux density – Electric potential – Electric dipole – Electric field in free space, conductors, dielectrics, - Dielectric polarization- Dielectric strength- Electric field in multiple dielectrics-– Boundary conditions, Poisson’s and Laplace’s equations, Capacitance, Energy density, Applications.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT III</td><td colspan="2">MAGNETOSTATICS</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Lorentz force, magnetic field intensity (H) – Biot–Savart’s Law - Ampere’s Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetic scalar and vector potential - Magnetic force, Torque and Moment - Magnetization, Magnetic field in multiple media – Boundary conditions, Poisson’s Equation, Inductance, Energy density, Applications.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT IV</td><td colspan="2">ELECTRODYNAMIC FIELDS</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Magnetic Circuits - Faraday’s law – Transformer and motional EMF – Displacement current - Maxwell’s equations (differential and integral form) – Time-Varying Potentials - Time-Harmonic Fields - Relation between field theory and circuit theory</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT V</td><td colspan="2">ELECTROMAGNETIC WAVES</td><td>6</td><td>3</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors- skin depth - Poynting vector – Plane wave reflection and refraction.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7" align="right">Total (30L + 15T) = 45 Periods</td></tr>
<tr><td colspan="7"></td></tr>
</table>

Text Books:

1.	Mathew N. O. Sadiku, “Principles of Electromagnetics”, 6th Edition, Oxford University Press Inc. Asian edition, 2015.
2.	William H. Hayt and John A. Buck, “Engineering Electromagnetics”, McGraw Hill Special Indian edition, 2014.
3.	Kraus and Fleish, “Electromagnetics with Applications”, McGraw Hill International Editions, Fifth Edition, 2010.

Reference Books:

1.	V.V. Sarwate, “Electromagnetic Fields and Waves”, First Edition, New Age Publishers, 1993.
2.	J.P. Tewari, “Engineering Electromagnetics - Theory, Problems and Applications”, Second Edition, Khanna Publishers.
3.	Joseph. A. Edminister, “Schaum’s Outline of Electromagnetics”, Third Edition (Schaum’s Outline Series), McGraw Hill, 2010.
4.	S.P. Ghosh, and Lipika Datta, “Electromagnetic Field Theory”, First Edition, McGraw Hill Education (India) Private Limited, 2012.
5.	K.A. Gangadhar, “Electromagnetic Field Theory”, Khanna Publishers; Eighth Reprint: 2015.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recognize the fundamental concept, laws and theorem of electric and magnetic fields.	L1: Remembering
CO2	:	Review the concepts in electrostatic fields and magnetic fields.	L2: Understanding
CO3	:	Analyze the Electric and magnetic Field in material space.	L4: Analysing
CO4	:	Apply the boundary conditions to the applications in electrostatic fields and magnetostatic fields. .	L3: Applying
CO5	:	Assess the knowledge of electromagnetic waves and characterizing parameters.	L4: Analysing

23PTEE202	SYNCHRONOUS AND INDUCTION MACHINES			SEMESTER		II
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Electrical Machines		**Hours / Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

This course provides understanding of AC machinery fundamentals, machine parts and helps to develop the skills for operating AC machines and equips students to analyse the equivalent circuits of Induction and Synchronous Machines.

UNIT I	ALTERNATOR	6	3	0	9

Construction, types, practical rating of synchronous generators, winding factors, production of EMF, armature reaction, Synchronous reactance, phasor diagram, Methods of pre-determination of voltage regulation- Synchronous impedance, ampere turn, Potier triangle methods. Two reaction theory–Slip test, synchronization -Change of excitation and mechanical input

UNIT II	SYNCHRONOUS MOTOR	6	3	0	9

Theory of operation–phasor diagrams, Torque equation – Operation on infinite bus bars, variation of current and power factor with excitation. Hunting and its suppression, V and inverted V curves, Synchronous condenser, method of starting.

UNIT III	THREE PHASE INDUCTION MACHINES	6	3	0	9

Constructional details, types, production of rotating magnetic field-principle of operation and practical rating of induction motors. Need for starting – Types of starters – DOL, Rotor resistance and Auto transformer starters. Generator action: self-excitation, operation, and applications.

UNIT IV	ANALYSIS AND TESTING OF THREE PHASE INDUCTION MOTORS	6	3	0	9

Phasor diagram, equivalent circuit, Torque equation-starting and maximum-torque, maximum-output, slip for maximum-output, Torque-slip characteristics, losses, and efficiency. Testing-no load and blocked rotor tests- equivalent circuit parameters, circle diagram.

UNIT V	SINGLE PHASE INDUCTION MOTOR	6	3	0	9

Constructional details of single-phase induction motor – Double field revolving theory and operation – Equivalent circuit – Starting methods of single-phase induction motors – Types: Split phase, Capacitor start – induction run, Capacitor-start capacitor run, and Shaded pole - Applications.

Total (30L + 15T) = 45 Periods

Text Books:

1.	D.P. Kothari, and I. J. Nagrath, "Electric Machines", 4th edition, Tata McGraw-Hill Company Ltd., New Delhi, 2010.
2.	Dr.P.S. Bimbhra, "Electrical Machinery", Khanna Publishers, Delhi, 2007.
3.	A.E. Fitzgerald, Charles Kingsley and Stephen. D. Umans, "Electric Machinery", Tata McGraw Hill Publishing Company Ltd, 2015.

References:

1.	B.L. Theraja and A.K. Theraja, "Electrical Technology", Vol. II, S. Chand & Company Ltd., New Delhi, 2015.
2	Alexander S. Langsdorf, "Theory of Alternating-Current Machinery", Tata McGraw Hill Publications, 2001.

Course Outcomes:			
Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Familiarize with construction, working principle, synchronizing techniques and performance of Synchronous Generator.	L1: Remembering
CO2	:	Understand the working principle, torque equation, and excitation control for Synchronous Motor.	L2: Understanding
CO3	:	Operate three phase Induction machine as motor and as a generator.	L4: Analysing
CO4	:	Analyse the performance of three phase induction motor with testing.	L4: Analysing
CO5	:	Know double field revolving theory and starting mechanisms for single-phase induction motors	L5: Evaluating

23PTEE203	ANALOG AND DIGITAL INTEGRATED CIRCUITS		SEMESTER			II
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Electron Devices and Circuits		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on the characteristics& applications of Operation Amplifier, functional diagram & applications of linear ICs
2.	To simplify the switching functions
3.	To design the combinational logic circuits and sequential logic circuits

UNIT I	OPERATIONAL AMPLIFIERS	9	0	0	9

Operational amplifiers - Equivalent circuit, voltage transfer curve - Open loop Op-amp configurations –Voltage series, Voltage shunt feedback amplifiers configurations, closed loop differential amplifiers for single and differential outputs.
Output offset voltage, minimizing output offset voltage due to input bias current and input offset current, factors affecting off set parameters, CMRR - Open loop and closed loop frequency response of op-amps, circuit stability, slew rate and its effects in applications.

UNIT II	APPLICATION OF OPERATIONAL AMPLIFIER AND LINEAR ICS	9	0	0	9

DC & AC amplifiers- Summing, Scaling and Averaging Amplifiers-Instrumentation amplifier- Voltage to Current converter for floating and grounded loads - Current to voltage converter - Integrator, Differentiator. Voltage comparators - Zero Crossing Detector - Schmitt trigger with voltage limiter- Precision Rectifier Circuits-Peak Detector-Sample and Hold circuit, Active Filters - Frequency response characteristics of major active filters, first and higher order low pass and high pass filters, all pass filters.
Functional block diagram and Applications of Linear ICs: IC 555 Timer -IC 566 Voltage controlled oscillator- IC 565 Phase-locked loops - IC LM317 voltage regulators.

UNIT III	COMBINATIONAL LOGIC CIRCUITS	9	0	0	9

Representation of logic functions: SOP and POS forms - Simplification of switching functions: K-maps method and Quine McCluskey (Tabulation) method.
Design: Adders -Subtractors– 2-bit Magnitude Comparator-Multiplexer- Demultiplexer- Encoder - Priority Encoder - Decoder – Code Converters. Implementation of combinational logic circuits using multiplexers and Decoder**.**

UNIT IV	SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS	9	0	0	9

Flip-flops: SR, D, JK and T- Conversion of flip-flops; Classification of sequential circuits: Moore and Mealy models - Analysis and design of synchronous sequential circuits - Design of synchronous counters- Universal shift register.

UNIT V	ASYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS	9	0	0	9

Fundamental mode and pulse mode circuits, Analysis procedure of asynchronous circuits with /without using of SR latches-primitive state / flow table – Reduction of state and flow table - state assignment –Design Procedure of asynchronous circuits with /without using of SR latches-Problems in asynchronous sequential circuits: cycles -Races –Hazards.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Ramakant A Gayakward, "Op-Amps and Linear Integrated Circuits", Fourth Edition, Pearson Education, 2003.
2.	Donald.E.Neaman, "Electronic Circuit, Analysis and Design", Tata McGraw Hill Publishing Company Limited, Second Edition, 2002.
3.	D.Roy Chowdhury and Shail B. Jain, "Linear Integrated Circuits", Fourth Edition, New Age International (P) Ltd Publishers, 2014.
4.	M. Morris Mano, "Digital Design", Third Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2010.
5.	S. Salivahanan and S. Arivazhagan, "Digital Circuits and Design", Third Edition, Vikas Publishing House Pvt. Ltd, New Delhi, 2019.

Reference Books:	
1.	Jacob Millman, and Christos C. Halkias, "Integrated Electronics- Analog and Digital circuits system", Tata McGraw Hill 2003.
2.	R.P.Jain, "Modern Digital Electronics", Third Edition, Tata McGraw–Hill Publishing company limited, New Delhi, 2011.
3.	Thomas L. Floyd, "Digital Fundamentals", Pearson Education, Inc, New Delhi, 2015
4.	Donald P. Leach and Albert Paul Malvino, "Digital Principles and Applications", Fifth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the Op-amp characteristics	L2: Understanding
CO2	:	Understand the applications of Op-amp and other linear ICs.	L2: Understanding
CO3	:	Apply K-map and tabulation methods to simplify the switching functions	L3: Applying
CO4	:	Design and implement of combinational logic circuits	L6: Creating
CO5	:	Analyse and design of synchronous & asynchronous sequential logic circuits	L4: Analyzing

23PTEE204	ELECTRICAL MACHINES LABORATORY		SEMESTER			II
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**1.5**
NIL		**Hours / Week**	**L**	**T**	**P**	**TH**
			0	**0**	**3**	**3**

Course Objectives:

1.	To expose the students to operate of DC and AC Machines and strength their experimental skill.

Experiments

1.	Open circuit and load characteristics of DC shunt generator.
2.	Load characteristics of DC long shunt and short shunt compound generator with cumulative and differential connections.
3.	Load test on DC series motor.
4.	Swinburne's test on DC machines.
5.	Speed control of DC shunt motor.
6.	Open circuit and short circuit tests on single phase transformer.
7.	Load test on single-phase transformer / three phase transformer.
8.	Predetermination of Voltage Regulation of three-phase alternator by EMF and MMF methods.
9.	V and inverted V curves of synchronous motor.
10.	Circle diagram for three phase induction motor with no load and blocked rotor test data.
11.	Load test on three-phase induction motor/single phase induction motor.
12.	Separation of losses in three phase induction motor.

Total (0 + 45P) = 45 Periods

Reference Books:

1.	G.P. Chhalotra, "Experiments in Electrical Engineering", 3rd Ed., Khanna Publishers, Delhi, 2004.
2.	C.S. Indulkar, "Laboratory Experiments in Electrical Power", 3rd Ed., Khanna Publishers, Delhi, 2010.
3.	DC machines and transformers laboratory manual prepared by the department.
4.	Synchronous and Induction Machines manual prepared by the department.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the voltage regulation of a given alternator using different methodologies and Transformer	L2: Understanding
CO2	:	Analyze the performance of a given synchronous motor under various excitation. Conditions	L4: Analyzing
CO3	:	Analyze the characteristics of a induction motor and DC machines under various load conditions	L4: Analyzing
CO4	:	Develop the equivalent circuit and analyze the characteristics of AC machine	L5: Creating
CO5	:	Do loss analysis in DC and AC machines.	L4: Analyzing

23PTEE301	CONTROL SYSTEMS			SEMESTER		III
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Electrical Machines and Electric circuit Analysis		**Hours / Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

1.	To understand the methods of representation of Physical systems and getting their transfer function models.
2.	To provide adequate knowledge in the time response of systems and steady state error analysis.
3.	To give basic knowledge in obtaining the open loop and closed loop frequency response of systems.
4.	To understand the concept of stability of control system and methods of stability analysis.
5.	To study the three ways of designing compensators for a Feedback control system.

UNIT I	**MODELING OF LINEAR TIME INVARIANT SYSTEM**	**6**	**3**	**0**	**9**

Basic elements in control systems – Open and closed loop systems – Feedback control system characteristics – Mathematical model and Electrical analogy of mechanical systems – Transfer function Representation - Synchro – AC and DC servo-motors – Block diagram reduction techniques – Signal flow graphs.

UNIT II	**TIME RESPONSE ANALYSIS**	**6**	**3**	**0**	**9**

Standard test signals – Time response of first order and second order systems – Time domain specifications – Steady-state errors and error constants – Type and order of control systems – Effect of adding poles and zeros to transfer functions – Response with P, PI, PD and PID controllers.

UNIT III	**FREQUENCY RESPONSE ANALYSIS**	**6**	**3**	**0**	**9**

Correlation between time and frequency response: Second order systems - Frequency domain specifications – Polar plots – Bode plots – Computation of Gain Margin and Phase Margin – Constant M and N-circles – Nichols chart.

UNIT IV	**STABILITY OF CONTROL SYSTEM**	**6**	**3**	**0**	**9**

BIBO stability – Necessary conditions for stability – Routh-Hurwitz stability criterion – Root locus concepts – Rules for the construction of Root loci – Nyquist stability criterion – Assessment of relative stability using Nyquist criterion.

UNIT V	**COMPENSATOR AND CONTROLLER DESIGN**	**6**	**3**	**0**	**9**

Need for compensation – Types of compensators – Electric network realization and frequency characteristics of basic compensators: Lag, lead and lag-lead compensators –Design of compensators using Root Locus and Bode plot techniques-PID controller- Design using reaction curve and Ziegler- Nichols technique.

Total (30L + 15T) = 45 Periods

Text Books:

1.	A. Anand Kumar, “Control Systems”, PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2017.
2.	I.J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International Publishers, Delhi, 7th Edition, 2021.

Reference Books:

1.	K. Ogata, “Modern Control Engineering”, Pearson Education, New Delhi, 5th Edition, 2021.
2.	M. Gopal, “Control Systems: Principles and Design”, TMH, New Delhi, 4th Edition, 2018.

E-References:	
1.	https://nptel.ac.in/courses/107106081
2.	https://nptel.ac.in/courses/108106098

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Develop the transfer function models of any electrical and electro-mechanical systems.	L2: Understanding
CO2	:	Obtain the time responses of the systems and construct root locus plot.	L3: Applying
CO3	:	Analyze the frequency response of the system	L3: Applying
CO4	:	Analyze the absolute / relative stability of a control system.	L4: Analyzing
CO5	:	Design the compensators and PID controller of a feedback control system.	L3: Applying

<table>
<tr><td>23PTEE302</td><td colspan="2">POWER ELECTRONICS</td><td colspan="3">SEMESTER</td><td>III</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Electron Devices and Circuits</td><td rowspan="2">Hours / Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">To study an overview of power semiconductor devices.</td></tr>
<tr><td>2.</td><td colspan="6">To obtain the knowledge of controlled rectifiers.</td></tr>
<tr><td>3.</td><td colspan="6">To acquire the principles of DC-DC converter.</td></tr>
<tr><td>4.</td><td colspan="6">To understand the principles of inverters and ac voltage controllers.</td></tr>
<tr><td>UNIT I</td><td colspan="2">POWER SEMICONDUCTOR DEVICES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Concept of power electronics- Structure, Operation, Static and Switching characteristics of power semiconductor devices: Power Diode, SCR, MOSFET, IGBT- Thyristor ratings and protection, Gate drive circuits for MOSFET and IGBT - Switching and Conduction losses in a generic power semiconductor device.</td></tr>
<tr><td>UNIT II</td><td colspan="2">PHASE CONTROLLED RECTIFIERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Single phase and three phase fully controlled rectifiers: Power circuit, Operation, Waveform analysis and performance parameters - Effect of source inductance for Single phase and Three phase fully controlled rectifier - Single phase and Three phase dual converters.</td></tr>
<tr><td>UNIT III</td><td colspan="2">DC TO DC CONVERTER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage– control strategy –Power Circuit and steady state analysis of Buck converter, Boost converter, Buck – boost converter and SEPIC converter- Design of inductor and capacitors for DC-DC converters.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">INVERTERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Power circuit of single phase voltage source inverter, square wave operation of the inverter, bipolar and unipolar sinusoidal modulation, modulation index and output voltage, Power circuit of a three-phase voltage source inverter, operation with three-phase sinusoidal modulation – Single phase Auto sequential Commutated Current Source Inverter.</td></tr>
<tr><td>UNIT V</td><td colspan="2">AC TO AC CONVERTERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction and principle of operation of Single phase and Three phase AC voltage controllers – Multistage sequence control –Applications of AC Voltage Controllers–Introduction to Matrix converters.</td></tr>
<tr><td colspan="7" align="right">Total (45L + 0T) = 45 Periods</td></tr>
<tr><td colspan="7">Text Books:</td></tr>
<tr><td>1.</td><td colspan="6">M.H.Rashid, “Power Electronics: Circuits, Devices and Applications”, Pearson Education, PHI 4th Edition, New Delhi, 2017.</td></tr>
<tr><td>2.</td><td colspan="6">P.S.Bimbra, “Power Electronics”, Khanna Publishers, New Delhi 2018.</td></tr>
<tr><td colspan="7">Reference Books:</td></tr>
<tr><td>1.</td><td colspan="6">Ned Mohan, Tore. M. Undel and William. P. Robbins, “Power Electronics: Converters, Applications and Design”, John Wiley and sons, 2007.</td></tr>
<tr><td>2.</td><td colspan="6">R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007.</td></tr>
<tr><td>3.</td><td colspan="6">M.D. Singh and K.B. Khanchandani, “Power Electronics”, McGraw Hill India, 2013.</td></tr>
</table>

E-References:	
1	www.onlinecourses.nptel.ac.in/
2	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Choose suitable Power Semiconductor Device for the power conversion.	L3: Applying
CO2	:	Know the operation of converters, inverters and AC voltage controllers.	L2: Understanding
CO3	:	Analyse the performance of converters and inverters.	L4: Analyzing
CO4	:	Design converter and inverter circuits.	L3: Applying
CO5	:	Identify suitable control techniques for the converter.	L1: Remembering

23PTEE303	ELECTRICAL MACHINE DESIGN		SEMESTER			III
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
DC Machines and Transformers, Synchronous and Induction Machines		**Hours / Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

1.	To Study mmf calculation and thermal rating of various types of electrical machines
2.	To Design armature and field systems for D.C. machines.
3.	To Design core, yoke, windings and cooling systems of transformers.
4.	To Design stator and rotor of induction machines.
5.	To Design stator and rotor of synchronous machines and study their thermal behavior

UNIT I	INTRODUCTION	6	3	0	9

Major considerations – Limitations – Electrical Engineering Materials – Space factor - Design of Magnetic Circuits: MMF calculation for Air gap and Teeth - Iron losses and Magnetizing current calculations. Design of lap winding and wave winding - Standard specification.

UNIT II	DC MACHINES	6	3	0	9

Design of rotating machines – D.C machines output equations – Main dimensions- Choice of Specific Electric and Magnetic Loading -Selection of number of poles – Armature design – Design of commutator and brushes-Design of slot, air gap, field coils.

UNIT III	TRANSFORMERS	6	3	0	9

KVA output for single and three phase transformers – Window space factor – Overall dimensions – Operating characteristics – Regulation – No load current – Temperature rise of Transformers– Design of Tank with & without cooling tubes – Thermal rating – Methods of cooling of Transformers – Design of inductors.

UNIT IV	INDUCTION MOTORS	6	3	0	9

Output equation of Induction motor – Main dimensions –Choice of electrical and magnetic loadings-Length of air gap- Rules for selecting rotor slots of squirrel cage machines– Design of rotor bars & slots – Design of end rings – Design of wound rotor-Operating characteristics –Short circuit current –Circle diagram.

UNIT V	SYNCHRONOUS MOTORS	6	3	0	9

Runaway speed – construction – output equations – choice of loadings – Design of salient pole machines – Short circuit ratio – shape of pole face – Armature design – Armature parameters – Estimation of air gap length– Design of rotor –Design of damper winding – Determination of full load field mmf – Design of field winding – Computer Program – design of Stator main dimensions

Total (30L + 15T) = 45 Periods

Text Books:

1.	A.K. Sawhney, "A Course in Electrical Machine Design", 6th edition, Dhanpat Rai & Sons, New Delhi, 2014.
2.	S.K. Sen, "Principles of Electrical Machine Designs with Computer Programmes", Oxford and IBH Publishing Co. Pvt Ltd. NewDelhi,2009.

Reference Books:

1.	R.K.Agarwal, Principles of Electrical Machine Design, S.K. Kataria and Sons, New Delhi 2014.

2.	V.N. Mittle, “Design of Electrical Machines”, 5th edition, Standard Publications and Distributors, New Delhi, 2013.
3.	V.Rajini, and V.S Nagarajan, “Electrical Machine Design”, Pearson, first edition 2018.
E-Reference:	
1.	http://cusp.umn.edu/machine_design.php

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Classify the materials used for the construction of electrical machines and be able to calculate the MMF in magnetic parts of rotating machines.	L4: Analyzing
CO2	:	Familiarize the importance of magnetic, thermal, and electrical loading of AC and DC Machines.	L2: Understanding
CO3	:	Design and Analyze Armature and Field Systems for DC Machines.	L4: Analyzing
CO4	:	Design and Analyze core, windings and cooling system of transformers.	L4: Analyzing
CO5	:	Design and analyze Stator and rotor of Induction Machines and Synchronous machines.	L4: Analyzing

23PTEE304	MEASUREMENTS AND INSTRUMENTATION		SEMESTER			III
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Electric Circuit Analysis		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To educate the fundamental concepts and characteristics of measurement System
2.	To introduce the fundamentals of electrical and electronic instruments for measurement of electrical and Non-electrical quantities
3.	To familiarize Oscilloscope and the bridge circuits for electrical parameters measurement

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement. Measurement of voltage and current - permanent magnet moving coil and moving iron type meters

UNIT II	**MEASUREMENT OF POWER, ENERGY AND FREQUENCY**	**9**	**0**	**0**	**9**

Measurement of power - single and three phase- electrodynamometer type watt meters – Construction, operation – torque equation for deflection – errors. Measurement of energy-Single phase induction type energy meters, Instrument transformers – Current and Potential transformers, Power factor meters- Single phase electrodynamometer type power factor meter, frequency meter-Electrical resonance type frequency meter

UNIT III	**DC AND AC BRIDGES**	**9**	**0**	**0**	**9**

Balance equations - Wheatstone bridge – Kelvin double Bridge –Maxwell's inductance capacitance bridge – Hay's bridge – Anderson's bridge – Schering bridge and De Sauty's bridge

UNIT IV	**POTENTIOMETERS, OSCILLOSCOPES AND DIGITAL INSTRUMENTS**	**9**	**0**	**0**	**9**

DC Potentiometer- Crompton's Potentiometer, AC potentiometer– Drysdale polar potentiometer- Gall Tinsley co-ordinate type potentiometer, Cathode Ray Oscilloscope and Digital storage Oscilloscope-Construction, operation and Applications, Digital multi-meters, Digital voltmeters.

UNIT V	**MEASUREMENT OF NON-ELECTRICAL QUANTITIES**	**9**	**0**	**0**	**9**

Classification of transducers –Position transducers, Piezo-electric transducers and Hall effect transducers. Measurement of pressure, temperature and displacement– Introduction to Smart Sensors

Total (45L + 0T) = 45 Periods

Text Books:

1.	A.K. Sawhney, "A Course in Electrical & Electronics Measurement & Instrumentation", Dhanpat Rai and Co, 2015
2.	E.O. Doebelin, "Measurements Systems- Application and Design", Tata McGraw Hill publishing company, 2015.

Reference Books:

1.	D.V.S. Moorthy, "Transducers and Instrumentation", Prentice Hall of India Pvt. Ltd, 2010.
2.	H.S. Kalsi, "Electronic Instrumentation", Tata McGraw Hill, 2015.
3.	Martin Reissland, "Electrical Measurements", New Age International(P) Ltd., Delhi, 2011.

E-Reference:

1.	https://archive.nptel.ac.in/courses/108/105/108105153/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of measurement system in electrical engineering.	L1: Remembering
CO2	:	Describe the working principle of different measuring instruments.	L2: Understanding
CO3	:	Choose appropriate instrument for measuring the electrical parameters.	L3: Applying
CO4	:	Employ the digital instruments in real time measurements.	L3: Applying
CO5	:	Select and use an appropriate transducer for measurement of non-electrical quantities.	L4: Analysing

23PTCY301	ENVIRONMENTAL SCIENCE AND ENGINEERING			SEMESTER			III
PREREQUISITES			**CATEGORY**	**ES**	**Credit**		**3**
Nil			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

To make the students conversant with the

1. Principles of environmental resources.
2. Preservation of ecosystem and biodiversity.
3. Principles of environmental threats and pollution.
4. Principles of solid waste management.
5. Environmental issues and ethics.

UNIT I	ENVIRONMENTAL RESOURCES	9	0	0	9

Forest resources – importance, deforestation – water resources – hydrological cycle – food resources – effects of modern agriculture, fertilizers, pesticides – Land Resources- Land degradation-soil erosion- Mineral resources –types – mining - environmental effects of extracting and using mineral resources.

UNIT II	ECOSYSTEM AND BIODIVERSITY	9	0	0	9

Environment – biotic and abiotic components – Ecosystem – components –Energy Partitioning in Food Chains and Food Webs -tropic levels – energy flow in ecosystem, ecological pyramids – ecological succession, types – Biodiversity, types, values of biodiversity, hot spots of biodiversity, threat to biodiversity, endangered and endemic species, conservation of biodiversity – In-situ and Ex-situ conservation.

UNIT III	ENVIRONMENTAL POLLUTION	9	0	0	9

Air pollution – classification of air pollutants - gaseous, particulates – sources, effects and control of gaseous pollutants, SO_x, NO_x, H_2S, CO and particulates – control methods – catalytic convertor, cyclone separator, electrostatic precipitator– Water pollution – heavy metal ions pollutants – organic pollutants, oxygen demanding wastes, aerobic and anaerobic decomposition, Dissolved oxygen (DO), BOD and COD - experimental determination of BOD only, treatment of domestic and industrial wastewater – Noise pollution –decibel scale - sources, effects and control measures.

UNIT IV	ENVIRONMENTAL THREATS AND SOLID WASTE MANAGEMENT	9	0	0	9

Eutrophication, bio amplification, acid rain, greenhouse effect and global warming, ozone layer depletion, photo chemical smog – disaster management – origin, effects and management of earthquake and floods. Solid waste management – solid wastes, classification, origin, effects – treatment methods – composting, sanitary land filling – destructive methods – incineration, pyrolysis, 3R (reduce, reuse and recycling).

UNIT V	SOCIAL ISSUES AND ENVIRONMENTAL ETHICS	9	0	0	9

From unsustainable to sustainable development, objectives, and ways of achieving – urban problems related to energy and energy conservation – water conservation and management, rainwater harvesting – waste land reclamation. Environmental ethics – consumerism – human population, exponential and logistic growth, population explosion, population policy, family welfare programme – population control methods – HIV and AIDS.

Total (45L + 0T) = 45 Periods

Text Books:

1. P.Meenakshi, “Elements of Environmental Science and Engineering”, Prentice — Hall of India, New Delhi, 2009.
2. Dr. S.S. Dara and D.D. Mishra, “A Textbook of Environmental Chemistry and Pollution Control: (With Energy, Ecology, Ethics and Society)”, Revised Edition, S. Chand & Company Ltd, 2014.

Reference Books:

1. Gilbert M. Masters and Wendell P. Ela, “Introduction to Environmental Engineering and Science”, Publisher: Prentice-Hall India, 3rd Edition, 2008.
2. Fldren D. Enger and Bredley F.Smith, “Environmental Science”, WCD McGraw Hill 14"Edition, 2015.

E-References:	
1.	www.onlinecourses.nptel.ac.in/
2.	www.ePathshala.nic.in

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Play an important role in conservation of natural resources for future generation.	L6: Creating
CO2	:	Paraphrase the importance of ecosystem and biodiversity.	L2: Understanding
CO3	:	Analyze the impact of pollution and hazardous waste in a global and social context.	L4: Analyzing
CO4	:	Understand contemporary issues that result in environmental degradation that would attempt to provide solutions to overcome the problems.	L2: Understanding
CO5	:	Consider the issues of environment and human population in their professional undertakings.	L3: Applying

23PTEE401	POWER GENERATION, TRANSMISSION AND DISTRIBUTION SYSTEM		SEMESTER			IV
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Electric circuit analysis**,** Electromagnetic Theory		**Hours / Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

1.	To impart knowledge on power generation plants and Substation
2.	To study the line parameters and analyze the performance of the transmission system
3.	To learn insulators, cables and grounding methodologies for power system

UNIT I	**POWER GENERATION SYSTEMS**	**6**	**3**	**0**	**9**

Structure of electric power system-Terms, factors and significance of Load curve –Economics of Power Generation-Cost of Electrical Energy- Power generating Station: layout and operation of Thermal power plant, Hydroelectric power plant and Nuclear power plants –Comparison of power plants.

UNIT II	**TRANSMISSION LINE PARAMETERS**	**6**	**3**	**0**	**9**

Line resistance- Inductance and capacitance calculations of single phase and three phase transmission lines with single and double circuits–Effect of earth on the capacitance of the transmission line– Skin and proximity effects-Inductive interference between power and communication lines.

UNIT III	**PERFORMANCE OF TRANSMISSION LINES**	**6**	**3**	**0**	**9**

Representation of Lines-Performance of Short line, medium line and long transmission line; equivalent circuits, Phasor Diagrams, transmission efficiency and voltage regulation, ABCD constants-surge-impedance loading-Ferranti effect and corona effect.

UNIT IV	**OVERHEAD LINE INSULATORS AND CABLES**	**6**	**3**	**0**	**9**

Insulators: Types, Potential distribution over a string of suspension insulators- improvement of string efficiency. Underground cables: Constructional features of LT and HT cables, capacitance of single core and 3- core cables, dielectric stress in a single core cable- grading of cables, thermal resistance of dielectric of a single core cable.

UNIT V	**SUBSTATION, GROUNDING SYSTEM AND DISTRIBUTION SYSTEM**	**6**	**3**	**0**	**9**

Substation: Lay out and operation-bus-bar arrangements in sub stations- Grounding: Need and Types, Neutral grounding and Resonant grounding- Transformer Earthling-Distribution system: Classification, Layout of AC and DC distribution, Connection Schemes of Distribution system.

Total (30L + 15T) = 45 Periods

Text Books:

1.	C.L. Wadhwa, “Electrical Power Systems”, New age International (P) Ltd., 2018.
2.	S.N.Singh, “Electric Power Generation, Transmission and Distribution”, Second Edition, PHI Pvt. Ltd., New Delhi, 2012.

Reference Books:

1.	Ray, “Electrical Power systems: Concepts, Theory and Practice”, PHI Pvt.Ltd., New Delhi,2012.
2.	V.K. Mehta and Rohit Mehta, “Principles of Power System”, S.Chand & Company Ltd., New Delhi, 2012.

E-Reference:	
1.	https://archive.nptel.ac.in/courses/108/102/108102047/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the operation of generating stations and substations.	L2: Understanding
CO2	:	Model the transmission lines using system parameters.	L3: Applying
CO3	:	Analyze the performance of different types of transmission lines.	L4: Analysing
CO4	:	Select an appropriate insulator and cable for transmission and distribution system.	L3: Applying
CO5	:	Describe the substation components and grounding techniques.	L1: Remembering

23PTEE402	MICROPROCESSOR AND MICROCONTROLLER				SEMESTER		IV
PREREQUISITES			CATEGORY	PC	Credit		3
C Programming			Hours / Week	L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To study the architecture of μP8085 and μC 8051
2.	To study the Interrupt structure of 8085 and 8051.
3.	To do simple applications development with programming 8085 and 8051.

UNIT I	8085 8 BIT MICROPROCESSOR	9	0	0	9

Fundamentals of microprocessors – Architecture of 8085 – Groups of Instructions - Addressing modes – Basic timing diagram – Organization and addressing of Memory and I/O systems –Interrupt structure – Stack and sub-routines - Simple 8085 based system design and programming.

UNIT II	8051 8 BIT MICROCONTROLLER	9	0	0	9

Fundamentals of microcontrollers – Architecture of 8051 – Groups of Instructions - Addressing modes – Organization of Memory systems – I/O Ports – Timers/Counters – Serial Port - Interrupt structure – Simple programming concepts using Assemblers and Compliers.

UNIT III	INTERFACING WITH 8051 MICROCONTROLLER	9	0	0	9

Need and requirements of interfacing – Interfacing – LED, 7 segment and LCD Displays – Tactile switches, Matrix keyboard – Parallel ADC – DAC – Interfacing of Current, Voltage, RTD and Hall Sensors.

UNIT IV	EXTERNAL COMMUNICATION INTERFACE	9	0	0	9

Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

UNIT V	APPLICATIONS OF MICROCONTROLLERS	9	0	0	9

Simple programming exercises- key board and display interface –Control of servo motor stepper motor control-Application to automation systems.

Total (45L + 0T) = 45 Periods

Text Books:

1.	R.S. Gaonkar, "Microprocessor Architecture Programming and Application with 8085", Wiley Eastern Ltd., New Delhi, 2013.
2.	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004.
3.	Muhammad Ali Mazidi, Janice GilliMazidi, and R.D.Kinely, "The 8051 Micro Controller and Embedded Systems", PHI Pearson Education, 5th Indian reprint, 2003.

Reference Books:

1.	R. Kamal, "Embedded System", McGraw Hill Education,2009.
2.	D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.

E-References:	
1.	www.onlinecourses.nptel.ac.in/noc18_ee41
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basics of microprocessor and microcontroller	L2: Understanding
CO2	:	Understand the architecture of microprocessor and microcontroller	L1: Remembering
CO3	:	Apply the digital concepts to measure and control simple electrical systems	L3: Applying
CO4	:	Design and interface communications between digital systems	L2: Understanding
CO5	:	Design a microcontroller based electrical control system.	L5: Evaluating

<table>
<tr><td>23PTEE403</td><td colspan="2">BIOMEDICAL INSTRUMENTATION</td><td colspan="3">SEMESTER</td><td>IV</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Basic Electrical and Electronics Engineering, Measurements and Instrumentation</td><td rowspan="2">Hours / Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">To provide an adequate knowledge of the human physiology systems.</td></tr>
<tr><td>2.</td><td colspan="6">To introduce different transducers for Biomedical applications.</td></tr>
<tr><td>3.</td><td colspan="6">To introduce the student to the various sensing and measurement devices of bio-medical electrical systems.</td></tr>
<tr><td>4.</td><td colspan="6">To provide awareness of electrical safety of medical equipment.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT I</td><td colspan="2">HUMAN PHYSIOLOGICAL SYSTEMS AND BIO POTENTIAL ELECTRODES AND TRANSDUCERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Cells and their structure – Nature of Cancer cells – Transport of ions through the cell membrane – resting and action potential – bio-electric potential – nerve tissues and organs – difference systems of human body. Physiology of Human body- Brain, heart, lungs-Cardiovascular system- Respiratory system- nervous system. Design of medical instruments components of biomedical instrument systems – electrodes - transducers.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT II</td><td colspan="2">BIO SIGNAL ACQUISITION BIO POTENTIAL RECORDERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Physiological signal amplifiers – isolation amplifiers – medical pre amplifier design – bridge amplifiers – line drive amplifiers – current amplifiers – chopper amplifiers – bio signal analysis – signal recovery and data acquisition – drift compensation in operational amplifiers – pattern recognition. Characteristics of recording system – Electrocardiography (ECG) – Electroencephalography (EEG) – Electromyography (EMG) – Electroretinography (ERG) & Electrooculography (EOG) – recorders for offline analysis.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT III</td><td colspan="2">SPECIALIZED MEDICAL EQUIPMENT AND BIO-TELEMETRY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Blood cell counter – Electron microscope – radiation detectors – photo meters and colorimeters – digital thermometer – audio meters – X-ray tube – X-ray machine – Radiography and fluoroscopy – image intensifiers – angiography – applications of X-ray examination. Biotelemetry</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT IV</td><td colspan="2">PHYSIOLOGICAL ASSIST DEVICES AND OPERATION THEATRE EQUIPMENT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Pacemakers – Pacemaker batteries – artificial heart walls – Defibrillators – nerve and muscle stimulators – heart lung machine – kidney machine. Surgical diathermy – short wave diathermy – microwave diathermy – ultrasonic diathermy – therapeutic effect of heat – range and area of irritation of different diathermy techniques – Ventilators – Anesthesia machines – blood flow meters – Cardiac output measurements – Pulmonary function analyzers – Blood gas analyzers – oxymeters – elements of intensive care monitoring.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT V</td><td colspan="2">SAFETY INSTRUMENTATION AND ADVANCES IN BIOMEDICAL INSTRUMENTATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Radiation safety instrumentation – physiological effects due to 50 Hz current passage – Micro shock and macro shock – electrical accidents in hospitals – Devices to protect against electrical hazards – hospital architecture. Computers in medicine – lasers in medicine – endoscope – Cryogenic surgery – Nuclear imaging techniques – computer tomography – thermography – ultrasonic imaging system – Magnetic resonance imaging – Positron emission tomography – digital subs traction angiography.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7" align="right">Total (45L + 0T) = 45 Periods</td></tr>
</table>

Text Books:	
1.	U. Satyanarayana “Biochemistry”, 5th edition – Sri Padmavathi Publications Ltd.,2017.
2.	N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, “Biology: Aglobal approach”, Pearson Education Ltd, 2014.
3.	Dr.M.Arumugam, “Bio-Medical Instrumentation”, Anuradha Agencies, 2012.
4.	Leslie Cromwell, Fred J.Weibell, and Erich A.Pfeiffer, “Bio-Medical Instrumentation and Measurements”, II edition, Pearson Education, 2011 / PHI.
Reference Books:	
1.	R.S.Khandpur, “Hand Book of Bio-Medical Instrumentation”, Tata McGraw Hill Publishing Co Ltd.,2012.
2.	L.A. Geddes and L.E.Baker, “Principles of Applied Bio-Medical Instrumentation”, John Wiley &Sons, 2011.
3.	C.Rajarao, “Medical Instrumentation”, John Wiley & Sons,2013.
4.	C.Rajarao and S.K. Guha, “Principles of Medical Electronics and Bio-medical Instrumentation”, Universities press (India) Ltd, Orient Longman ltd, 2012.
E-Reference:	
1.	www.onlinecourses.nptel.ac.in

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Remember the purpose & methods of measurement.	L1: Remembering
CO2	:	Understand different display and recording devices for various applications.	L2: Understanding
CO3	:	Evaluate electrical & non electrical physiological measurements and bio amplifier.	L5: Evaluating
CO4	:	Apply physiological assist devices and operational theatre equipment.	L3: Applying
CO5	:	Design biomedical equipment as it is a challenging interdisciplinary process	L6: Creating

23PTHS401	UNIVERSAL HUMAN VALUES			SEMESTER			IV
PREREQUISITE		**CATEGORY**		**HS**	**Credit**		**3**
Universal human values introduction		**Hours / Week**		**L**	**T**	**P**	**TH**
				2	**1**	**0**	**3**

COURSE OBJECTIVES

1.	To development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2.	To understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence.
3.	To strengthening of self-reflection.
4.	To development of commitment and courage to act.

UNIT I	BASIC CONCEPTS OF HUMAN VALUES	6	3	0	9

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education. Purpose and motivation for the course, recapitulation from Universal Human Values-I. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario Method to fulfil the above human aspirations- understanding and living in harmony at various levels.

UNIT II	UNDERSTANDING HARMONY IN THE HUMAN BEING	6	3	0	9

Understanding Harmony in the Human Being - Harmony in Myself! Understanding human being as a co-existence of the sentient 'I' and the material 'Body' Understanding the needs of Self ('I') and 'Body' - happiness and physical facility. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer) Understanding the characteristics and activities of 'I' and harmony in 'I' Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail Programs to ensure Sanyam and Health.

UNIT III	UNDERSTANDING HARMONY IN THE FAMILY AND SOCIETY	6	3	0	9

Understanding Harmony in the Family and Society- Harmony in Human- Human Relationship Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship. Understanding the meaning of Trust; Difference between intention and competence. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

UNIT IV	UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE	6	3	0	9

Understanding Harmony in the Nature and Existence - Whole existence as Coexistence. Understanding the harmony in the Nature. Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature. Understanding Existence as Co-existence of mutually interacting units in all- pervasive space. Holistic perception of harmony at all levels of existence.

UNIT V	HOLISTIC UNDERSTANDING OF HARMONY	6	3	0	9

Implications of the above Holistic Understanding of Harmony on Professional Ethics. Natural acceptance of human values. Definitiveness of Ethical Human Conduct. Basis for Humanistic Education, Humanistic Constitution and Humanistic

Universal Order. Competence in professional ethics, Strategy for transition from the present state to Universal Human Order.	
	Total (30L + 15T) = 45 Periods
Text Books:	
1.	R.R.Gaur, R.Sangal, and G.P.Bagaria, "Human Values and Professional Ethics", Excel Books, New Delhi, 2010.
Reference Books:	
1.	Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2.	Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3.	The Story of Stuff (Book)
4.	The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5.	Small is Beautiful - E. F Schumacher.
6.	Slow is Beautiful - Cecile Andrews
7.	Economy of Permanence - J C Kumarappa
8.	Bharat Mein Angreji Raj - PanditSunderlal
9.	Rediscovering India - by Dharampal
10.	Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11.	India Wins Freedom - Maulana Abdul Kalam Azad
12.	Vivekananda - Romain Rolland (English)
13.	Gandhi - Romain Rolland (English)

COURSE OUTCOMES: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Become more aware of themselves, and their surroundings (family, society, nature) and become more responsible in life	L5: Evaluating
CO2	:	Handle problems with sustainable solutions, while keeping human relationships and human nature in mind	L3: Applying
CO3	:	Become sensitive to their commitment towards what they have understood (human values, human relationship and human society)	L5: Evaluating
CO4	:	Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.	L3: Applying

23PTEE404	MICROPROCESSOR AND MICROCONTROLLER LABORATORY		SEMESTER			IV
PREREQUISITES		CATEGORY	PC	Credit		1
Analog and Digital Integrated Circuits, Microprocessor and Microcontroller		Hours / Week	L	T	P	TH
			0	0	2	2

Course Objectives:

1. Able to write own programs for different applications and interface the programs for interconnected digital systems

LIST OF EXPERIMENTS:

1. Simple arithmetic operations: addition / subtraction / multiplication / division.
2. Programming with control instructions:
    a. Ascending / Descending order, Maximum / Minimum of numbers
    b. Programs using Rotate instructions
    c. Hex / ASCII / BCD code conversions.
3. Interface Experiments: with 8085
    a. A/D Interfacing. & D/A Interfacing.
4. Traffic light controller.
5. I/O Port / Serial communication
6. Programming Practices with Simulators/Emulators/open source
7. Keyboard interfacing
8. LCD interfacing 4bit/8bit mode
9. Demonstration of basic instructions with 8051 Micro controller execution, including:
    a. Conditional jumps, looping
    b. Calling subroutines.
10. Programming I/O Port 8051
    a. Interface with external A/D & D/A
    b. Interface with stepper motor
11. Interrupt programming with external sensors/ devices
12. Programming for communication using Zigbee protocol.

Total (0T + 30P) = 30 Periods

Reference Books:

1. R. S. Gaonkar, "Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996.
2. K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004.
3. M.A.Mazidi, J.G. Mazidi and R. D. McKinlay, "The 8051Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2007.
4. R. Kamal, "Embedded System", McGraw Hill Education, 2009.
5. D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Write coding to implement different types of algorithms	L1: Remembering
CO2	:	Design and implement simple controllers	L3: Applying
CO3	:	Use simulators and emulators for debugging and verifying codes	L3: Applying
CO4	:	Write efficient codes using interrupts for time critical applications	L4: Analyzing
CO5	:	Interface any application module to microprocessor/microcontroller.	L5: Evaluating

23PTEE501	POWER SYSTEM ANALYSIS AND STABILITY		SEMESTER			V
PREREQUISITES		CATEGORY	PC	Credit		3
Circuit Theory, Electrical Machines, Power Generation, Transmission and Distribution System		Hours / Week	L	T	P	TH
			2	1	0	3

Course Objectives:

1.	To model the power system under steady state operating condition
2.	To apply efficient numerical methods to solve the power flow problem
3.	To model and analyse the power systems under abnormal (or) fault conditions
4.	To model and analyse the transient behaviour of power system when it is subjected to a fault.

UNIT I	POWER SYSTEM OVERVIEW AND MODELLING	6	3	0	9

Basic components of modern power system - Per-phase analysis: Generator model - Synchronous motor model- Three-phase transformer model - Three-winding transformer model - Line model, Load model- Per unit quantities: - Changing the base of per-unit quantities - Single line diagram -Impedance and reactance diagrams.

UNIT II	POWER FLOW ANALYSIS	6	3	0	9

Bus classification – Bus admittance matrix Formulation: Direct inspection method and Singular transformation method - Development of power flow model - solution of load flow equations: Gauss Seidel method - Newton Raphson method- Fast decoupled method – Flowcharts – Comparison of the three power flow solution methods.

UNIT III	FAULT ANALYSIS - BALANCED FAULT	6	3	0	9

Importance of short circuit studies-Assumptions in short circuit analysis – Balanced three phase fault – Short circuit capacity - Algorithm for formation of the bus impedance matrix- Systematic fault analysis using bus impedance matrix - Post fault bus voltages – Fault level - Current limiting reactors - Selection of circuit breakers.

UNIT IV	FAULT ANALYSIS - UNBALANCED FAULT	6	3	0	9

Fundamentals of symmetrical components – Sequence impedances – Construction of sequence networks – Unsymmetrical faults on power system: Single line-ground fault, line-line fault – Double line-ground fault- Unbalanced fault analysis using Thevenin's theorem and Z-bus computation of post fault currents in symmetrical component and phasor domains.

UNIT V	STABILITY STUDIES	6	3	0	9

Importance of stability studies – Classification of power system stability – Stability limits – Power angle equation- Inertia constant- Swing equation of single-machine connected to infinite bus – Solution of swing equation by step-by-step method-II – Modified Euler's method – Runge-Kutta method – Equal area criterion – Critical clearing angle and time -Factors affecting transient stability – Techniques for transient stability improvement.

Total (30L + 15T) = 45 Periods

Text Books:

1.	Hadi Saadat, "Power System Analysis", Tata McGraw Hill Publishers, New Delhi, 3rd edition, 2011.
2.	D.P.Kothari and I.J.Nagrath, "Modern Power System Analysis", Tata McGraw Hill Education Private limited, New Delhi, Fourth Edition, 2019.

Reference Books:

1.	John J. Grainger and W.D. Stevenson Jr., "Power System Analysis", McGraw Hill Inc., New Delhi, 2017.
2.	B.R. Gupta, "Power System Analysis and Design", S.Chand & Co. Ltd., New Delhi, 2012.

3.	C. L. Wadhwa, “Electrical Power Systems”, New Age International Publishers, New Delhi, 2021.
E-References:	
1.	https://onlinecourses.nptel.ac.in/, for power system analysis course, IIT Kharagpur
2.	NPTEL courses on Power System Generation, Transmission and Distribution, IIT Delhi.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Develop the single line diagram for the power system.	L3: Applying
CO2	:	Perform and analyse load flow computations using bus admittance matrix	L4: Analysing
CO3	:	Perform and analyse balanced fault using bus impedance matrix	L4: Analysing
CO4	:	Develop computational models for unsymmetrical fault analysis in power systems	L6: Creating
CO5	:	Demonstrate the transient stability studies.	L3: Applying

23PTEE502	POWER SYSTEM PROTECTION AND SWITCH GEAR			SEMESTER			V
PREREQUISITES			**CATEGORY**	**PC**	**Credit**		**3**
Power Generation, Transmission and Distribution systems, Measurements and Instrumentation.			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To acquire knowledge about the power system protection and switchgear components.
2.	To understand the concepts of various protection schemes for power system equipment.
3.	To study the functioning of static relays and numerical protection schemes.

UNIT I	**PROTECTION AND RELAYS**	**9**	**0**	**0**	**9**

Need for protective system – Protection system components – Zones of protection – Primary and Backup protection - Essential qualities of protection – Basic principle of operation of relays – classifications of relays - Universal torque equation – Basic Relay terminology : relay time, pick up and reset current, PSM and TSM – calculation of relay operating time- construction and principle of operation: Electromagnetic relays – directional and non-directional over current relays – Distance relays: Impedance, reactance and mho type – Differential relays – Translay relay – Negative sequential relays and under frequency relays.

UNIT II	**CIRCUIT BREAKERS**	**9**	**0**	**0**	**9**

HRC fuses : construction, working, characteristics, and applications - Physics of arcing phenomenon and arc interruption theories –recovery voltage and restriking voltage – expression for RRRV – current chopping – interruption of capacitive current – Resistance switching - Types of circuit breakers - Minimum oil, Air-blast , air break, SF_6, MCBs, MCCBs and Vacuum circuit breakers - Problems of circuit interruption: - Rating of circuit breakers – Testing of circuit breakers – Selection of circuit breakers - HVDC circuit breakers.

UNIT III	**ALTERNATOR AND TRANSFORMER PROTECTION**	**9**	**0**	**0**	**9**

Alternator protection: Stator protection: Differential protection- Percentage differential relays, balanced earth-fault protection, Stator inter turn protection - Field ground fault protection - Protection of stator windings by overvoltage relays - Protection against stator open circuits, loss of synchronism, loss of excitation, rotor fault protection - numerical problems on % winding unprotected.

Transformer protection: differential protection – biased differential protection-numerical problem on design of CTs ratio - restricted earth fault relay -Buchholz relay protection- harmonic restraint relay.

UNIT IV	**MOTOR, BUS BAR AND TRANSMISSION LINE PROTECTION**	**9**	**0**	**0**	**9**

AC Motor protection against short circuit, overload, and single phasing.
Bus bar protection: Differential and Fault bus protection – Transmission line protection: Over Current, Carrier Current, distance or impedance relay, Translay Relay.

UNIT V	**STATIC RELAYS AND NUMERICAL PROTECTION**	**9**	**0**	**0**	**9**

Static relays – Phase, Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Over current protection, transformer differential protection, distance protection of transmission line.

Total (45L + 0T) = 45 Periods

Text Books:	
1.	Sunil S. Rao, “Switchgear and Protection”, Khanna Publishers, New Delhi, Fourth Edition, 2010.
2.	Badri Ram and D.N. Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw Hill, 2015.
3.	A. Chakrabarti, M. L. Soni, P. V. Gupta and Bhatnagar, “A Text Book on Power System Engineering”, Dhanpat Rai & Co. (Pvt.) Ltd., Delhi, Second Revised Edition 2017.
4.	B.Ravindranath and N. Chander, “Power System Protection and Switchgear”, New Age International (P) Ltd, Second Edition, 2018.
Reference Books:	
1.	Arun Ingole, “Switchgear and Protection”, Pearson Education India, 2017.
2.	T.S. Madhav Rao, “Power System Protection Static Relays with Microprocessor Applications”, Tata McGraw-Hill, 1998.
3.	Y.G. Paithankar and S.R. Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India Private Ltd, New Delhi, 2010.
4.	C.L.Wadhwa, “Electrical Power Systems”, 6th Edition, New Age International (P) Ltd., 2010.
E-References:	
1.	NPTEL Course: Power System Protection - Prof. S.A. Soman, IIT-B.
2.	NPTEL Course: Power System Protection – organized by IIT-B.
3.	www.cdeep.iitb.ac.in. (Electrical Engineering)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Analyse the characteristics and functions of protective relays.	L3: Applying
CO2	:	Acquire knowledge on functioning of circuit breaker.	L2: Understanding
CO3	:	Assess the protection schemes of alternator and transformer.	L1: Remembering
CO4	:	Assess the protection schemes of motor, bus bar and transmission lines.	L1: Remembering
CO5	:	Develop the knowledge on static and numeric type relays.	L4: Analysing

23PTEE503	ELECTRICAL DRIVES AND CONTROL		SEMESTER			V
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
DC Machines and Transformers, Synchronous and Induction Machines, and Power Electronics		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To know about the analyze the operation of the chopper fed dc drive, both qualitatively and quantitatively.
2.	To understand the operation and performance of AC motor drives.

UNIT I	DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES	9	0	0	9

Review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed. Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper.

UNIT II	MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE	9	0	0	9

Review of Four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, current controller specification and design, speed controller specification and design.

UNIT III	INDUCTION MOTOR CHARACTERISTICS	9	0	0	9

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency. Review of three-phase voltage source inverter, generation of three-phase PWM signals, constant V/f control of induction motor

UNIT IV	CONTROL OF SLIP RING INDUCTION MOTOR	9	0	0	9

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

UNIT V	CONTROL OF SRM AND BLDC MOTOR DRIVES.	9	0	0	9

SRM construction - Principle of operation - SRM drive design factors-Torque controlled SRM- Block diagram of Instantaneous Torque control using current controllers and flux controllers. Construction and Principle of operation of BLDC Machine -Sensing and logic switching scheme-Sinusoidal and trapezoidal type of Brushless dc motors – Block diagram of current controlled Brushless dc motor drive

Total (45L + 0T) = 45 Periods

Text Books:

1.	G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2.	R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall,2010
3.	B.K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, New Delhi, 2010.

Reference Books:

1.	G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2012.
2.	W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

E-Reference:	
1.	https://www.iith.ac.in/~ketan/drives.html

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the characteristics of dc motors and induction motors.	L2: Understanding
CO2	:	Summarize the operation of chopper fed DC drives.	L4: Analyzing
CO3	:	Understand the principles of speed-control of dc motors and induction motors.	L2: Understanding
CO4	:	Identify suitable power electronic converters used for dc motor and induction motor speed control.	L3: Applying
CO5	:	Analyze the SRM and BLDC motor drive control.	L4: Analyzing

23PTEE504	SPECIAL ELECTRICAL MACHINES				SEMESTER		V
PREREQUISITES			CATEGORY		PC	Credit	3
Electrical Machines, Power Electronics.			Hours / Week		L	T	P	TH
					3	0	0	3

Course Objectives:

1.	To learn the fundamental concepts of special electrical machines.
2.	To select proper special machines based on applications.

UNIT I	SYNCHRONOUS RELUCTANCE MOTORS	9	0	0	9

Constructional features – Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram - Characteristics – Vernier motor.

UNIT II	PERMANENT MAGNET BRUSHLESS D.C. MOTORS	9	0	0	9

Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Power controllers – Motor characteristics and control.

UNIT III	PERMANENT MAGNET SYNCHRONOUS MOTORS	9	0	0	9

Principle of operation – EMF and torque equations – Reactance – Phasor diagram – Power controllers - Converter - Volt-ampere requirements – Torque speed characteristics - Microprocessor based control.

UNIT IV	SWITCHED RELUCTANCE MOTORS	9	0	0	9

Constructional features – Principle of operation – Torque prediction – Power controllers – Non-linear analysis – Microprocessor based control - Characteristics – Computer control.

UNIT V	STEPPING MOTORS	9	0	0	9

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi stack configurations – Theory of torque predictions – Linear and non-linear analysis – Characteristics – Drive circuits

Total (45L + 0T) = 45 Periods

Text Books:

1.	T.J.E. Miller, “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
2.	P.P. Acarnley, “Stepping Motors – A Guide to Motor Theory and Practice”, Peter Perengrinus, London, 1982.

Reference Books:

1.	R. Krishnan, “Switched Reluctance Motor Drives”, CRC Press, 2001.
2.	R. Krishnan, “Permanent Magnet Synchronous and Brushless DC Motor Drives”, CRC Press, 2010.

E-References:

1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the principles behind the different special machines.	L2: Understanding
CO2	:	Apply the electromagnetic concepts for development of EMF and Torque in machines.	L3: Applying
CO3	:	Select the control structure in terms of hardware to control the special machines.	L4: Analyzing
CO4	:	Analyze appropriate control techniques for efficient control of special machines.	L4: Analyzing
CO5	:	Develop strategy and methods to implement suitable application-based projects.	L2: Understanding

23PTEE505	POWER ELECTRONICS AND DRIVES LABORATORY			SEMESTER			V
PREREQUISITES		CATEGORY	PC	Credit			1.5
Electrical Machines, Power Electronics		Hours / Week	L	T	P		TH
			0	0	3		3

Course Objectives:

To study, analyse the performance of different power electronic converter circuits and learn to simulate different power electronic converter circuits and analyze their performance.

LIST OF EXPERIMENTS:

1.	Characteristics of power diode and SCR
2.	Static and Switching Characteristics of Power MOSFET
3.	Static and Switching Characteristics of Power IGBT
4.	Single phase AC to DC fully controlled converter
5.	Step down and step-up chopper
6.	IGBT based single-phase PWM inverter
7.	IGBT based three-phase PWM inverter
8.	TRIAC based single phase AC voltage controller
9.	Speed control of separately excited chopper fed DC Drive.
10.	V/f speed control method of Three phase Induction Motor.
11.	Speed control of BLDC Motor.
12.	Speed control of Switched Reluctance Motor

Total (0T+ 45P) = 45 Periods

Reference Books:

1.	M.H. Rashid, "Power Electronics: Circuits, Devices and Applications", Pearson Education, PHI Third Edition, New Delhi, 2009.
2.	P.S. Bimbra, "Power Electronics", Khanna Publishers, New Delhi 2016.
3.	Seung-Ki Sul, "Control of Electric Machine Drive Systems", John Wiley & Sons, Ltd., 2011.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Analyze the characteristics of MOSFET, SCR and IGBT.	L1: Analyzing
CO2	:	Demonstrate the performance of DC-DC Converters.	L3: Applying
CO3	:	Demonstrate the performance of DC-AC Converters.	L3: Applying
CO4	:	Analyze the performance characteristics of Power Converters for DC and AC Drive.	L4: Analyzing
CO5	:	Analyze the performance characteristics of Power Converters for Special Electrical Machine.	L5: Evaluating

23PTEE601	POWER SYSTEM OPERATION AND CONTROL			SEMESTER			VI
PREREQUISITES			**CATEGORY**	**PC**	**Credit**		**3**
Power Generation, Transmission and Distribution Systems; Power System Analysis and Stability			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1. To familiarize the significance of power system operation and control.
2. To understand the concepts of real power – frequency control, and reactive power – voltage control.
3. To acquire knowledge on economic power system operations, and computer aided control of power system.

UNIT I	OVERVIEW OF POWER SYSTEM OPERATION AND CONTROL	9	0	0	9

Power scenario in Indian grid – National and Regional load dispatching centers – requirements of good power system - necessity of voltage and frequency regulation. System load variation: System load characteristics, load curves -daily, weekly and annual, load-duration curve, load factor, diversity factor. Reserve requirements: Installed, spinning, cold and hot reserves. Basic concepts of economic dispatch, unit commitment, load shedding and islanding, deregulation, governor control, LFC, AVR, system voltage control and security control - Tariff: characteristics and types.

UNIT II	REAL POWER - FREQUENCY CONTROL	9	0	0	9

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 of uncontrolled and controlled cases; Multi-area systems: Two-area system modeling: static analysis, uncontrolled case, tie-line with frequency bias control; state variable model- integration of economic dispatch control with LFC.

UNIT III	REACTIVE POWER–VOLTAGE CONTROL	9	0	0	9

Generation and absorption of reactive power - basics of reactive power control – Automatic Voltage Regulator (AVR) – brushless AC excitation system – block diagram representation of AVR loop - static and dynamic analysis – stability compensation – voltage drop in transmission line - methods of reactive power injection - tap changing transformer, SVC and STATCOM for voltage control.

UNIT IV	ECONOMIC DISPATCH AND UNIT COMMITMENT	9	0	0	9

Statement of economic dispatch problem - input and output characteristics of thermal plant Incremental cost curve, co-ordination equations with and without loss, solution by direct method and Lambda -iteration method (No derivation of loss coefficients)- Base point and participation factors method.

Statement of Unit Commitment problem- Constraints in Unit Commitment: spinning reserve- thermal unit constraints- hydro constraints- fuel constraints and other constraints; Unit Commitment solution methods: Priority-list methods, forward dynamic programming approach, numerical problems only in priority-list method using full-load average production cost.

UNIT V	COMPUTER CONTROL OF POWER SYSTEMS	9	0	0	9

EMS functions - Energy control centre functions: Monitoring, data acquisition and control, energy control centre levels - SCADA: system hardware configuration –master station-remote terminal units- and functions; Network topology determination- state estimation, security analysis and control - Various operating states: normal, alert, emergency, extremis and restorative; State transition diagram showing various state transitions and control strategies.

Total (45L + 0T) = 45 Periods

Text Books:	
1.	Allen J. Wood and Bruce F.Wollenberg, "Power Generation, Operation and Control", Wiley India Ltd, New Delhi, Second Edition, Reprint 2016.
2.	Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction", Tata McGraw Hill Publishing Company Ltd, New Delhi, 34th reprint 2010.
3.	P. Kundur, "Power System Stability & Control", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint 2010.
Reference Books:	
1.	D,P. Kothari, and I.J. Nagrath, "Modern Power System Analysis", Fourth, Tata McGraw Hill Education Pvt., Limited, New Delhi, 2011.
2.	L.L. Grigsby, "The Electric Power Engineering, Hand Book", CRC Press & IEEE Press, 2001.
3.	B.M. Weedy and B.J. Cory, "Electric Power systems", Wiley, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recognize the fundamentals of power system operation and control.	L2: Understanding
CO2	:	Interpret the control action to meet the real power demand variations.	L3: Applying
CO3	:	Employ the reactive power injections for voltage profile improvement.	L3: Applying
CO4	:	Formulate the economic scheduling problems in power system.	L4: Analysing
CO5	:	Examine the need of computer aided control for power system operations and control.	L4: Analysing

23PTEE602	UTILIZATION OF ELECTRICAL ENERGY				SEMESTER		VI
PREREQUISITES		**CATEGORY**	**PC**	**Credit**			**3**
Electrical Machines, Power System, Power Electronics		**Hours / Week**	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Objectives:

1.	To understand the economics of generation, tariff, and energy conservation methods.
2.	To impart knowledge on principle and design of illumination systems.
3.	To analyze the performance and different methods of electric heating and electric welding.
4.	To impart knowledge on electric traction systems and their performance.
5.	To understand electric drives for various industrial applications.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Economics of generation – definitions – load duration curve – number and size of generator units – Cost of electrical energy – tariff – Availability Based Tariff (ABT) – Battery Energy Storage System (BESS) - Frequency Based energy measurement - Need for electrical energy conservation – methods- Introduction to Energy Audit

UNIT II	**ILLUMINATION**	**9**	**0**	**0**	**9**

Introduction-nature of radiation – definition – laws of illumination – luminous efficacy-photometry – lighting calculations – design of illumination systems for residential, commercial, street lighting and sports ground– types of lamps –incandescent lamp- mercury vapour –fluorescent lamp-energy efficiency lamps – types of lighting schemes – requirements of good lighting

UNIT III	**HEATING AND WELDING**	**9**	**0**	**0**	**9**

Introduction- classification of methods of heating – requirements of a good heating material – design of heating element – temperature control of resistance furnace – electric arc furnace –induction heating – dielectric heating – electric welding – resistance welding – electric arc welding-electrical properties of arc-applications of electric arc welding.

UNIT IV	**ELECTRIC TRACTION**	**9**	**0**	**0**	**9**

Introduction – requirements of an ideal traction system – supply systems – train movement -mechanism of train movement – traction motors and control –speed control of three phase induction motor- multiple unit control – braking – recent trends in electric traction.

UNIT V	**DRIVES AND THEIR INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**

Electric drive –advantages of electric drive-individual drive and group drive –factors affecting selection of motor – types of loads – steady state –transient characteristics –size of motor– load equalization – industrial applications – modern methods of speed control of D.C drives-dynamic braking using thyristors-regenerative braking using thyristors.

Total (45L + 0T) = 45 Periods

Text Books:

1.	C.L. Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Pvt.Ltd, 2003.
2.	Eric Openshaw Taylor, “Utilisation of Electric Energy”, English Universities Press Limited, 1937.
3.	J.B. Gupta, “Utilization of Electric Power and Electric Traction”, S.K. Kataria and Sons, 2002.

Reference Books:

1.	G.C. Garg, S.K. Gridhar and S.M. Dhir, “A Course in Utilization of Electrical Energy”, Khanna Publishers, New Delhi, 2003.

2.	H. Partab, "Art and Science of Utilization of Electrical Energy", Dhanpat Rai and Co, New Delhi, 2004.
E-References:	
1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the economics of generation, tariff, and energy conservation methods.	L2: Understanding
CO2	:	Interpret the concept behind illumination and design a suitable illumination system for a specific application.	L3: Applying
CO3	:	Design and choose an appropriate heating method for specific application and gain knowledge about electric welding system.	L4: Analyzing
CO4	:	Explain the concepts and recent trends of traction system.	L4: Analyzing
CO5	:	Discuss the concepts of electric drives and their characteristics.	L2: Understanding

23PTEE603	SOLAR AND WIND ENERGY CONVERSION SYSTEMS				SEMESTER		VI
PREREQUISITES		**CATEGORY**	**PC**	**Credit**			**3**
Engineering Physics, Electrical Machines and Power Electronics		**Hours / Week**	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Objectives:

1.	To understand the concepts of power generation through Solar and Wind Power
2.	To learn the optimal extraction of renewable power and their integration to grid

		L	T	P	TH
UNIT I	**FUNDAMENTALS OF SOLAR ENERGY**	**9**	**0**	**0**	**9**

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

		L	T	P	TH
UNIT II	**FUNDAMENTALS OF WIND ENERGY**	**9**	**0**	**0**	**9**

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.

		L	T	P	TH
UNIT III	**SOLAR PHOTOVOLTAICS**	**9**	**0**	**0**	**9**

Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT- P&O, Incremental conductance) algorithms - Converter Control.

		L	T	P	TH
UNIT IV	**WIND GENERATOR TOPOLOGIES**	**9**	**0**	**0**	**9**

Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power converters. Generator-Converter configurations, Converter Control.

		L	T	P	TH
UNIT V	**GRID INTEGRATION**	**9**	**0**	**0**	**9**

Overview of grid code technical requirements. Fault ride-through for wind farms – real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Chetan Singh Solanki, "Solar Photovoltaics Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2009.
2.	T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd., 2012, 2nd edition.
3	P.S. Bimbhra, "Power Electronics", Khanna Publishers, New Delhi, 4th Edition, 2018.
4.	M.H. Rashid, "Power Electronics: Circuits, Devices and Applications", Pearson, 3rd Edition, 2013.

Reference Books:

1.	G.D. Rai, "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2011.
2.	G. M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley and Sons, 2013.
3.	G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004.

4.	H. Siegfried and R. Waddington, "Grid integration of wind energy conversion systems" John Wiley India Sons Ltd.,2006.
5.	N. Mohan et al. "Power Electronics: Converters, Application and Design", Wiley India (P) Ltd, New Delhi, 2008.
E – References:	
1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the physics behind the solar and wind power generation.	L2: Understanding
CO2	:	Implement the optimal extraction techniques in renewable power generation.	L3: Applying
CO3	:	Apply power electronics to renewable power optimization.	L3: Applying
CO4	:	Understand integration techniques used, power quality issues and their mitigation.	L2: Understanding
CO5	:	Device methods to create an approximate energy conversion systems.	L6: Creating

23PTEE701	HIGH VOLTAGE ENGINEERING			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PC**	**Credit**		**3**
Measurements and Instrumentation, Power Generation, Transmission and Distribution system			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To expose the various types of over voltage transients and their effect on power system.
2.	To introduce the concept of insulation co-ordination technique.
3.	To provide an overview of solid, liquid and gaseous dielectrics breakdown mechanism
4.	To show how to generate over voltages in the HV testing laboratory
5.	To show how to measure of high voltage and current quantity in HV testing laboratory
6.	To introduce testing procedure of HV power apparatus.

UNIT I	**OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS AND INSULATION CO-ORDINATION**	**9**	**0**	**0**	**9**

Causes of over voltages and its effect on power system – Lightning, switching surges and temporary over voltages – Reflection and Refraction of travelling waves – Bewley lattice diagram-protection against over voltages; Principle of Insulation Coordination on High voltage and Extra high voltage power systems.

UNIT II	**DIELECTRIC BREAKDOWN**	**9**	**0**	**0**	**9**

Properties of Dielectric materials- Gaseous breakdown in uniform and non-uniform fields – Corona discharges – Vacuum breakdown - Conduction and Breakdown in pure and commercial liquids dielectrics – Breakdown mechanisms in solid and composite dielectrics- Application of insulating materials in electrical equipment.

UNIT III	**GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS**	**9**	**0**	**0**	**9**

Generation of High DC voltages: Rectifiers, voltage multipliers and Van de Graff generator- Generation of High AC voltages: cascaded transformer, resonant transformer and tesla coil- Generation of High impulse voltages: single and multistage Marx circuits - Generation of switching voltages - Generation of impulse currents. Tripping and control of impulse generators.

UNIT IV	**MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS**	**9**	**0**	**0**	**9**

Measurement of high DC, AC, impulse voltages – Measurement of high currents: Direct, Alternating and Impulse – digital techniques in impulse voltage and current measurements.

UNIT V	**HIGH VOLTAGE TESTING OF ELECTRICAL POWER APPARATUS**	**9**	**0**	**0**	**9**

Overviews of International and Indian standards- laboratory test procedure: multi-level method, Up and Down method - HV Testing of Insulators, Bushings, Circuit Breakers, Power transformers, Surge Arresters, Power capacitors and Cables.

Total (45L + 0T) = 45 Periods

Text Books:

1.	M.S. Naidu and V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill Publishing Company Ltd, New Delhi, Fifth Edition, 2013.

Reference Books:

1.	E. Kuffel W.S. Zaengl, and J.Kuffel, "High Voltage Engineering Fundamentals", Newnes Publishers, Second Edition, Elsevier, New Delhi, 2005.
2.	C.L. Wadhwa, "High Voltage Engineering", New Age International (P) Ltd Publishers, Fourth Edition, 2020.

3.	Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, New Age International (P) Ltd Publishers, Third Edition, 2006.
E-references:	
1.	www.onlinecourses.nptel.ac.in/noc18_ee41
2.	NPTEL courses on High Voltage Engineering, IIT Kanpur.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Explain the various over voltages and its effect on power system.	L2: Understanding
CO2	:	Understand high voltage breakdown phenomena in insulating materials.	L2: Understanding
CO3	:	Explain the method of generating high DC, AC and impulse voltages	L3: Applying
CO4	:	Use appropriate procedure for measurement of high DC, AC and impulse currents.	L3: Applying
CO5	:	Comprehend the HV test procedures on electrical apparatus as per the Indian standards.	L2: Understanding

23PTEE702	SMART GRID TECHNOLOGIES			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PC**	**Credit**		**3**
Power Generation, Transmission and Distribution System			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1. To learn communication and automation technologies and high-performance computing for smart operation of power grid.

UNIT I	SMART GRID ARCHITECTURE	9	0	0	9

Introduction-Conceptual model of Smart Grid, Smart Grid architecture and Components, Smart Grid Control, Smart Grid Characteristics, Smart Grid Enabling Technologies, Stages for Grid Modernization, Smart Grid Benefits and Challenges

UNIT II	COMMUNICATION AND INFORMATION SECURITY	9	0	0	9

Requirements of Smart Grid Communications, Communication infrastructure for the Smart Grid, communication technologies for Smart Grid, Information Layer of Smart Grid, SG Security Objectives, Cyber Security Requirements for Smart Grid

UNIT III	CONTROL AND AUTOMATION TECHNOLOGIES	9	0	0	9

Smart metering: Benefits, Architecture, Key components and operation, communications architecture for smart metering, Demand-side integration (DSI): Definitions and services provided by DSI, Substation automation equipment: architecture, components and functions, Intelligent electronic devices (IED), Relay IED, Bay controller.

UNIT IV	SMART TRANSMISSION AND DISTRIBUTION MANAGEMENT SYSTEMS	9	0	0	9

Structure of Energy management systems- Phasor Measurement Unit (PMU) - Wide-Area Measurement (WAM) for transmission Systems- Structure and main components of Distribution Management System- Supervisory Control and Data Acquisition (SCADA)- Customer information system

UNIT V	CLOUD COMPUTING AND DATA MANAGEMENT IN SMART GRID	9	0	0	9

Relationship between Smart Grid, cloud computing, and big data, Cloud Computing Characteristics in Improving Smart Grid, Cloud Computing Service Models, Cloud computing platform coupled with Smart Grid, Cloud Applications for Energy Management, Privacy Information Impacts on Smart Grid, Meter Data Management for Smart Grid

Total (45L + 0T) = 45 Periods

Text Books:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, and Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley, 2012
2. Stuart Borlase, “Smart Grids Advanced Technologies and Solutions”, Second Edition, CRC, 2018.

Reference Books:

1. James Momoh, “Smart Grid Fundamentals of Design and Analysis”, Wiley, 2012.

E-Reference:

1. https://archive.nptel.ac.in/courses/108/107/108107113/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the Smart Grid modernization process and its present developments.	L1: Remembering
CO2	:	Select the suitable communication networks for smart grid applications.	L4: Analyzing
CO3	:	Use a suitable smart device for Smart Grid operation.	L3: Applying
CO4	:	Illustrate a smart transmission and distribution system using PMU, WAM and SCADA.	L4: Analyzing
CO5	:	Explain the need of high end computing and big data analytics in smart grid.	L2: Understanding

23PTHS701	INDUSTRIAL MANAGEMENT AND ECONOMICS			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**HS**	**Credit**		**3**
Mathematics			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1. To understand the concept of management, economics and Indian financial system

UNIT I	MODERN CONCEPT OF MANAGEMENT	9	0	0	9

Scientific management-Functions of management-Planning- Organising- Staffing-Directing- Motivating- Communicating- Co-ordinating- Controlling-Organizational structures- Line, Line and staff and Functional relationships- Span of control- Delegation- Management by Objectives.

UNIT II	PERSONNEL MANAGEMENT	9	0	0	9

Objectives and functions of personnel management- Recruitment-Selection and training of workers- Labour Welfare- Industrial Fatigue- Industrial disputes-Trade Unions- Quality circles. Formation of companies: Proprietory-Partnership-Joint stock companies- Public sector- Joint sector and Co-operative sector.

UNIT III	MARKETING MANAGEMENT	9	0	0	9

Pricing- Promotion- Channels of distribution- Market research-Advertising. Production Management: Batch and mass production- Inventory control- EOQ-Project planning by PERT/CPM- Construction of Network (Basic ideas only).

UNIT IV	BASICS OF ECONOMICS	9	0	0	9

Theory of demand and supply- Price mechanism- Factors of production- Land, labour, capital and organization- National income- Difficulties in estimation- Taxation- Direct and indirect taxes- Progressive and regressive- Black money- Inflation- Causes and consequences.

UNIT V	INDIAN FINANCIAL SYSTEM	9	0	0	9

Reserve bank of India: Functions- Commercial banking system-Development financial institutions- IDBI- ICICI- SIDBI- IRBI- NABARD- Investment institutions-UTI- Insurance companies- Indian capital market- Stock market- Functions- Role of the public sector- Privatisation- Multinational corporations and their impact on the Indian economy

Total (45L + 0T) = 45 Periods

Text Books:

1. O.P. Khanna, "Industrial Management", Dhanpat Rai Publications,4th edition, 1980.
2. Philip Kotler, Kevin Lane Keller, SweeHoon Ang, Chin Tiong Tan, and Siew Meng Leong, "Marketing Management: An Asian Perspective" Pearson Education Limited, 7th Edition, 2017
3. A. N. Agrawal, "Indian Economy", Vikas Publishing House PVT, 4th edition, 1978.

Reference Books:

1. K. K. Ahuja, "Industrial Management" Khanna Publishers, 1978.
2. K.K. Dewett, and Shyam Lal, "Modern Economic Theory", S. Chand and Company Limited, 2008.

E-References:

1. www.onlinecourses.nptel.ac.in/
2. www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the concepts of management	L2: Understanding
CO2	:	Remember various types of management.	L1: Remembering
CO3	:	Analyze the Indian economics	L4: Analyzing
CO4	:	Create an organization efficiently for its upliftment	L6: Creating
CO5	:	Apply marketing concept to any organization to earn more profit.	L3: Applying

23PTEE801	PROJECT WORK			SEMESTER		VIII
PREREQUISITE		**CATEGORY**	**EEC**	**Credit**		**3**
		Hours / Week	**L**	**T**	**P**	**TH**
			0	**0**	**6**	**6**

COURSE OBJECTIVES:

The student should be made to learn methodology to select a good project and able to work in a team leading to development of hardware/software product. Prepare a good technical report. Gain Motivation to present the ideas behind the project with clarity.

GUIDELINES AND EVALUATION

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The aim of the project work is to deepen Comprehension of principles by applying them to a new problem which may be the design /fabrication of any power component / circuit / sensor / Activator / Controller, a research investigation, a computer or management project or a design problem.

The students may be grouped into 2 to 4 and work under a project supervisor. The device/system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible, with an industry.

The progress of the project is evaluated for internal assessment based on a minimum of three reviews. The project review committee may be constituted by the Head of the Department. The student shall be instructed to meet the supervisor periodically and to attend the review committee meetings for evaluating the progress.

A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

Total (90P) = 90 Periods

COURSE OUTCOMES: On completion of the course the student will be able to			**Bloom's Taxonomy Mapped**
CO1	:	Ability to identify, formulate, design, interpret, analyze and provide solutions to complex engineering and societal issues by applying knowledge gained on basics of science and Engineering	L6: Creating
CO2	:	Ability to choose, conduct and demonstrate a sound technical knowledge of their selected project topics in the field of power components, protection, high voltage, electronics, process automation, power electronics and drives, instrumentation and control by exploring suitable engineering and IT tools.	L6: Creating
CO3	:	Ability to understand, formulate and propose new learning algorithms to solve engineering and societal problems of moderate complexity through multidisciplinary projects understanding commitment towards sustainable development.	L2: Understanding
CO4	:	Ability to demonstrate, prepare reports, communicate and work in a team as a member/leader by adhering to ethical responsibilities	L6: Creating
CO5	:	Ability to acknowledge the value of continuing education for oneself and to stay up with technology advancements.	L5: Evaluating

23PTEEE11	ADVANCED CONTROL SYSTEMS			SEMESTER			VI
PREREQUISITES		CATEGORY		PE	Credit		3
Signals and Systems, Control systems		Hours / Week		L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To gain knowledge in the analysis of non-linear system
2.	To gain knowledge in the analysis of digital control of linear system.

UNIT I	NON-LINEAR SYSTEM – DESCRIPTION & STABILITY	9	0	0	9

Linear vs non-linear – Examples – Incidental and Intentional – Mathematical description - Equilibria and linearization - Stability – Lyapunov function – Construction of Lyapunov function.

UNIT II	PHASE PLANE AND DESCRIBING FUNCTION ANALYSIS	9	0	0	9

Construction of phase trajectory – Isocline method – Direct or numerical integration – Describing function analysis – Computation of amplitude and frequency of oscillation.

UNIT III	Z - TRANSFORM AND DIGITAL CONTROL SYSTEM	9	0	0	9

Z transfer function – Block diagram – Signal flow graph – Discrete root locus – Bode plot.

UNIT IV	STATE-SPACE DESIGN OF DIGITAL CONTROL SYSTEM	9	0	0	9

State equation – Solutions – Realization – Controllability – Observability – Stability – Jury's test.

UNIT V	MUTLI INPUT MULTI OUTPUT (MIMO) SYSTEM	9	0	0	9

Models of MIMO system – Matrix representation – Transfer function representation – Poles and Zeros – Decoupling – Introduction to multivariable Nyquist plot and singular values analysis – Model predictive control.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Benjamin C. Kuo, “Digital Control Systems”, Oxford University Press, 2010.
2.	I.J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International Publishers, 2021.

Reference Books:

1.	Raymond T. Stefani & Co., “Design of feedback Control systems”, Oxford University, 2010.
2.	George J. Thaler, “Automatic Control Systems”, Jaico Publishers, 2011.

E-References:

1.	https://nptel.ac.in/courses/108103007
2.	https://www.google.co.in/books/edition/Advanced_Control_Systems/k7AVfjnoS7IC?hl=en&gbpv=1&dq=advanced+control+system&printsec=frontcover

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO1	:	Use the conventional technique of non-linear system analysis.	L2: Understanding
CO2	:	Solve the problems in digital control systems using Z transform.	L5: Evaluating
CO3	:	Analyze discrete time systems using conventional techniques.	L3: Applying
CO4	:	Analyze the digital control system using state-space formulation.	L3: Applying
CO5	:	Know the formulation and analysis of MIMO systems.	L6: Creating

<table>
<tr><td>23PTEEE12</td><td colspan="2">DISCRETE CONTROL SYSTEMS</td><td colspan="3">SEMESTER</td><td>VI</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Control Systems</td><td rowspan="2">Hours / Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
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Course Objectives:

1.	To understand the digital signal processing.
2.	To study the design of sampled data control systems in state space.
3.	To impart knowledge on digital control algorithms and stability study.

		L	T	P	TH
UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Review of frequency and time response analysis and specifications of continuous time systems - need for controllers - continuous time compensations - continues time PI, PD, PID controllers, Realization of basic compensators: Lag, Lead and Lag-Lead compensation schemes - problems.

		L	T	P	TH
UNIT II	**SIGNAL PROCESSING IN DIGITAL CONTROL**	**9**	**0**	**0**	**9**

Need for digital control – Configuration of basic digital control scheme – Principles of signal conversion – Basic discrete-time signals – Time domain and frequency domain models for discrete-time systems - Aliasing – Reconstruction of analog signals – Practical aspects of the choice of sampling rate – Discretization based on bilinear transformation.

		L	T	P	TH
UNIT III	**MODELING AND ANALYSIS OF SAMPLED DATA CONTROL SYSTEM**	**9**	**0**	**0**	**9**

Differential equation description – Z-transform method of description– Z-transform analysis of sampled data control systems –Jury's stability test – Routh stability criterion on the r-plane – State variable concepts: First companion – Second companion – Jordan canonical models – Discrete state variable models – Elementary principles.

		L	T	P	TH
UNIT IV	**DESIGN OF DIGITAL CONTROL ALGORITHMS**	**9**	**0**	**0**	**9**

Introduction – z-plane specifications of control system design –Digital lead, lag and lag-lead compensator design using frequency response plots - Digital lead lag compensator design using Root locus plots – z-plane synthesis – Digital controllers for deadbeat performance - Examples.

		L	T	P	TH
UNIT V	**PRACTICAL ASPECTS OF DIGITAL CONTROL ALGORITHMS**	**9**	**0**	**0**	**9**

Development and implementation of digital PID control algorithms – Tunable PID controllers - Digital temperature control system: Control algorithm – Digital position control system: Digital measurement of shaft position/speed, control algorithm – Stepping motors and their controls: Torque-speed curves, Interfacing of stepper motors to microprocessors

Total (45L + 0T) = 45 Periods

Text Books:

1.	M. Gopal, "Digital Control and Static Variable Methods", Tata McGraw Hill, New Delhi, 2009.
2.	I.J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Publishers, New Delhi, 2021.

Reference Books:

1.	B.C. Kuo, "Digital Control Systems", Oxford University Press, 2nd Edition,2007.
2.	K. Ogata, "Modern Control Engineering", Pearson Education, 2002.

3.	Kenneth J. Ayala, "The 8051 Microcontroller- Architecture, Programming and Applications", Penram International, 2nd Edition, 1996.
E-References:	
1.	https://nptel.ac.in/courses/108103008/
2.	https://www.sciencedirect.com/topics/engineering/digital-control-system

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Outline sampling techniques to control systems.	L1: Remembering
CO2	:	Design the various digital control algorithms.	L4: Analyzing
CO3	:	Predict the performance of various types of digital controllers.	L4: Analyzing
CO4	:	Identify the various types of digital compensators.	L2: Understanding
CO5	:	Illustrate applications of digital control.	L3: Applying

23PTEEE13	DIGITAL CONTROLLER IN POWER ELECTRONICS APPLICATIONS		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Control Systems, Power Electronics		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the concepts of discrete time systems.
2.	To analyze systems in z domain.
3.	To design the digital controllers

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction-Comparison between analog and digital control-Importance of digital control-Structure of digital control-Examples of digital control system-Difference equations-Z-transform-MATLAB examples. Frequency response of discrete time systems-Properties of frequency response of discrete time systems-Sampling theorem.

UNIT II	**Z-PLANE ANALYSIS OF DISCRETE-TIME CONTROL SYSTEMS**	**9**	**0**	**0**	**9**

Impulse sampling and data hold -Pulse transfer function - Realization of digital controllers- Mapping between s-plane and z plane - Stability analysis of closed loop systems in z-plane–Transient and steady state analyses.

UNIT III	**STATE SPACE APPROACH TO DISCRETE-TIME CONTROL SYSTEMS**	**9**	**0**	**0**	**9**

State space representation of continuous and digital control systems - Solution of continuous and discrete time state space equations -Pulse transfer function matrix - Discretization of continuous time state space equations.

UNIT IV	**DIGITAL CONTROLLER DESIGN METHODS**	**9**	**0**	**0**	**9**

Cascade compensators using Root Locus- Design of PID controllers by using bilinear transformation- Digital controller design using bilinear transformation- Dead-beat response design- Deadbeat controller without and with prescribed manipulated variable-Choice of sample time for deadbeat controller-Realization of Digital controllers- Computer based simulation.

UNIT V	**DIGITAL CONTROLLERS IN POWER ELECTRONICS APPLICATIONS**	**9**	**0**	**0**	**9**

Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation.

Total (45L + 0T) = 45 Periods

Text Books:

1.	M. Gopal, "Digital Control and State Variable Methods", McGraw Hill Education, 4th Edition, 2014.
2.	K. Ogata, "Discrete- Time control systems", Pearson Education, India, 2nd Edition, 2015.
3.	B.C. Kuo, "Digital Control System", Oxford University Press; 2ndEdition, 2012.
4.	Karl J. Astrom and Tore Hagglun, "PID Controllers: Theory, Design and Tuning" International Society for Measurement and Control, 1995.

Reference Books:	
1.	G.F. Franklin, J. David Powell and M. Workman, Digital Control of Dynamic Systems, 3rd ed., Addison Wesley, 2000.
2.	Constantine H. Houpis and Gary B. Lamont, “Digital Control Systems: Theory, Hardware, Software”, McGraw-Hill Book Company, 1985.
3.	M. J. Robert, “Fundamentals of Signals and Systems”, McGraw Hill Education, 2007.
E-Reference:	
1.	https://nptel.ac.in/courses/108103008

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	To understand the digital control system	L2: Understanding
CO2	:	Capable of determining the stability in z domain	L1: Applying
CO3	:	To understand the state space analysis	L1: Remembering
CO4	:	To design the various types of digital controllers	L3: Analysing
CO5	:	To check the digital controllers in power electronics design	L5: Evaluating

23PTEEE14	ROBOTICS AND AUTOMATION		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Signals and Systems		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic concepts associated with the design, functioning, applications, and social aspects of robots
2.	To study about the electrical drive systems and sensors used in robotics for various applications.
3.	To learn about analyzing robot kinematics, dynamics through different methodologies and study various design aspects of robot arm manipulator and end-effector
4.	To learn about various motion planning techniques and the associated control architecture.
5.	To understand the implications of AI and other trending concepts of robotics.

UNIT I	**BUILDING BLOCKS OF A ROBOT**	**9**	**0**	**0**	**9**

Robot kinematics - Geometric approach for 2R, 3R manipulators, homogenous transformation using D-H representation, kinematics of WMR, Lagrangian formulation for 2R robot dynamics.

UNIT II	**KINEMATICS AND DYNAMICS**	**9**	**0**	**0**	**9**

Robot kinematics - Geometric approach for 2R, 3R manipulators, homogenous transformation using D-H representation, kinematics of WMR, Lagrangian formulation for 2R robot dynamics.

UNIT III	**DESIGN OF ROBOTS & END-EFFECTORS**	**9**	**0**	**0**	**9**

Mechanical design aspects of a 2R manipulator, WMR; End-effector - common types – selection of the right end effector, End effector control, Maintenance, Uses and Benefits.

UNIT IV	**NAVIGATION, PATH PLANNING AND CONTROL ARCHITECTURE**	**9**	**0**	**0**	**9**

Mapping & Navigation – SLAM, Path planning for serial manipulators; types of control architectures - Cartesian control, Force control and hybrid position/force control, Behaviour based control, application of Neural network, fuzzy logic, optimization algorithms for navigation problems, programming methodologies of a robot.

UNIT V	**RECENT SEARCH TRENDS IN ROBOTICS**	**9**	**0**	**0**	**9**

Application of Machine learning - AI, Expert systems; Tele-robotics and Virtual Reality, Micro &Nanorobots, Unmanned vehicles, Cognitive robotics, Evolutionary robotics, Humanoids.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Saeed. B. Niku, “Introduction to Robotics, Analysis, System, Applications”, Pearson Educations, 2002.
2.	Roland Siegwart, and Illah Reza Nourbakhsh, “Introduction to Autonomous Mobile Robots”, MIT Press, 2011.

Reference Books:

1.	Richard David Klafter, Thomas A. Chmielewski, and Michael Negin, “Robotic Engineering: An Integrated Approach”, Prentice Hall, 1989.
2.	J.J. Craig, “Introduction to Robotics: Mechanics and Control”, 2nd Edition, Addison-Wesley, 1989.
3.	K.S. Fu, R.C. Gonzalez and C.S.G. Lee, “Robotics: Control, Sensing, Vision and Intelligence”, McGraw-Hill, 1987.
4.	Wesley E Snyder R, “Industrial Robots, Computer Interfacing and Control”, Prentice Hall International Edition, 1988.
5.	Robin Murphy, “Introduction to AI Robotics”, MIT Press, 2000.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basic building blocks of robot.	L2: Understanding
CO2	:	Understand the Design concepts in robotics.	L2: Understanding
CO3	:	Analyze the AI trends in robotics.	L4: Analysing
CO4	:	Apply the algorithms in control architecture.	L3: Applying
CO5	:	Analyze the mathematical solutions for robot dynamics.	L4: Analysing

23PTEEE15	INDUSTRIAL AUTOMATION AND CONTROL		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Control System		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To educate on design of signal conditioning circuits for various applications
2.	To educate on signal transmission techniques and their design
3.	Study of components used in data acquisition systems interface techniques
4.	To educate on the components used in distributed control systems
5.	To introduce the communication buses namely field bus and profibus.

UNIT I	**DESIGN OF SIGNAL CONDITIONING AND TRANSMISSION**	**9**	**0**	**0**	**9**

Design of V/I Converter and I/V Converter- Analog and Digital filter design and Adaptive filter design – Signal conditioning circuit for pH measurement, Level Measurement –Temperature measurement: Thermocouple, RTD and Thermistor - Cold Junction Compensation and Linearization – software and Hardware approaches - Electrical, Pneumatic and fiber optic transmissions-Digital transmission protocols-Study of two wire and four wire transmitters – Design of RTD based Temperature Transmitter, Thermocouple based Temperature Transmitter, Capacitance based Level Transmitter and Smart Flow Transmitters-smart sensors.

UNIT II	**DATA ACQUISITION AND INSTRUMENT INTERFACE**	**9**	**0**	**0**	**9**

Programming and simulation of Building block of instrument Automation system – Signal analysis, I/O port configuration with instrument bus protocols - ADC, DAC, DIO, counters &timers, PC hardware structure, timing, interrupts, DMA, software and hardware installation, current loop, RS 232/RS485, GPIB, USB protocols.

UNIT III	**PLC AND SCADA**	**9**	**0**	**0**	**9**

Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC – Relay logic and Ladder logic – Functional blocks – Communication Networks for PLC. PLC based control of processes – Computer control of liquid level system – heat exchanger – Smart sensors and Field bus. SCADA: - Remote terminal units, Master station, Communication architectures and Open SCADA protocols.

UNIT IV	**DISTRIBUTED CONTROL SYSTEM**	**9**	**0**	**0**	**9**

Evolution - Different architectures - Local control unit - Operator Interface – Displays -Engineering interface- Factors to be considered in selecting DCS.

UNIT V	**COMMUNICATION PROTOCOLS**	**9**	**0**	**0**	**9**

Introduction- Evolution of signal standard – HART communication protocol –Communication modes – HART Networks – HART commands –HART and OSI models-HART applications Field bus:- Introduction, General Field bus architecture, Basic requirements of Field bus standard, Field bus topology, Interoperability and Interchange ability Profibus:- Introduction, Profibus protocol stack, Profibus communication model, Communication objects, System operation and Troubleshooting – Foundation fieldbus versus Profibus.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Alan S Morris, "Measurement and Instrumentation Principles", Elsevier, 2006.
2.	C.J.Chesmond, P.A.Wilson, and M.R.Lepla, "Advanced Control System Technology", Viva Books Private Limited, 1998.

Reference Book:

1.	Patrick H.Garrett, "High Performance Instrumentation and Automation", CRC Press, Taylor & Francis Group, 2005.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Design of signal conditioning circuits for various applications is educated to students.	L3: Applying
CO2	:	Familiar with signal transmission techniques and their design	L3: Applying
CO3	:	Use the components in data acquisition systems, interface techniques	L3: Applying
CO4	:	Familiar on the components used in distributed control systems	L2: Understanding
CO5	:	Familiar on communication buses namely field bus and profibus	L2: Understanding

23PTEEE21	HVDC TRANSMISSION SYSTEMS			SEMESTER		VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power System Generation, Transmission and Distribution Systems		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the concept, planning of DC power transmission and comparison with AC power transmission.
2.	To analyze the converters used in HVDC system.
3.	To study about the HVDC system control.
4.	To understand the reactive power requirements of the converter and Static VAR control methods.
5.	To understand the harmonics generation in HVDC system and design of harmonics filters.
6.	To impart knowledge on modelling and analysis of HVDC systems.

UNIT I	**DEVELOPMENT OF HVDC TECHNOLOGY**	**9**	**0**	**0**	**9**

Introduction – Comparison of AC and DC transmission – Applications of DC transmission – HVDC system configurations and components – Planning for HVDC transmission – Modern trends in HVDC technology - DC breaker - Operating problems - HVDC transmission based on voltage source converter - MTDC System: types and applications

UNIT II	**ANALYSIS OF HVDC CONVERTERS**	**9**	**0**	**0**	**9**

Line commutated converter - Pulse number – Choice of best topology for HVDC – Analysis of six pulse bridge converter without overlap, and with overlap less than 60˚ - Equivalent circuit model - Converter bridge characteristics – Analysis of 12 pulse converters - Analysis of Capacitor Commutated Converter (CCC) - Analysis of VSC based HVDC Converter.

UNIT III	**CONTROL OF HVDC SYSTEMS**	**9**	**0**	**0**	**9**

Basic principles of DC link control – Converter control characteristics – System Control Hierarchy – Firing angle control – Current and Extinction angle control – Starting and stopping of DC link and power control – Higher level controllers – Control of VSC based HVDC link.

UNIT IV	**REACTIVE POWER CONTROL, HARMONICS AND FILTERS**	**9**	**0**	**0**	**9**

Reactive power requirements in steady state – Sources of reactive power – SVC and STATCOM.
Generation of Harmonics: characteristic and non-characteristics harmonics – Troubles caused by harmonics - Design of AC filters – Design of DC Filters –Active filters.

UNIT V	**MODELLING AND ANALYSIS OF HVDC SYSTEMS**	**9**	**0**	**0**	**9**

System models: converter – converter controllers – DC networks and AC networks; System simulation: Philosophy and tools – Physical model (HVDC simulator) and Parity simulator – Modelling of DC systems for digital dynamic simulation - Transient simulation of DC and AC networks.

Total (45L + 0T) = 45 Periods

Text Books:

1.	K.R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, New Delhi, Third Edition, 2015.
2.	Edward Wilson Kimbark, “Direct Current Transmission”, Vol. I, Wiley Interscience, New York, 1971.

Reference Books:

1.	Colin Adamson and N.G. Hingorani, “High Voltage Direct Current Power Transmission”, Garraway Limited, London, First edition, 1960.
2	J. Arrillaga, “HVDC Transmission”, Peter Peregrinus, London, 1983.

3	Erich Uhlmann, “Power Transmission by Direct Current”, B.S. Publications, 2004.
4	S. Kamakshaiah and V. Kamaraju, “HVDC Transmission”, First Edition, Tata McGraw Hill, 2011.
E-Reference:	
1.	www.onlinecourses.nptel.ac.in/noc18_ee41

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Outline the concept of HVDC technology and MTDC systems.	L2: Understanding
CO2	:	Analyze the converters used in HVDC system	L4: Analyzing
CO3	:	Acquire knowledge about basic principles of HVDC system control	L2: Understanding
CO4	:	Design of static VAR systems for reactive power control and filters for harmonic mitigation in HVDC system.	L3: Applying
CO5	:	Develop the modelling and Analysis of HVDC systems.	L4: Analyzing

23PTEEE22	EHVAC TRANSMISSION SYSTEMS			SEMESTER			VI
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1. To emphasize the fundamental concept of EHVAC transmission, electrostatic effects, corona effects and voltage controller for an EHVAC transmission system

UNIT	TITLE	L	T	P	TH
UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Necessity of EHV AC transmission, benefits and challenges, power handling capacity and line losses, mechanical considerations, resistance of conductors, temperature rise of conductors and current-carrying capacity, properties of bundled conductors – numerical problems.

UNIT	TITLE	L	T	P	TH
UNIT II	**LINE AND GROUND REACTIVE PARAMETERS**	**9**	**0**	**0**	**9**

Inductance of EHV line configurations, line capacitance calculation, sequence inductances and capacitances, line parameters for modes of propagation, resistance and inductance of ground return.

UNIT	TITLE	L	T	P	TH
UNIT III	**VOLTAGE GRADIENTS OF CONDUCTORS**	**9**	**0**	**0**	**9**

Electrostatics, field of sphere gap, field of line changes and properties, charge – potential relations for multi-conductors lines, surface voltage gradient on conductors, distribution of voltage gradient on sub-conductors of bundle, effect of high electro static field on humans, animals and plants.

UNIT	TITLE	L	T	P	TH
UNIT IV	**CORONA EFFECTS**	**9**	**0**	**0**	**9**

Power loss and corona loss, charge-voltage (q–V) diagram and corona loss, attenuation of travelling waves due to corona loss, audible noise: generation and characteristics, limits for audible, audible noise measurement and meters, formulae for audible noise and its use in design, relation between single-phase and three-phase AN levels example

UNIT	TITLE	L	T	P	TH
UNIT V	**POWER FREQUENCY VOLTAGE CONTROL**	**9**	**0**	**0**	**9**

Power circle diagram and its use - voltage control using synchronous condensers - cascade connection of shunt and series compensation - sub synchronous resonance in series capacitor - compensated lines - static VAR compensating system

Total (45L + 0T) = 45 Periods

Text Books:

1. R. D. Begamudre, “EHVAC Transmission Engineering” New Age International (P)Ltd., Fourth Edition, 2011.
2. Sunil. S. Rao, “HVAC and DC Transmission practice”, Khanna Publishers, Delhi, 2023.

Reference Books:

1. Shobhit Gupta and Deepak Gupta, “EHV AC/DC Transmission”, Genius Publications, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Summarize the trends in EHVAC Transmission and calculate Line inductance and capacitances of bundled conductors.	L2: Understanding
CO2	:	Analyze the transmission line parameters.	L4: Analysing
CO3	:	Recall the electrostatic effects and corona effects.	L1: Remembering
CO4	:	Select the appropriate voltage control devices.	L4: Analysing
CO5	:	Apply the compensation techniques.	L3: Applying

23PTEEE23	FLEXIBLE AC TRANSMISSION SYSTEMS		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To introduce the reactive power control techniques.
2. To educate on static VAr compensators and their applications
3. To provide knowledge on thyristor-controlled series capacitors
4. To study about STATCOM devices
5. To acquire knowledge on FACTS controllers

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Reactive Power Control in Electrical Power Transmission Lines -Uncompensated Transmission Line – Series Compensation – Basic Concepts of Static Var Compensator (SVC) – Thyristor Controlled Series Capacitor (TCSC) – Unified Power Flow Controller (UPFC).

UNIT II	**STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS**	**9**	**0**	**0**	**9**

Voltage Control by SVC – Advantages of Slope in Dynamic Characteristics – Influence of SVC on System Voltage – Design of SVC Voltage Regulator –Modelling of SVC for Power Flow and Fast Transient Stability – Applications: Enhancement of Transient Stability – Steady State Power Transfer – Enhancement of Power System Damping.

UNIT III	**THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS**	**9**	**0**	**0**	**9**

Operation of the TCSC – Different Modes of Operation – Modelling of TCSC – Variable Reactance Model – Modelling for Power Flow and Stability Studies. Applications: Improvement of the System Stability Limit – Enhancement of System Damping

UNIT IV	**VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS**	**9**	**0**	**0**	**9**

STATCOM – Principle of Operation – V-I Characteristics. Applications: Steady State Power Transfer-Enhancement of Transient Stability – Prevention of Voltage Instability. SSSC-Operation of SSSC and the Control of Power Flow –Modelling of SSSC In Load Flow and Transient Stability Studies.

UNIT V	**CO-ORDINATION OF FACTS CONTROLLERS**	**9**	**0**	**0**	**9**

Controller Interactions – SVC – SVC Interaction – Co-ordination of Multiple Controllers using Linear Control Techniques – Control Coordination using Genetic Algorithm.

Total (45L + 0T) = 45 Periods

Text Books:

1. R.Mohan Mathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers For Electrical Transmission Systems", IEEE Press And John Wiley & Sons, Inc, 2002.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006, 2011.
3. K.R.Padiyar, " FACTS Controllers in Power Transmission and Distribution", New Age International Publishers New Delhi, second edition, 2016

Reference Books:	
1.	A.T.John, "Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers (IEEE), 1999.
2.	V.K.Sood, "HVDC And FACTS Controllers – Applications of Static Converters in Power System", Kluwer Academic Publishers, 2004.
3.	Xiao – Ping Zang, Christian Rehtanz and Bikash Pal, "Flexible AC Transmission System: Modelling and Control" Springer, 2012.
E-References:	
1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify suitable compensator for reactive power compensation.	L3: Applying
CO2	:	Analyse the impacts in network operations due to SVC placement.	L4: Analyzing
CO3	:	Visualise the significance of TCSC in network operation.	L3: Applying
CO4	:	Evaluate the performance of steady state and transients of FACTS controllers.	L5: Evaluating
CO5	:	Elaborate the features of coordination of FACTS controllers.	L3: Applying

23PTEEE24	SUBSTATION ENGINEERING AND AUTOMATION			SEMESTER			VI
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Electrical Measurements; Power Generation, Transmission and Distribution system			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To understand the importance of the substation design
2.	To outline the different factor for effecting substation design
3.	To classify the bus configurations
4.	To know the design criteria for substation grounding
5.	To understand the importance of substation automation

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Background, Need Determination, Budgeting, Financing, Traditional and innovative Substation Design, Site Selection and Acquisition, Design, Construction and Commissioning Process

UNIT II	**HIGH VOLTAGE SWITCHING EQUIPMENT**	**9**	**0**	**0**	**9**

Ambient conditions, Disconnect switches, Load Break switches, high speed grounding switches, power fuses, circuit switches, circuit breakers.

UNIT III	**TYPES OF SUBSTATIONS & BUS/SWITCHING CONFIGURATIONS**	**9**	**0**	**0**	**9**

Transmission substation, distribution substation, collector substation, switching substations, gas insulated substations, air insulated substations, bus configurations: single bus, double bus, double break, main and transfer bus, double bus, single breaker, ring bus, break-and-a-half, Comparison of configurations.

UNIT IV	**DESIGN OF SUBSTATION GROUNDING AND PROTECTION**	**9**	**0**	**0**	**9**

Reasons for substation grounding system, accidental ground circuit, Design criteria-Actual Touch and step voltage, soil resistivity, grid resistance, grid current, use of the design equations, selection of conductors, grounding fence, other design considerations. Lightning stroke protection-lightning parameters, empirical design methods. Substation fire protection-Fire hazards, fire protection measures, fire protection selection criterion.

UNIT V	**SUBSTATION AUTOMATION AND COMMUNICATIONS**	**9**	**0**	**0**	**9**

Introduction , components of substation automation system, automation applications, protocol fundamentals, supervisory control and data acquisition (SCADA) historical perspective, SCADA functional requirements, SCADA communication requirements, components of SCADA system, SCADA communication protocols, the structure of a SCADA communication protocol, security for substation communications, security methods, security assessment.

Total (45L + 0T) = 45 Periods

Text Books:

1.	John D. McDonald, “Electrical Power Substation Engineering”, CRC Press, 3rd Edition, 2017.

Reference Books:

1.	R. S. Dahiya and Vinay Attri, “Sub-Station Engineering Design & Computer Applications”, S K Kataria and son Publications, 1 st Edition, 2013.
2.	P. S. Satnam and P. V. Gupta, “Substation Design and Equipment”, Dhanapat Rai Publications, 1st Edition, 2013.
3.	Turan Gonen, “Electric Power Distribution Engineering”, CRC Press, Third Edition, 2014.

E-References:	
1.	https://www.transgrid.com.au/what-we-do/our-network/connections
2.	https://new.abb.com/substations
3.	https://ieeexplore.ieee.org/document/178016
4.	https://www.sciencedirect.com/topics/engineering/substations

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the commissioning of substation	L2: Understanding
CO2	:	Know working principles of substation switching equipment	L2: Understanding
CO3	:	Identify the different types of bus configurations	L1: Remembering
CO4	:	Design substation grounding and protection	L6: Creating
CO5	:	Analyse the substation communication (SCADA)	L4: Analysing

23PTEEE25	POWER SYSTEM AUTOMATION			SEMESTER			VI
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System; Power System Analysis and Stability			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To acquire fundamental knowledge on power system instrumentation.
2.	To familiarise on automations in electric power distribution systems.
3.	To get conceptual aspects in modern tools for power system automation.

UNIT I	**MEASUREMENTS AND SIGNAL TRANSMISSION TECHNIQUES**	**9**	**0**	**0**	**9**

Object and philosophy of power system instrumentation to measure large currents, high voltages, Torque and Speed - Standard specifications - Data acquisition systems for Power System applications - Data Transmission and Telemetry - PLC equipment, RTU, IED - computer control of power system - Man Machine Interface.

UNIT II	**COMMUNICATION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Communication requirements; Two-way capability – outages and faults; Public switched telephone network, Power line carrier communication – ripple control, cyclocontrol, carrier frequency (PLC, DLC, BPL), Radio communication (UHF point to point, UHF multi address system radio, VHF, PSN, Cellular radio), Fibre optics, Satellite communication. Standards: IEE802, IEC61850

UNIT III	**DISTRIBUTION SYSTEM INSTRUMENTATION**	**9**	**0**	**0**	**9**

Definitions – automation switching control – management information systems (MIS) – remote terminal units – communication method for data transfer – consumer information service (CIS) – graphical information systems (GIS) - automatic meter reading (AMR) – Remote control load management.

UNIT IV	**DISTRIBUTION AUTOMATION**	**9**	**0**	**0**	**9**

Introduction to distribution automation: Customer automation- Feeder automation – Substation automation, Subsystems in distribution control centre – Distribution management systems-Outage management systems, Distribution management system framework-Advanced real time DMS applications- Advanced analytical DMS applications – DMS coordination with other systems.

UNIT V	**CONCEPTS FOR SMART SYSTEMS**	**9**	**0**	**0**	**9**

Smart system solutions – Asset optimization, Demand optimization, distribution optimization, smart meter and communications, transmission optimization; Demand side management and demand response – DSM Planning-DSM techniques; Advanced metering infrastructure integration with distribution automation, distribution management system, and outage management system; Smart homes with home energy management systems.

Total (45L + 0T) = 45 Periods

Text Books:

1.	A.S. Pabla, “Electric Power Distribution”, Tata McGraw Hill, New Delhi, 2019.
2.	Mini S Thomas, and John D McDonald, “Power System SCADA and Smart Grids”, Taylor and Francis, 2015.
3.	Mahalanabis, Kothari and Ahson, “Computer Aided Power System Analysis and Control”, Tata McGraw Hill Publishers, 1991.

Reference Books:	
1.	Momoh A. Momoh and James A. Momoh., “Electric Power Distribution, Automation, Protection, and Control”, CRC Press, 2007.
2.	Gonen, “Electric Power Distribution System Engineering”, BSP Books, Pvt. Ltd, 2007.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the conceptual aspects in power system measurements and signal transmission techniques.	L2: Understanding
CO2	:	Demonstrate various communication technologies for data transmission.	L3: Applying
CO3	:	Acquire proficiency to distribution system instrumentation.	L3: Applying
CO4	:	Demonstrate the automation in power distribution system.	L3: Applying
CO5	:	Conceptualize the smart tools for automation.	L3: Applying

23PTEEE31	**POWER SYSTEM TRANSIENTS**		**SEMESTER**			**VII**
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution Systems; Power System Analysis and Stability		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To impart knowledge on generation of switching transients and their control.
2. To familiarise on the mechanism of lighting strokes and the production of lighting surges.
3. To understand the propagation, reflection and refraction of travelling waves.
4. To acquire knowledge on voltage transients caused by faults, circuit breaker action, load rejection on integrated power system.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Review and importance of the study of transients - causes for transients. RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems – role of the study of transients in system planning.

UNIT II	**SWITCHING TRANSIENTS**	**9**	**0**	**0**	**9**

Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit. Capacitance switching - effect of source regulation - capacitance switching with a restrike, with multiple restrikes. Illustration for multiple restriking transients - Ferro resonance.

UNIT III	**LIGHTNING TRANSIENTS**	**9**	**0**	**0**	**9**

Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design - protection using ground wires - tower footing resistance - Interaction between lightning and power system.

UNIT IV	**TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS**	**9**	**0**	**0**	**9**

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely’s lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves.

UNIT V	**TRANSIENTS IN INTEGRATED POWER SYSTEM**	**9**	**0**	**0**	**9**

The short line and kilometric fault - distribution of voltages in a power system - Line dropping and load rejection - voltage transients on closing and reclosing lines - over voltage induced by faults -switching surges on integrated system Qualitative application of EMTP for transient computation.

Total (45L + 0T) = 45 Periods

Text Books:

1. Allan Greenwood, “Electrical Transients in Power Systems”, Wiley Inter Science, New York, 2nd Edition, 1991.
2. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2009.

3.	C.S. Indulkar, D.P. Kothari, and K. Ramalingam, "Power System Transients – A Statistical Approach", PHI Learning Private Limited, Second Edition, 2010.
Reference Books:	
1.	M.S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill, Fifth Edition, 2013.
2.	R.D. Begamudre, "Extra High Voltage AC Transmission Engineering", Wiley Eastern Limited, 1986.
3.	Y. Hase, "Handbook of Power System Engineering", Wiley India, 2012.
4.	J.L. Kirtley, "Electric Power Principles, Sources, Conversion, Distribution and Use", Wiley, 2012.
5.	Akihiro Ametani, "Power System Transient Theory and Applications", CRC press, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Interpret the switching and lightning transients.	L4: Analysing
CO2	:	Examine the generation of switching transients and their control.	L4: Analysing
CO3	:	Analyse the mechanism of lightning strokes.	L4: Analysing
CO4	:	Recognize the importance of propagation, reflection, and refraction of travelling waves.	L1: Understanding
CO5	:	Review the concept of circuit breaker action, line dropping, and load rejection in an integrated power system.	L1: Understanding

23PTEEE32	**DISTRIBUTED GENERATION AND MICRO GRID**		**SEMESTER**			**VII**
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution Systems		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on distributed generation technologies.
2.	To familiarise on impact on grid integration.
3.	To understand the microgrid operation and control.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Conventional power generation: advantages and disadvantages, Energy crises, non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II	**DISTRIBUTED GENERATIONS**	**9**	**0**	**0**	**9**

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT III	**IMPACT OF GRID INTEGRATION**	**9**	**0**	**0**	**9**

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 IV	**BASICS OF A MICROGRID**	**9**	**0**	**0**	**9**

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.

UNIT V	**CONTROL AND OPERATION OF MICROGRID**	**9**	**0**	**0**	**9**

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication-based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

Total (45L + 0T) = 45 Periods

Text Books:

1.	H. Lee Willis and Walter G. Scott, “Distributed Power Generation – Planning and Evaluation”, Marcel Decker Press, 2000.
2.	M. Godoy Simoes and Felix A. Farret, “Renewable Energy Systems – Design and Analysis with Induction Generators”, CRC Press, 2004.
3.	Robert Lasseter and Paolo Piagi, “Micro-grid: A Conceptual Solution”, PESC, June 2004.

Reference Books:

1.	John Twidell and Tony Weir, “Renewable Energy Resources”, Taylor and Francis Publications, 2005.
2.	Dorin Neacsu, “Power Switching Converters: Medium and High Power”, CRC Press, Taylor & Francis, 2006.

3.	Amirnaser Yezdani and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.
4.	F. Katiraei and M.R. Iravani, "Transients of a Micro-Grid System with Multiple Distributed Energy Resources", International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.
5.	Z. Ye, R. Walling, N. Miller, P. Du and K. Nelson, "Facility Microgrids", General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify various forms of energy sources.	L2: Understanding
CO2	:	Recognize various DG technologies.	L2: Understanding
CO3	:	Analyse the impact on grid while integrating DGs.	L4: Analysing
CO4	:	Demonstrate the concepts of microgrids.	L3: Applying
CO5	:	Categorize various microgrid control schemes.	L4: Analysing

23PTEEE33	RESTRUCTURED POWER SYSTEM			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System; Power System Analysis and Stability			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on power system restructuring.
2.	To familiarise on electricity market models.
3.	To understand various network operations / analyses including transmission system operations, optimal power flow, and automatic generation control.

UNIT I	**POWER SYSTEM RESTRUCTURING**	**9**	**0**	**0**	**9**

Introduction –Deregulation - Need for deregulation – Power system restructure models - Electricity Market Participants – GENCOS- DISCOS- TO- ISO- PX- SC - trading arrangements - Operational Planning Activities (OPA) of Electricity Market Participants - Causes of restructuring- types and effects of restructuring – restructure models

UNIT II	**ELECTRICAL UTILITY**	**9**	**0**	**0**	**9**

Electrical utility restructuring Power System Operation in competitive environment –Electricity Market Models (Pool Co-bilateral- hybrid)- Components of restructured system - Power Sector restructuring and influence on environment - Functions and responsibilities of PX- ISO- RTO and ITP - Electric Utility Market – Market Models - wholesale electricity market characteristic – Electricity Market types (energy- ancillary services- transmission- forward- real time) – Market power evaluation and mitigation

UNIT III	**EVALUATION OF TRANSMISSION SYSTEM**	**9**	**0**	**0**	**9**

Electricity pricing and Transmission pricing in a restructured market - Congestion management in a deregulated market – Available Transfer Capabilities (ATC) of transmission system – Application of Monte Carlo Simulation in ATC calculation – ATC calculation with sensitivity analysis method - Tagging Electricity Transaction – Tagging process – Implementation-Curtailment and cancellation of transaction - Availability Based Tariff

UNIT IV	**OPTIMUM POWER FLOW (OPF) ANALYSIS IN MARKET ENVIRONMENT**	**9**	**0**	**0**	**9**

Introduction – Approaches to OPF – Application of OPF analysis in Electricity and Power Markets with Electricity Market Participants – Power Flow Tracing – current decomposition axioms- Mathematical model of loss allocation- usage sharing problem on transmission facilities - Methodology of graph theory - Economic issues- Mechanism and transmission issues in the new market environment.

UNIT V	**AGC IN RESTRUCTURED POWER SYSTEM**	**9**	**0**	**0**	**9**

Introduction – Traditional Vs Restructured Scenario –AGC in New market environment - Block diagram and State Space representation of a two-area interconnected power system in deregulated environment – Load-Frequency Control (LFC) dynamics and Bilateral Contacts – Modelling- DISCO Participation Matrix (DPM)- Generation Participation Matrix (GPM).

Total (45L + 0T) = 45 Periods

Text Books:

1. Loi Lei Lai, "Power System Restructuring and deregulation", John Wiley & Sons, 2001.

2.	Md. Shahidehpour and MuwaffagAlmoush, "Restructured Electric Power System – Operation- Trading and Volatility", Marcel Dekker Inc, New York, 2001.
3.	Arthur. R. Bergen and Vijay Vittal, "Power System Analysis", Prentice Hall, New Jersey, 2000.
Reference Books:	
1.	Xi Fan, Wang, Yonghua Song and Malcolm Irving, "Modern Power System Analysis", Springer, 2008.
2.	D. Das, "Electrical Power Systems", New Age International (P) Ltd, New Delhi, 2008.
3.	M. Iiic, F. Galiana and L. Fink, "Power Systems Restructuring", Norwell M A Kluwer, 1998.
4.	L.Philipson and Willis H. Le, "Understanding Electric Utilities and de-regulation", Marcel Dekker Inc Publishers, New York, 2006.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recognize components in restructured power system.	L2: Understanding
CO2	:	Interpret various models in electricity market.	L3: Applying
CO3	:	Examine the congestion management and ATC in transmission system.	L4: Analysing
CO4	:	Formulate the power flow problem in restructured power system.	L4: Analysing
CO5	:	Develop automatic generation control in restructured power system.	L4: Analysing

23PTEEE34	POWER QUALITY		SEMESTER			VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution system, Power System Protection and Switchgear		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To introduce the power quality terms and definitions
2. To understand the sources and issues of various power quality problems.
3. To gain in-depth knowledge of the mitigation/ suppression techniques of voltages sags, interruptions and harmonics.
4. To introduce the computer tools for transient's analysis.
5. To expose the various methods of power quality monitoring.

UNIT I	**INTRODUCTION TO POWER QUALITY**	**9**	**0**	**0**	**9**

Terms and definitions of Power quality, General classes of power quality problems: transients- long duration voltage variations- short duration voltage variations, voltage Imbalance, waveform distortion, voltage fluctuation, Power frequency variations-International standard of power quality- Power Acceptability curves: CBEMA and ITI curves.

UNIT II	**VOLTAGE SAGS AND LONG DURATION VOLTAGE VARIATIONS**	**9**	**0**	**0**	**9**

Sources of sags and interruptions, estimating voltage sag performance, fundamental principles of voltage sag Protection – voltage sag mitigation solution at the End-User level- Evaluating the economics of different ride-through alternatives –Motor Starting sags.

Long Duration voltage variations: Principles of regulating the voltage – devices for voltage regulation-utility voltage regulator application- capacitor for voltage regulation- End user capacitor application - Flicker: sources and mitigation techniques.

UNIT III	**TRANSIENT OVERVOLTAGE**	**9**	**0**	**0**	**9**

Sources of transient over voltage- Principles of overvoltage Protection- Devices for mitigation of over voltages – Utility capacitor-switching transients – Utility system lightning protection - Managing Ferro resonance- switching transients problems with loads - computer tools for transients analysis: PSCAD and EMTP.

UNIT IV	**HARMONICS**	**9**	**0**	**0**	**9**

Fundamentals of Harmonics: Harmonic Distortion, voltage versus current distortion, Harmonics versus transients- harmonics phase sequences- triplen harmonics -harmonic indices, harmonic sources from commercial and industrial loads. Locating harmonic sources - power system response characteristics – Effects of Harmonics Distortion –Interharmonics - harmonic distortion evaluations, Principles and devices for controlling harmonic distortion, IEEE and IEC standards on harmonics.

UNIT V	**POWER QUALITY MONITORING**	**9**	**0**	**0**	**9**

Monitoring considerations - power quality measurement equipment: disturbance analyser, spectrum and harmonics analysers, flicker meters, applications of Intelligent system for power quality monitoring

Total (45L + 0T) = 45 Periods

Text Books:	
1.	Roger. C. Dugan, Mark. F. McGranaghan, Surya Santoso and H.Wayne Beaty, “Electrical Power Systems Quality”, Tata McGraw Hill Publishing Company Ltd, New Delhi, Third Edition, 2012.
Reference Books	
1.	C. Sankaran, “Power Quality”, CRC Press, First Indian Edition, 2009.
2.	G.T. Heydt, “Electric Power Quality”, Stars in a Circle publishers, Second Edition, 2011.
3.	Arindam Ghoshand and Gerald Ledwich, “Power Quality Enhancement Using Custom Power Devices”, Springer-Verlag Publishers, New York Inc., Second Edition.2002.
E-Reference:	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recite the definitions and characterization of various power quality issues.	L1: Remembering
CO2	:	Discuss the sources of sag & long duration voltage variations and its control methods	L2: Understanding
CO3	:	Summarize the sources of transient overvoltage and principle of control methods	L2: Understanding
CO4	:	Understand about harmonics problem and apply filters to suppress harmonics in distribution system	L3: Applying
CO5	:	Demonstrate the operation and application of power quality measuring equipment.	L3: Applying

23PTEEE35	POWER PLANT ENGINEERING			SEMESTER		VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution Systems		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

To familiarize with operation of various power plants

UNIT I	THERMAL POWER PLANT	9	0	0	9

Thermal Stations- layout- main components- boiler- economizer- air preheater- super heater- reheater- condenser- feed heater- cooling powers- FD and ID fans- Coal handling plant-water treatment plant- Ash handling plant- Types of boilers and their characteristics- Steam turbines- and their characteristics- governing system for thermal stations.

UNIT II	HYDRO POWER PLANT	9	0	0	9

Hydro Electric Stations- Selection of site- layout- classification of hydro plants- general arrangement and operation of a hydro-plant- governing system for hydel plant- types of turbines-pumped storage plants.

UNIT III	NUCLEAR POWER PLANT	9	0	0	9

Nuclear power plants - Principles of nuclear energy -Working of Nuclear Reactors: Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANada Deuterium- Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors - location - advantages and disadvantages of nuclear power plants - Reactor control

UNIT IV	POWER FROM RENEWABLE ENERGY	9	0	0	9

Principle, Construction and working of Solar Thermal, Solar Photo Voltaic (SPV), Wind, Tidal, Geothermal, Biogas and Fuel Cell power systems.

UNIT V	POWER PLANT ECONOMICS AND ENVIRONMENTAL HAZARDS	9	0	0	9

Economics of power generation -Capital & Operating Cost of different power plants. Environmental aspect of power generation- Comparison of site selection criteria, relative merits & demerits of different plants -Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants- safety measures for Nuclear Power plants.

Total (45L + 0T) = 45 Periods

Text Books:

1. P.K. Nag, "Power Plant Engineering", 4^{th} ed., Tata McGraw-Hill, 2017.
2. S. Domkundwar, "Power Plant Engineering", Dhanpat Rai & Sons, 2016.
3. M.M. El-Wakil, "Power Plant Technology", McGraw-Hill Book Co, 2002.

Reference Books:

1. M.V. Deshpande, "Elements of Electrical Power Station Design", Pitman, New Delhi, Tata McGraw Hill, 2008.
2. Soni Gupta, Bhatnagar and Chakrabarti, "A Text Book on Power Systems Engineering", Dhanpat Rai and Sons, New Delhi, 1997.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the construction and principle of working for different power plants.	L1: Remembering
CO2	:	Identify the site requirements and component requirements.	L2: Understanding
CO3	:	Analyze the concept governors and their control of power plant.	L4: Analysing
CO4	:	Assess the power plant and its suitability for the environment.	L3: Applying
CO5	:	Interpret the economics involved in design of power plant.	L2: Understanding

23PTEEE41	INDUSTRIAL ELECTRICAL SYSTEMS		SEMESTER			VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Distribution System, Measurements and Instrumentation		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To emphasize the electrical components, safety equipment, residential and commercial installations, illumination systems and automation in Electrical Systems

UNIT I	ELECTRICAL SYSTEM COMPONENTS	9	0	0	9

LT system wiring components - Selection of cables, wires, switches, distribution box, metering system, Protection components- Fuse, MCB, MCCB, ELCB, RCCB – Construction and working of Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices, Single Line Diagram (SLD) of wiring system.

UNIT II	COMMERCIAL ELECTRICAL SYSTEMS	9	0	0	9

Types of commercial wiring systems, general rules and guidelines for installation, load calculations, selection and sizing of components, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, earthing of commercial installation.

UNIT III	ILLUMINATION SYSTEMS	9	0	0	9

Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

UNIT IV	PROTECTION AND COMPENSATION MEASURES	9	0	0	9

HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

UNIT V	ELECTRICAL SYSTEM AUTOMATION	9	0	0	9

Study of basic PLC, Role of PLC in automation, advantages of process automation, PLC based control system design, Panel Metering, Introduction to SCADA system for distribution automation.

Total (45L + 0T) = 45 Periods

Text Books:

1.	S.L. Uppal and G.C. Garg, “Electrical Wiring, Estimating & Costing”, Khanna publishers, 2008.
2.	K. B. Raina, “Electrical Design, Estimating & Costing”, New age International, 2007.
3.	S. Singh and R. D. Singh, “Electrical estimating and costing”, Dhanpat Rai and Co., 1997.
4.	H. Joshi, “Residential Commercial and Industrial Systems”, McGraw Hill Education, 2008.

Reference Books:

1.	Partab, “Art and Science of Utilization of Electrical Energy”.
2.	Open Shaw Taylor, “Utilization of Electrical Energy”, Oriented Longmans Limited, (Revised in SI Units), 1971.
3.	C. L. Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Publishers, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Associate the various components of industrial electrical system	L2: Understanding
CO2	:	Apply appropriate criteria for selection and sizing of the different electrical systems.	L3: Applying
CO3	:	Recall the various terms and factors for illuminations systems	L1: Remebering
CO4	:	Analyse the essential safety, protection and compensation measures.	L4: Analysing
CO5	:	Select the appropriate electrical system for automation.	L4: Analysing

23PTEEE42	MODERN ELECTRICAL DRIVES			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Electrical Drives and Control			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To know about the overview of Electrical drives.
2.	To know about the Vector control strategies for DC motor drives.
3.	To understand the concepts of various DSP based control.

UNIT I	**DC MOTOR DRIVES**	**9**	**0**	**0**	**9**
Modeling of DC motors, State space modeling, block diagram & Transfer function, Single phase, three phases fully controlled and half controlled DC drives. Dual converter control of DC drives Closed loop control of separately excited dc motor drive. Supply harmonics and ripple in motor current chopper-controlled DC motor drives.					
UNIT II	**INDUCTION MOTOR DRIVES**	**9**	**0**	**0**	**9**
Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control (DTC)					
UNIT III	**SYNCHRONOUS MOTOR DRIVES**	**9**	**0**	**0**	**9**
Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.					
UNIT IV	**PERMANENT MAGNET MOTOR AND SWITCHED RELUCTANCE MOTOR DRIVES**	**9**	**0**	**0**	**9**
Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives. Various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.					
UNIT V	**DSP BASED MOTION CONTROL**	**9**	**0**	**0**	**9**
Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.					

Total (45L + 0T) = 45 Periods

Text Books:

1.	B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, Asia, 2003.
2.	P. C. Krause, O. Wasynczuk and S. D. Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley & Sons, 2013.

Reference Books:

1.	H. A. Taliyat and S. G. Campbell, “DSP based Electromechanical Motion Control”, CRC press, 2003
2.	R. Krishnan, “Permanent Magnet Synchronous and Brushless DC motor Drives”, CRC Press, 2009.
3.	https://nptel.ac.in/courses/

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO1	:	Apply Power converters for DC drives.	L1: Remembering
CO2	:	Understand the basics of Permanent magnet motor and Switched reluctance motor drives.	L2: Understanding
CO3	:	Learn the concepts of Synchronous motor drives.	L5: Evaluating
CO4	:	Gain knowledge of Induction motor drives.	L4: Analyzing
CO5	:	Explain DSP based motion control.	L3: Applying

23PTEEE43	MULTILEVEL POWER CONVERTERS			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the fundamentals of multilevel voltage source inverters and multilevel current source inverters with its modulation control

UNIT I	**DIODE-CLAMPED MULTILEVEL INVERTERS**	**9**	**0**	**0**	**9**

Three-Level Inverter - Converter Configuration and Switching State, Space Vector Modulation - Stationary Space Vectors, Dwell Time Calculation and Switching Sequence Design, Neutral-Point Voltage Control 164
Discontinuous Space Vector Modulation, SVM Based on Two-Level Algorithm, High-Level Diode-Clamped Inverters - Four- and Five-Level Diode-Clamped Inverters

UNIT II	**MULTILEVEL VOLTAGE SOURCE INVERTERS**	**9**	**0**	**0**	**9**

Introduction, NPC/H-Bridge Inverter, Inverter Topology and Modulation Scheme, Waveforms and Harmonic Content, Multilevel Flying-Capacitor Inverters, Inverter Configuration, Modulation Schemes

UNIT III	**CASCADED MULTILEVEL INVERTERS**	**9**	**0**	**0**	**9**

H-Bridge Inverter, Bipolar Pulse-Width Modulation and Unipolar Pulse-Width Modulation, CHB Inverter with Equal DC Voltages, H-Bridges with Unequal DC Voltages, Carrier Based PWM Schemes, Phase-Shifted Multicarrier Modulation, Level-Shifted Multicarrier Modulation, Comparison Between Phase- and Level-Shifted PWM Schemes

UNIT IV	**MODULAR MULTILEVEL INVERTER**	**9**	**0**	**0**	**9**

Five level Modular Multilevel Inverter- Power circuit, operation and applications, DC Voltage balance control, Carrier Based PWM for Modular Multilevel Inverter

UNIT V	**PWM TECHNIQUES**	**9**	**0**	**0**	**9**

Trapezoidal Modulation, Selective Harmonic Elimination, Space Vector Modulation-Switching States, Space Vectors, Dwell Time Calculation, Switching Sequence, Harmonic Content

Total (45L + 0T) = 45 Periods

Text Books:

1.	Bin Wu and Mehdi Narimani, “High-Power Converters and AC Drives”, 2nd Edition, Wiley-IEEE Press, 2017.

Reference Books:

1.	N. Mohan, T. M. Undeland, et al., “Power Electronics—Converters, Applications and Design”, 3rd edition, John Wiley & Sons, New York, 2003.

E-Reference:

1.	https://archive.nptel.ac.in/courses/108/102/108102157/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the configurations for multilevel voltage source inverters.	L1: Remembering
CO2	:	Describe the working principle of multilevel current source inverters	L2: Understanding
CO3	:	Draw the topology structure of different types of multilevel inverters	L3: Applying
CO4	:	Understand the principle of space vector modulation for multilevel inverters	L1: Remembering
CO5	:	Select an appropriate modulation scheme for multilevel inverters	L4: Analyzing

<table>
<tr><td>23PTEEE44</td><td colspan="2">MODELLING AND CONTROL OF POWER CONVERTERS</td><td colspan="3">SEMESTER</td><td>VII</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Power Electronics and Control Systems</td><td rowspan="2">Hours / Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
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Course Objectives:

1.	To learn the basics of control system simulation.
2.	To do symbolic calculation and study the principles of sliding mode control and the way of apply smc for buck converter.
3.	To learn the concept of power factor correction.
4.	To design simulate smc for buck converter and power factor correction circuit with controller.

UNIT I	SIMULATION BASICS IN CONTROL SYSTEMS	9	0	0	9

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 II	SYMBOLIC CALCULATIONS	9	0	0	9

Symbolic Variables - Symbolic Vector Variables, Commands for Handling Polynomial Expressions - Extracting Parts of a Polynomial -. Factorization and Roots of Polynomials, Symbolic Matrix Algebra - Operations with Symbolic Matrices - Other Symbolic Matrix Operations.

UNIT III	SLIDING MODE CONTROL BASICS	9	0	0	9

Introduction- Introduction to Sliding-Mode Control- Basics of Sliding-Mode Theory- Application of Sliding-Mode Control to DC-DC Converters—Principle-Sliding mode control of buck converter.

UNIT IV	POWER FACTOR CORRECTION CIRCUITS	9	0	0	9

Introduction, Operating Principle of Single-Phase PFCs, Control of boost converter based PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems.

UNIT V	CONTROLLER DESIGN FOR PFC CIRCUITS	9	0	0	9

Power factor correction circuit using other SMPS topologies: Cuk and SEPIC converter - PFC circuits employing bridgeless topologies.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Dean Frederick and Joe Chow, “Feedback Control Problems using MATLAB and the Control System Tool Box”, Cengage Learning, 1st Edition, 2000.
2.	Ned Mohan, “Power Electronics: A First Course”, John Wiley, 1st Edition, 2013.
3.	Marian K. Kazimierczuk and Agasthya Ayachit, “Laboratory Manual for Pulse-Width Modulated DC-DC Power Converters”, Wiley, 1st Edition, 2016.
4.	S.K.Varenina, “Power Electronics handbook”, Industrial Electronics Series, CRC Press, 1st Edition, 2002.

Reference Books:

1.	Slew-Chong Tan, Yuk Ming Lai and Chi-Kong Tse, “Sliding Mode Control for Switching Power Converters: Techniques and Implementation”, 1st Edition, CRC Press, 2011.

2.	Andre Kislovski, “Dynamic Analysis of Switching-Mode DC/DC Converters”, Springer 1991.
3.	Lopez Cesar, “MATLAB Symbolic Algebra and Calculus Tools”, Apress, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	To calculate transfer function for constant, differential, integral, First order and Second order factors.	L2: Understanding
CO2	:	To illustrate the effect of poles and zero’s in the ‘s’ plane.	L1: Remembering
CO3	:	To select Symbolic equations for solving problems related with Matrices, Polynomial and vectors.	L5: Evaluating
CO4	:	To compute the control expression for DC – DC buck converter using sliding mode control theory	L3: Applying
CO5	:	To determine the controller expression for power factor correction circuits and to simulate sliding mode control of buck converter and power factor correction circuit.	L5: Evaluating

23PTEEE45	CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
NIL			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To understand electric power Generation, Transmission and Distribution
2.	To study Power System Operation and Control

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.

UNIT II	**CONVENTIONAL ENERGY CONVERSION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies

UNIT III	**NON-CONVENTIONAL ENERGY CONVERSION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies - batteries, fly wheels, super capacitors and ultra-capacitors.

UNIT IV	**CONTROL ISSUES AND CHALLENGES**	**9**	**0**	**0**	**9**

Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell-based generators, Dimensioning of filters, Fault-ride through Capabilities.

UNIT V	**INTEGRATION OF ENERGY CONVERSION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems –classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC Codes and standards for renewable energy grid integrations.

Total (45L + 0T) = 45 Periods

Text Books:

1.	G. Masters, “Renewable and Efficient Electric Power Systems”, IEEE-John Wiley and Sons Ltd. Publishers, 2nd Edition, 2013.
2.	S. Chowdhury, S. P. Chowdhury and P. Crossley, “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012.
3.	Ali Keyhani Mohammad Marwali and Min Dai, “Integration and Control of Renewable Energy in Electric Power System”, John Wiley publishing company, 2nd Edition, 2010.

Reference Books:

1.	Chetan Singh Solanki, “Solar Photovoltaic: Fundamentals, Technologies & Applications”, PHI Publishers, 3rd Edition. 2019.

2.	Rabindra Kumar Satpathy and Venkateswarlu Parmuru, “Solar PV Power: Design, Manufacturing and Applications from Sand to Systems”, Academic Press, 2020.
3.	Quing-Chang Zhong, “Control of Power Inverters in Renewable Energy and Smart Grid Integration”, IEEE-John Wiley and Sons Ltd. Publishers, 1st Edition, 2013.
4.	Bin Wu, Yongqiang Lang and Navid Zargari, “Power Conversion and Control of Wind Energy Systems”, IEEE- John Wiley and Sons Ltd. Publishers, 1st Edition, 2011.
5.	Report on “Large Scale Grid Integration of Renewable Energy Sources - Way Forward” Central Electricity Authority, GoI, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the importance of renewable energy sources.	L2: Understanding
CO2	:	Familiarize the conventional energy system.	L5: Evaluating
CO3	:	Familiarize the nonconventional energy system.	L3: Applying
CO4	:	Analyze and simulate control strategies for grid connected and off-grid systems.	L4: Analyzing
CO5	:	Develop converters to comply with grid standards to obtain grid integration.	L6: Creating

23PTEEE51	DIGITAL SIGNAL PROCESSING		SEMESTER			VIII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Signals and Systems, and Control systems		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To classify signals and systems & their mathematical representation.
2. To analyze the discrete time systems.
3. To study about filters and their design for digital implementation.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Classification of systems: Continuous, discrete, linear, causal, stable, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect. Digital signal representation.

UNIT II	**DISCRETE TIME SYSTEM ANALYSIS**	**9**	**0**	**0**	**9**

Z-transform and its properties, inverse z-transforms; difference equation – Solution by z transform, application to discrete systems - Stability analysis, frequency response – Convolution – Introduction to Fourier transform – Discrete time Fourier transform.

UNIT III	**DISCRETE FOURIER TRANSFORM AND COMPUTATION**	**9**	**0**	**0**	**9**

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

UNIT IV	**DESIGN OF DIGITAL FILTERS**	**9**	**0**	**0**	**9**

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; digital design using impulse invariant and bilinear transformation – Warping, Prewarping – Frequency transformation.

UNIT V	**DIGITAL SIGNAL PROCESSORS**	**9**	**0**	**0**	**9**

Introduction – Architecture of one DSP processor for motor control – Features – Addressing Formats – Functional modes - Introduction to Commercial Processors.

Total (45L + 0T) = 45 Periods

Text Books:

1. J.G. Proakis and D.G. Manolakis, "Digital Signal Processing Principles, Algorithms and Applications", Pearson Education, New Delhi, 2006.
2. Robert Schilling and Sandra L.Harris, "Introduction to Digital Signal Processing using Matlab", Cengage Learning, 2014.
3. B. Venkataramani, and M. Bhaskar, "Digital Signal Processor, Architecture, Programming and Application", Tata McGram Hill, New Delhi, 2003.

Reference Books:

1. Emmanuel C Ifeachor and Barrie W Jervis, "Digital Signal Processing Principles – A Practical approach", Pearson Education, Second edition
2. Alan V. Oppenheim, Ronald W. Schafer and John R. Buck, "Discrete – Time Signal Processing", Pearson Education, New Delhi , 2003.
3. Sen M. Kuo, and Woonseng. S. Gan, "Digital Signal Processors, Architecture, Implementations & Applications", Pearson, 2013.
4. S.K. Mitra, "Digital Signal Processing – A Computer Based Approach", McGraw Hill Edu, 2013.

E-References:	
1.	https://nptel.ac.in/courses/108105055/34
2.	https://books.google.co.in/books?isbn=8131710009

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the types of systems and signals.	L2: Understanding
CO2	:	Solve problems in digital system using Z transform.	L5: Evaluating
CO3	:	Apply Fourier transforms for processing of digital signals.	L3: Applying
CO4	:	Analyze digital systems using Fast Fourier transform.	L3: Applying
CO5	:	Design digital filters algorithms in digital signal processor platforms	L5: Evaluating

23PTEEE52	EMBEDDED SYSTEM DESIGN			SEMESTER			VIII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Microprocessor and Microcontroller, C programming			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To acquaint the students the building blocks of embedded system, selection of various components for building an embedded system.
2.	To understand different communication protocols used in embedded system
3.	To study the different programming techniques used in embedded system software engineering
4.	To understand the concepts of operating systems that are exclusively used in embedded systems.

UNIT I	**INTRODUCTION TO EMBEDDED SYSTEM**	**9**	**0**	**0**	**9**

Introduction to functional building blocks of embedded systems – Embedded Hardware Core - Bus Structure - Block Diagram of Embedded System - a Microprocessor-Based System – a Microcontroller-Based System – DSP - Register, memory devices, ports, timer, interrupt controllers.

UNIT II	**PROCESSOR AND MEMORY ORGANIZATION**	**9**	**0**	**0**	**9**

Structural units in a processor; selection of processor and memory devices; shared memory; DMA; interfacing processor, memory and I/O units; memory management – Cache mapping techniques, dynamic allocation - Fragmentation.

UNIT III	**DEVICES AND BUSES**	**9**	**0**	**0**	**9**

Timers, Counters, serial communication using I2C, CAN, USB buses- parallel communication using ISA, PCI, PCI/X buses; interfacing with devices/ports, device drivers in a system – Serial port & parallel port.

UNIT IV	**EMBEDDED PROGRAMMING**	**9**	**0**	**0**	**9**

Structure of Embedded C Program, C Program build process, Type, Storage Class and Scope of Variables, Building a C Program, Bitwise operations, Pointer variables and memory addresses, Functions and structures, Pointers to functions and structures, Interrupt functions in C program

UNIT V	**REAL TIME OPERATING SYSTEM RTOS**	**9**	**0**	**0**	**9**

Introduction to basic concepts of RTOS, Context switching, pre-emptive & non-pre-emptive multitasking, semaphores - Scheduling – Thread states, pending threads, context switching, round robin scheduling, priority based scheduling, assigning priorities, deadlock, watch dog timers. –Interrupt handling, task scheduling; embedded system design issues in system development process – Action plan, use of target system, emulator, use of software tools

Total (45L + 0T) = 45 Periods

Text Books:

1.	Daniel W. Lewis, “Fundamentals of Embedded Software”, Prentice Hall of India, 2004.
2.	James K. Peckol, “Embedded System - A Contemporary Design Tool”, John Wiley, 2nd Edition, 2019
3.	Steve Heath, “Embedded System Design”, II edition, Elsevier, 2003.
4.	David E. Simon, “An Embedded Software Primer”, Pearson Education, 2004.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basic concepts of Embedded Systems.	L2: Understanding
CO2	:	Appreciate the general organization of Embedded Systems	L1: Remembering
CO3	:	Understand various devices required for an Embedded System Design	L2: Understanding
CO4	:	Understand the implementation of Programming techniques for Embedded System	L3: Applying
CO5	:	Know the various blocks of RTOS and its implementation in Design	L5: Evaluating

23PTEEE53	ARTIFICIAL INTELLIGENCE AND COMPUTER VISION		SEMESTER			VIII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Soft computing		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the various characteristics of Intelligent agents
2.	To learn the different search strategies in AI
3.	To learn to represent knowledge in solving AI problems
4.	To understand the different ways of designing software agents
5.	To know about the various applications of AI
6.	To provide introduction to computer vision

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction-Definition – Future of Artificial Intelligence – Characteristics of Intelligent Agents – Typical Intelligent Agents – Problem Solving Approach to Typical AI problems.

UNIT II	**PROBLEM SOLVING METHODS**	**9**	**0**	**0**	**9**

Problem solving Methods – Search Strategies – Uninformed – Informed – Heuristics – Local Search Algorithms and Optimization Problems – Searching with Partial Observations – Constraint Satisfaction Problems – Constraint Propagation – Backtracking Search – Game Playing – Optimal Decisions in Games – Alpha – Beta Pruning – Stochastic Games

UNIT III	**KNOWLEDGE REPRESENTATION**	**9**	**0**	**0**	**9**

First Order Predicate Logic – Prolog Programming – Unification – Forward Chaining – Backward Chaining – Resolution – Knowledge Representation – Ontological Engineering – Categories and Objects – Events – Mental Events and Mental Objects – Reasoning Systems for Categories – Reasoning with Default Information

UNIT IV	**SOFTWARE AGENTS AND AI APPLICATIONS**	**9**	**0**	**0**	**9**

Architecture for Intelligent Agents – Agent communication – Negotiation and Bargaining – Argumentation among Agents – Trust and Reputation in Multi-agent systems.

AI applications: Language Models – Information Retrieval – Information Extraction – Natural Language Processing – Machine Translation – Speech Recognition – Robot – Hardware –Perception – Planning – Moving.

UNIT V	**COMPUTER VISION**	**9**	**0**	**0**	**9**

Digital Image Processing: Image formation –image filtering- Edge detection- principal component analysis-corner detection – SIFT –Large scale image search application

Geometric techniques in computer vision: Image transformations – Camera projections- camera calibration – Depth from stereo – two view structure from motion- object tracking

Machine learning for computer vision: introduction to machine learning-Image classification – object detection – semantic segmentation

Total (45L + 0T) = 45 Periods

Text Books:	
1.	S. Russel and P. Norvig, “Artificial Intelligence: A Modern Approach”, Prentice Hall, Third Edition, 2009.
2.	I. Bratko, “Prolog: Programming for Artificial Intelligence”, Fourth Edition, Addison-Wesley Education Publishers Inc., 2011.
3	David A. Forsyth and Jean Ponce, “Computer Vision: A Modern Approach”, Pearson Publications, Second Edition, 2012.
4	Richard Hartley and Andrew Zisserman, “Multiple View Geometry in Computer Vision”, Cambridge University Press, Second Vision, 2004.

Reference Books:	
1	M. Tim Jones,” Artificial Intelligence: A systems Approach (Computer science)”, Jones and Bartlett Publishers Inc., First Edition, 2008.
2	Nils J. Nilsson,” The Quest for Artificial Intelligence”, Cambridge University Press, 2009.
3	William F. Clocksin and Christopher S. Mellish, “Programming in Prolog: Using ISO standard”, Fifth Edition, Springer, 2003.
4	Gerhard Weiss, “Multi Agent systems”, Second Edition, MIT Press, 2013.
5	David L. Poole and Alan K. Mackworth, “Artificial Intelligence: Foundations of Computational Agents”, Cambridge University Press 2010.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Use appropriate search algorithms for any AI problem	L3: Applying
CO2	:	Represent using first order and predicate logic	L2: Understanding
CO3	:	Provide the apt agent strategy to solve a given problem	L4: Analyzing
CO4	:	Use Artificial Intelligence for various application	L3: Applying
CO5	:	Understand to use AI techniques in computer vision	L2: Understanding

23PTEEE54	SOFT COMPUTING			SEMESTER			VIII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Mathematics, 'C' Programming			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To provide Basics of artificial neural network.
2.	To provide adequate knowledge of genetic algorithms and its application to economic dispatch and unit commitment problems
3.	To expose the students to the features of hybrid control systems

UNIT I	ARTIFICIAL NEURAL NETWORK	9	0	0	9

Review of fundamentals – Biological neuron, artificial neuron, activation function, 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 – online learning algorithms, BP through time – RTRL algorithms – Reinforcement learning.

UNIT II	NEURAL NETWORKS FOR MODELLING AND CONTROL	9	0	0	9

Modelling of non-linear systems using ANN – Generation of training data – Optimal architecture– Model validation – Control of non-linear systems using ANN – Direct and indirect neuro control schemes – Adaptive neuro controller – Familiarization with neural network toolbox.

UNIT III	FUZZY SET THEORY	9	0	0	9

Fuzzy set theory – Fuzzy sets – Operation on fuzzy sets – Scalar cardinality, fuzzy cardinality, union, and intersection, complement (Yager and Sugeno), equilibrium points, aggregation, projection, composition, cylindrical extension, fuzzy relation – Fuzzy membership functions.

UNIT IV	FUZZY LOGIC FOR MODELLING AND CONTROL	9	0	0	9

Modelling of non-linear systems using fuzzy models – TSK model – Fuzzy logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification – Adaptive fuzzy systems – Familiarization with fuzzy logic toolbox.

UNIT V	HYBRID CONTROL SCHEMES	9	0	0	9

Fuzzification and rule base using ANN – Neuro fuzzy systems – ANFIS – Fuzzy neuron– GA – Optimization of membership function and rule base using Genetic Algorithm – Introduction to other evolutionary optimization techniques, support vector machine– Case study – Familiarization with ANFIS toolbox.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Laurance Fausett, and Englewood Cliffs, N.J., "Fundamentals of Neural Networks", Pearson Education, 1992.
2.	S.N. Sivanandam and S.N. Deepa, "Principles of Soft Computing", Wiley India Edition, 2nd Edition, 2013.
3.	Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Tata McGraw Hill, 1997.

Reference Books:

1.	Simon Haykin, "Neural Networks", Pearson Education, 2003.
2.	Hagan, Demuth, Beale, "Neural Network Design", Cengage Learning, 2012.
3.	N.P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford, 2013.
4.	W.T. Millon, R.S. Sutton and P.J. Webrose, "Neural Networks for Control", MIT press, 1992.
5.	Goldberg, "Genetic Algorithm in Search, Optimization and Machine learning", Addison Wesley Publishing Company Inc. 1989.

E-References:

1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Ability to understand and apply basic Artificial neural network.	L2: Understanding
CO2	:	To understand and apply modelling and control of neural network.	L3: Applying
CO3	:	To remember modelling and control of fuzzy control systems.	L1: Remembering
CO4	:	Evaluate hybrid control schemes.	L5: Evaluating
CO5	:	Design a fuzzy controller.	L6: Creating

23PTEEE55	INTERNET OF THINGS FOR ELECTRICAL SYSTEM		SEMESTER			VIII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Microprocessors and microcontrollers		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To illustrate the concept of Internet of Things (IoT).
2. To familiarize with implementations of IoT for electrical engineering applications.

		L	T	P	TH
UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Internet of Things - Definition- IoT conceptual framework-IoT architecture and Features, Major Components of IoT System, IoT software components for device hardware, Development Tools for IoT.

		L	T	P	TH
UNIT II	**IOT DEVICES**	**9**	**0**	**0**	**9**

Sensors: Sensing the Real World, Analog Sensors and Digital Sensors, Sensors for Temperature, Humidity, Distance, Light, Acceleration, Vibrations and Shocks, Orientation and Direction Compass, Magnetic Sensors/Magnetometer, Sound, Sensing the Things: Reading Barcodes, QR Code, Motion Sensors for Moving Objects, Environmental Monitoring Sensor, GPS, Actuator: Piezoelectric vibrators and sounders, Speakers, Solenoids, Servomotor, Relay switch.

		L	T	P	TH
UNIT III	**IOT COMMUNICATION SYSTEM**	**9**	**0**	**0**	**9**

M2M Communication for IoT, M2M Architecture, M2M Software and Development Tools, Modified OSI Model for the IoT/M2M Systems, Near-Field Communication, RFID, Bluetooth BR/EDR and Bluetooth Low Energy, ZigBee, Wi-Fi, GPRS/GSM Cellular Networks-Mobile Internet, Differences between NFC, BT LE, ZigBee and WLAN protocols.

		L	T	P	TH
UNIT IV	**IOT DATA PROCESSING AND ANALYSIS**	**9**	**0**	**0**	**9**

Data Acquiring and Storage: Data Generation, Data Acquisition, Data Validation, Data Categorization, Data Store, Data Centre Management, Server Management, Database Management System, Query Processing, SQL, NOSQL, Online Transactions and Processing, Business Intelligence, Complex Applications Integration, Online analytical processing, Analytics using Big Data in IoT/M2M, Knowledge-Management Reference Architecture.

		L	T	P	TH
UNIT V	**IOT APPLICATIONS**	**9**	**0**	**0**	**9**

Industrial IoT, Automotive IoT: Connected Cars Technology, Vehicle-to-Infrastructure Technology, Predictive and Preventive Maintenances, RFID IoT Systems: RFID IoT Network Architecture and Components of an RFID System, Wireless Sensor Network IoT Applications.

Total (45L + 0T) = 45 Periods

Text Books:

1. Pethuru Raj and Anupama C Mohan, "The Internet of Things – Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.

Reference Books:

1. Raj Kamal, "Internet of Things Architecture and Design Principles", McGraw Hill Education (India) Private Limited, 2017

E-Reference:

1. https://archive.nptel.ac.in/courses/106/105/106105166/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the structure and components of IOT system.	L1: Remembering
CO2	:	Select an appropriate device to interface IOT system with physical world	L4: Analyzing
CO3	:	Apply suitable communication technologies for IOT system	L3: Applying
CO4	:	Classify the data processing schemes for IoT application	L4: Analyzing
CO5	:	Use IOT platform for real time engineering solutions	L3: Applying

<table>
<tr><td>23PTEEE61</td><td colspan="2">ELECTRICAL ENERGY CONSERVATION AND AUDITING</td><td colspan="3">SEMESTER</td><td>VIII</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Power Generation, Transmission and Distribution System</td><td rowspan="2">Hours / Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">To get knowledge about basics of energy and energy scenario of India.</td></tr>
<tr><td>2.</td><td colspan="6">To familiarise the energy conservation methods.</td></tr>
<tr><td>3.</td><td colspan="6">To acquire knowledge on energy auditing, energy efficiency and modern energy efficient devices.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT I</td><td colspan="2">ENERGY SCENARIO</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Commercial and non-commercial energy -Primary energy resources - Commercial energy production - Final energy consumption - Energy needs of growing economy - Long term energy scenario - Energy pricing - Energy sector reforms - Energy and environment - Energy security - Energy conservation and its importance - Restructuring of the energy supply sector - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT II</td><td colspan="2">BASICS OF ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Electricity tariff - Load management and maximum demand control - Thermal Basics-fuels - Thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT III</td><td colspan="2">ENERGY MANAGEMENT AND AUDIT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Definition - Energy audit – Need and types of energy audit. Energy management (audit) approach understanding energy costs - Bench marking - Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements, fuel and energy substitution - Energy audit instruments. Material and energy balance: Facility as an energy system - Methods for preparing process flow, material and energy balance diagrams.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT IV</td><td colspan="2">ENERGY EFFICIENCY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Electrical system: Electricity billing - Electrical load management and maximum demand control -Power factor improvement and its benefit - Selection and location of capacitors - Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types - Losses in induction motors - Motor efficiency - Factors affecting motor performance - Rewinding and motor replacement issues - Energy saving opportunities with energy efficient motors.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT V</td><td colspan="2">ENERGY EFFICIENT TECHNOLOGIES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Maximum demand controllers - Automatic power factor controllers - Energy efficient motors –Soft starters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7" align="right">Total (45L+ 0T) = 45 Periods</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Text Books:</td></tr>
<tr><td>1.</td><td colspan="6">Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2015.</td></tr>
<tr><td>2,</td><td colspan="6">S.C. Tripathy, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.</td></tr>
<tr><td>3.</td><td colspan="6">Hossam A Gabbar, “Energy Conservation in Infrastructure Systems”, Wiley-IEEE Press, New Jersey, 2018</td></tr>
<tr><td colspan="7">Reference Books:</td></tr>
<tr><td>1.</td><td colspan="6">General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, New Delhi, 2015.</td></tr>
<tr><td>2.</td><td colspan="6">Energy Efficiency in Electrical Utilities, Bureau of Energy Efficiency, New Delhi, 2015.</td></tr>
</table>

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify the present energy scenario and future energy strategy.	L1: Understanding
CO2	:	Recognize the various forms of energy.	L1: Understanding
CO3	:	Interpret energy management methods and energy auditing.	L3: Applying
CO4	:	Familiar in energy efficiency of electrical systems.	L4: Analysing
CO5	:	Familiar with the advanced energy efficient technologies.	L4: Analysing

23PTEEE62	ELECTRICAL WIRING, ESTIMATION AND COSTING			SEMESTER			VIII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Basic Electrical Engineering			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To describe the fundamental electrical tools required for electrical wiring and estimate the costing of electrical wiring for residential, industrial, overhead, underground and substations.

UNIT I	ELECTRICAL WIRING & GENERAL PRINCIPLES OF ESTIMATION	9	0	0	9

Guidelines for electrical wiring – Schematic diagram of electrical wiring system, sizes of wires, stranded wires, types of wires, wire splicing and termination, difference between neutral and earth wire, General idea about I.E rule - Indian Electricity Act.

General principles of estimation - Electrical Schedule of rates, catalogues, Survey and source selection, Recording of estimates Quantity and cost of material required. Purchase system, Purchase enquiry and selection of appropriate purchase mode, Comparative statement, Purchase orders, Payment of bills

UNIT II	RESIDENTIAL INSTALLATION	9	0	0	9

Guidelines for electrical wiring installations of residential and positioning of equipment, Circuit design in lightning and power circuits, Method of drawing single line diagram, Selection of type of wiring and rating , Load calculations, Selection of rating of main switch, distribution board, cable selection, earthing, selection of switchgear, Sequence to be followed for preparing estimate, Preparation of detailed estimates and costing for residential installations.

UNIT III	COMMERCIAL INSTALLATION	9	0	0	9

Fundamental considerations for planning of electrical wiring installation for commercial buildings, Design considerations, Load calculations and selection of size of service connection, Deciding the size of cables, busbar and busbar chambers, Selection of rating of main switch, distribution board, Earthing, cable selection, ,Selection of rating of main switch, distribution board, cable selection, earthing, selection of switchgear, Sequence to be followed for preparing estimate, Preparation of detailed estimates and costing for commercial installations.

UNIT IV	OVERHEAD AND UNDERGROUND DISTRIBUTION SYSTEM	9	0	0	9

Overhead distribution system and underground distribution system: materials and accessories required for the overhead distribution system, estimate for 440V/3-phase/ 4 wires or 3 wires overhead distribution system, types of service connections, method of installation of service connection (1-phase and 3-phase), I.E. rules pertaining to overhead lines and service connection.

UNIT V	SUBSTATION	9	0	0	9

Classification of substation, selection and location of site for substation, main electrical connections, graphical symbols for various types of apparatus and circuit elements on substation, main connection diagram, key diagram of typical sub stations, equipment for substation and switchgear installations, substation auxiliaries supply, substation earthing.

Total (45L + 0T) = 45 Periods

Text Books:	
1.	K.B. Raina and S.K. Bhattacharya, “Electrical Design, estimating & Costing”, New Age International (p) Limited, New Delhi,2007.
2.	J.B. Gupta, “Electrical Installation Estimating & Costing”, S. K. Kataria& Sons, New Delhi,2015.
3.	S.L. Uppal, “Electrical Estimating & Costing”, New Age International (p) Limited, New Delhi ,2008

Reference Books:	
1.	Surjith Singh, “Electrical Estimating and Costing”, Danpat Rai &Co.
2.	CEA Regulations 2010.
3.	I.E rules for wiring and supply act manuals.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall the guidelines for electrical wiring installations.	L1: Remembering
CO2	:	Apply appropriate select criteria and sizing of the electrical wiring for different systems.	L3: Applying
CO3	:	Analyse the load calculations and provide appropriate earthing provision.	L4: Analysing
CO4	:	Prepare a detailed estimate and costing.	L5: Evaluating
CO5	:	Differentiate the various electrical installation.	L2: Understanding

23PTEEE63	ENERGY MANAGEMENT SYSTEM AND SCADA			SEMESTER			VIII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power System			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on energy management systems.
2.	To understand network analysis function of EMS.
3.	To study the function and control of SCADA.
4.	To analyze the concept of SCADA hardware and software.
5.	To study the concept of power system automation using SCADA.

UNIT I	ENERGY MANAGEMENT SYSTEM	9	0	0	9

Introduction to EMS, Objectives, Evolution of EMS, Evolution of SCADA, Function and Benefits of EMS, EMS Architecture, Practical EMS, Working of EMS, Power System Security: Introduction, Static Security Assessment, Operating states of Power System. Real Time or Online Application: Control Function, Protection Function, Operating States of Power System

UNIT II	NETWORK ANALYSIS FUNCTION OF EMS	9	0	0	9

Real Time Function, Extended Real Time Function, State Estimation: Introduction, Conventional State Estimation, Linea state estimation. Economic Dispatch and Optimal Power Flow: Introduction, Economic Dispatch, Generation Mode Economic c Dispatch Problem, Optimal Power Flow problem Formulation.

UNIT III	SCADA	9	0	0	9

Introduction to SCADA, Evolution of SCADA, Benefits of SCADA, Function of SCADA, SCADA in Process control, SCADA Application, Usage of SCADA, Real-Time Monitoring and Control using SCADA, Data Acquisition, Data Communication, Data Presentation, and Control.

UNIT IV	SCADA HARDWARE AND SOFTWARE	9	0	0	9

Introduction, SCADA hardware Functions, Remote Terminal Units, SCADA RTU, Basic Functions, RTU Standards, Difference Between RTU and PLC, Features of SCADA. SCADA Software and Protocols: Introduction to ISO Model, DNP3 Model, Important Features of DNP3, IEC60870 PROTOCOL, HDLC, Modbus Protocol.

UNIT V	POWER SYSTEM AUTOMATION	9	0	0	9

Power System Automation – Benefits - Architecture for Power System Automation, Classification of Power system Automation, Implementation of Power System Automation and Protection using SCADA, SCADA based Model for Automation and Digital Protection.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Wayne C. Turner, Steve Doty, “Energy Management Hand book”, The Fairmont Press, 6th Edition, 2007.
2.	Handschin, E. “Energy Management Systems”, Springer Verlag, 1990.
3.	Mini S. Thomas and John D McDonald, “Power System SCADA and Smart Grids”, CRC Press, 2015.

Reference Books:

1.	John D Mc Donald, “Electric Power Substation Engineering”, CRC press, 2001

2.	E. Handschin, “Real Time Control of Electric Power Systems”, Elsevier, 1972.
E-Reference:	
1.	NPTEL Online Courses, Energy Management Systems and SCADA, IIT Madras. Link : “https://nptel.ac.in/courses/108106022/12“

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Explore the objectives of EMS.	L2: Understanding
CO2	:	Understand the real time function of EMS.	L1: Remembering
CO3	:	Explain the real time monitoring and control of SCADA.	L4: Analyzing
CO4	:	Analyze the hardware and software functions of SCADA.	L4: Analyzing
CO5	:	Outline the power system automation and protection using SCADA.	L2: Understanding

23PTEEE64	DIGITAL PROTECTION OF ELECTRICAL SYSTEM			SEMESTER			VIII
PREREQUISITES		**CATEGORY**		**PE**	**Credit**		**3**
Digital Signal Processing		**Hours / Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

To understand the basic concepts of numerical relaying principles, the mathematical methods involved and its implementation for equipment protection.

UNIT	TITLE	L	T	P	TH
UNIT I	**ELEMENTS OF DIGITAL PROTECTION AND ARCHITECTURE OF NUMERICAL RELAY**	**9**	**0**	**0**	**9**
Components of Digital Relay – Signal Conditioning Sub systems – Conversion Sub-systems - The DSP Signal Processing Chain – ADC – Types - Quantization error – Sampling – Anti Aliasing Filter – Digital Relay sub-system - Functional Block Diagram of Numerical Relay					
UNIT II	**SINUSOIDAL WAVE BASED ALGORITHM, FOURIER AND WALSH BASED TECHNIQUES**	**9**	**0**	**0**	**9**
Sample and first-derivative method - First and Second-derivative method - Two sample technique - Three sample technique - Full cycle, fractional cycle, Fourier transform and Walsh based algorithms					
UNIT III	**LEAST SQUARE AND DIFFERENTIAL EQUATION BASED TECHNIQUES**	**9**	**0**	**0**	**9**
Integral LSQ fit - Power series LSQ fit - multi-variable series LSQ technique - Differential equation protection - Basic Principles - Simultaneous DE Techniques					
UNIT IV	**DIGITAL DIFFERENTIAL PROTECTION OF TRANSFORMERS**	**9**	**0**	**0**	**9**
Principles of Transformer protection - FIR based algorithms - LSQ curve fitting algorithms - Fourier based algorithms - Flus restrained current differential relay - Basic hardware requirements.					
UNIT V	**DIGITAL LINE DIFFERENTIAL PROTECTION**	**9**	**0**	**0**	**9**
Introduction - Current based differential schemes - Principles - Frequency modulation - Modal current - protection scheme - Composite voltage and current based scheme					
					Total (45L + 0T) = 45 Periods

Text Books:

1.	Johns and Salman, "Digital Protection for Power Systems", Peter Peregrinus Ltd. UK, 1995.
2.	S.R. Bhide, "Digital Power System Protection", PHI Pvt. Ltd. Delhi 2014.
3.	Power System Protection. Vol.4: Digital Protection and Signalling, Institution of Engineering and Technology, 1994.
4.	Vladimir Gurevich, "Digital Protective Relays - Problems and Solutions", CRC Press, 2011.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basic concepts of digital protection and numerical relay.	L2: Understanding
CO2	:	Appreciate various mathematical techniques in digital protection	L1: Remembering
CO3	:	Understand how mathematical techniques are applied for digital protection	L2: Understanding
CO4	:	Understand the implementation of techniques for Transformer and Line protection	L2: Understanding
CO5	:	Able to select appropriate hardware required for the digital protection.	L3: Applying

23PTEEE65	TRACTION ENGINEERING			SEMESTER			VIII
PREREQUISITES			CATEGORY	PE	Credit		3
Power Electronics, Electrical Machines			Hours / Week	L	T	P	TH
				3	0	0	3
Course Objectives:							
1.	To learn the fundamentals of electric traction, power substation, distribution system and overhead contact system design, construction and operation						
2.	To learn the traction mechanics, power supply systems and role of battery banks and maintenance						
3.	To learn the traction motor drives and control						
4.	To learn about traction power supply and protection						
5.	To learn about railway signalling						
UNIT I	**INTRODUCTION TO ELECTRIC TRACTION**			9	0	0	9
Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.							
UNIT II	**TRACTION MECHANICS**			9	0	0	9
Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.							
UNIT III	**TRACTION MOTOR AND DRIVES**			9	0	0	9
Type of traction motor best suited for traction duties, Available motor characteristics and their suitability for traction duties, speed control methods, Braking methods, special Emphasis and techniques of regenerative braking, Optimization of design and construction features for improved power to weight ratio, Power Factor and Harmonics, Tractive Effort and Drive Ratings, Important Features of Traction Drives, conventional DC and AC Traction drives, Semiconductor/IGBT based Converter Controlled Drives, DC Traction using Chopper Controlled Drives, AC Traction employing Poly-phase motors, Traction control of DC locomotives and EMU's, Traction control system of AC locomotives, Control gear, PWM control of induction motors, Power & amp; Auxiliary circuit equipment (Other than traction motors), Linear Induction motors, introduction to Maglev Technology.							
UNIT IV	**POWER SUPPLY AND PROTECTION**			9	0	0	9
Traction substation, spacing and location of Traction substations, Major equipment at traction substation, selection and sizing of major equipment like transformer and Switchgear, Types of protection provided for Transformer and overhead lines, surge protection, maximum demand and load sharing between substations, sectionalizing paralleling post and feeder posts, Booster transformers, Return Conductor, 2X25KV AC system, controlling/monitoring, Railway SCADA systems, Train lighting and Air-conditioning. Design requirement of catenary wire, contact wire, Dropper, Height, span length, Automatic weight tensioning, section insulator, overlap, Different techniques of current collection (overhead and underground systems), neutral section, overhead crossing of power lines, Protection							

UNIT V	RAILWAY SIGNALING	9	0	0	9
Block Section Concept, AC/DC Track Circuits, Interlocking Principle, Train speed and signaling, Solid state Interlocking, Automatic Warning Systems, CAB signaling, Signaling level crossing. Permissible limit of EMI and EMC, Permissible capacitively-coupled current, Coupling between circuits, conductive coupling, Electrostatic induction.					
Total (45L + 0T) = 45 Periods					

Reference Books:	
1.	E. A. Binney, "Electric Traction Engineering: An Introduction", Cleaver-Hume Press, 1955, 1 Oct 2007
2.	Douglas W. Hinde and M. Hinde, "Electric Traction Systems and Equipment", Elsevier Science & Technology, 1968
3.	Samuel Sheldon and Erich Hausmann, "Electric Traction and Transmission Engineering", Van Nostrand, 1911
4.	Frederick William Carter, "Railway Electric Traction", E. Arnold & Company, 1922
5.	Edward Parris Burch, "Electric traction for railway trains; a book for students, electrical and mechanical engineers, superintendents of motive power and others", New York, McGraw-Hill Book Company
6.	Edward Trevert, "Electric Railway Engineering", Lynn, Mass. :Bubier Pub. Co.
7.	Burch Edward Parris, "Electric Traction for Railway Trains; a Book for Students, Electrical and Mechanical Engineers, Superintendents of Motive Power and Others", Arkose Press, ISBN: 9781345582376, 9781345582376

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basics of traction and supply systems.	L2: Understanding
CO2	:	Understand the traction mechanics and ideal choice of supply systems.	L4: Analyzing
CO3	:	Describe the concepts of traction motors and applying the solid-state drive control.	L3: Applying
CO4	:	Design the protection system for the traction power supply system	L5: Evaluating
CO5	:	Understand the concepts of railway signaling	L2: Understanding

23PTEEE71	**ELECTRIC VEHICLES AND CONTROL**		**SEMESTER**			**VIII**
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Electrical Drives and Control		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide knowledge on electric vehicle architecture and its configurations
2.	To impart knowledge on vehicle control, use of energy storage systems and energy management in Electric Vehicle

UNIT I	**ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Configurations of Electric Vehicles (EV), Performance of Electric Vehicles, Tractive Effort in Normal Driving and Energy Consumption, Hybrid Electric Vehicles (HEV): Classification, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains

UNIT II	**PLUG-IN HYBRID ELECTRIC VEHICLES (PHEV) AND FUEL CELL ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Functions and Benefits of PHEV, Components of PHEVs, Operating Principles of Plug-in Hybrid Vehicle, Control Strategy of PHEV, Fuel Cell: Operation and Types, Fuel Cell Electric Vehicle: Configuration and Control Strategy

UNIT III	**ELECTRIC PROPULSION SYSTEMS**	**9**	**0**	**0**	**9**

Typical electric propulsion system, Classification of electric motor drives for EV and HEV, Multiquadrant Control of Chopper-Fed DC Motor Drives, Vector Control of Induction Motor drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives for Electric Vehicles

UNIT IV	**ENERGY STORAGE SYSTEM**	**9**	**0**	**0**	**9**

Status of Battery Systems for Automotive Applications, Battery Technologies: Nickel–Metal Hydride (Ni–MH) Battery, Lithium–Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors: Features, operation and performance, Ultrahigh-Speed Flywheels, Hybridization of Energy Storages

UNIT V	**ENERGY MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**

Energy Management System (EMS) in Electric Vehicle, Rule-based control strategy: Deterministic rule-based control, Fuzzy logic-based control, and Neural network-based control. Optimization based control strategy: Dynamic Programming, Metaheuristic optimization methods and Model predictive control, Semi-active type Hybrid Energy Storage System-based EMS, Fully active type Hybrid Energy Storage System-based EMS

Total (45L + 0T) = 45 Periods

Text Books:

1.	Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, Taylor & Francis Group, Second Edition, 2011.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRC Press, 2016.

Reference Books:

1.	Ali Emadi, Mehrdad Ehsani and John M.Miller, “Vehicular Electric Power Systems”, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010.

E-Reference:

1.	https://archive.nptel.ac.in/courses/108/106/108106170/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of electric vehicle and its mechanics	L1: Remembering
CO2	:	Explain the architecture of different forms of hybrid electric vehicles.	L2: Understanding
CO3	:	Illustrate the four-quadrant operation of DC drive, induction motor drive and SRM drive for Electric Vehicles.	L4: Analyzing
CO4	:	Select an appropriate energy storage system for Electric vehicle	L4: Analyzing
CO5	:	Use the suitable energy management control strategy for hybrid electric vehicle	L3: Applying

23PTEEE72	TESTING OF ELECTRIC VEHICLES		SEMESTER			VIII
PREREQUISITES		CATEGORY	PE	Credit		3
Electrical Machines and Power Electronics		Hours / Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To know various standardization procedures
2.	To learn the testing procedures for EV & HEV components
3.	To know the functional safety and EMC
4.	To realize the effect of EMC in EVs
5.	To study the effect of EMI in motor drives and in DC-DC converter system

UNIT I	**EV STANDARDIZATION**	**9**	**0**	**0**	**9**

Introduction - Current status of standardization of electric vehicles, electric Vehicles and Standardization - Standardization Bodies Active in the Field – Standardization activities in countries like Japan. The International Electro Technical Commission - Standardization of Vehicle Components.

UNIT II	**TESTING OF ELECTRIC MOTORS AND CONTROLLERS FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Test Procedure Using M-G Set, electric motor, controller, application of Test Procedure, Analysis of Test Items for the Type Test – Motor Test and Controller Test (Controller Only). - Test Procedure Using Eddy Current Type Engine Dynamometer, Test Strategy, Test Procedure, Discussion on Test Procedure. Test Procedure Using AC Dynamometer.

UNIT III	**FUNDAMENTALS OF FUNCTIONAL SAFETY AND EMC**	**9**	**0**	**0**	**9**

Functional safety life cycle- Fault tree analysis - Hazard and risk assessment – software development - Process models - Development assessments - Configuration management - Reliability - Reliability block diagrams and redundancy - Functional safety and EMC - Functional safety and quality - Standards - Functional safety of autonomous vehicles.

UNIT IV	**EMC IN ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Introduction - EMC Problems of EVs, EMC Problems of Motor Drive, EMC Problems of DC-DC Converter System, EMC Problems of Wireless Charging System, EMC Problem of Vehicle Controller, EMC Problems of Battery Management System, Vehicle EMC Requirements.

UNIT V	**EMI IN MOTOR DRIVE AND DC-DC CONVERTER SYSTEM**	**9**	**0**	**0**	**9**

Overview -EMI Mechanism of Motor Drive System, Conducted Emission Test of Motor Drive System, IGBT EMI Source, EMI Coupling Path, EMI Modelling of Motor Drive System. EMI in DC-DC Converter, EMI Source, The Conducted Emission High-Frequency, Equivalent Circuit of DC-DC Converter System, EMI Coupling Path

Total (45L + 0T) = 45 Periods

Reference Books:

1.	Ali Emadi, “Handbook of Automotive Power Electronics and Motor Drives”, Taylor & Francis, 1st Edition, 2005.
2.	Li Zhai, “Electromagnetic Compatibility of Electric Vehicle”, Springer, 1st Edition, 2021.
3.	Kai Borgeest, “EMC and Functional Safety of Automotive Electronics”, IET, 1st Edition, 2018.
4.	Druce Archambeault, Colin Branch and Omar M. Ramachi, “EMI/EMC Computational Modeling Handbook”, Springer, 2nd Edition, 2012.

5.	Mark Steffika, “Automotive EMC”, Springer, 1st Edition, 2013.
6.	Beate Müller, and Gereon Meyer, “Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative”, Springer, 1st Edition, 2015.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	To describe the status and other details of standardization of EVs	L1: Remembering
CO2	:	To illustrate the testing protocols for EVs and HEV components	L2: Understanding
CO3	:	To analyze the safety cycle and need for functions safety for EV	L4: Analyzing
CO4	:	To analyze the problems related with EMC for EV components.	L4: Analyzing
CO5	:	To evaluate the EMI in motor drive and DC-DC converter system.	L5: Evaluating

23PTEEE73	HYBRID ELECTRIC VEHICLES		SEMESTER			VIII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Electric Drives, Electric Vehicles		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	This course introduces the fundamental concepts, principles and analysis of hybrid and electric vehicles.

UNIT I	**HISTORY OF HYBRID ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance, Capabilities, Automation system computer facilities.

UNIT II	**HYBRID ELECTRIC VEHICLES - INTRODUCTION**	**9**	**0**	**0**	**9**

Micro hybrid vehicles, mild hybrid vehicles, full hybrid vehicles, Parallel Hybrid vehicles, series Hybrid Vehicles, Series-Parallel Hybrid vehicles, plug-in hybrid vehicles, power flow diagrams for various operating modes. Plug-in Hybrid Vehicles: Operating principle, architectures: series-parallel-series-parallel, challenges related to grid connection. Range-extended Electric Vehicles: Classification and configurations, Fuel Cell Electric Vehicles, Solar electric Vehicles, Electric Bi-cycles and their propulsion systems, Vehicle-to- grid, vehicle- to-home concepts, Concept of Hybrid Electric Vehicles.

UNIT III	**ELECTRIC PROPULSION UNIT**	**9**	**0**	**0**	**9**

Electric components used in electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives, Drive system efficiency.

UNIT IV	**ELECTRIC DRIVE-TRAINS**	**9**	**0**	**0**	**9**

Basic concept of electric traction, introduction to various electric drivetrain topologies, power flow control in electric drive-train topologies, fuel efficiency analysis

UNIT V	**EV MODELLING AND SIMULATION**	**9**	**0**	**0**	**9**

Modelling of BEV-Forward looking Model-Driver Perspective, Backward Looking Model-Drive Cycle Perspective, Modelling of Driver, Modelling of Brake Control Unit, Modelling of Vehicle Control Strategy, Modelling of Vehicle Chassis Sizing of Components- Steady State Energy Balance Equation, Powertrain Dimensioning-Peak vs Continuous performance, Type of Drive cycles, Types of Control Strategy, Analysis-Performance, Range, Consumption Prediction

Total (45L + 0T) = 45 Periods

Text Books:

1.	Gordon A. Goodarzi and John G Hayes, “Electric Powertrain: Energy Systems, Power Electronics & Drives for Hybrid, Electric & Fuel Cell Vehicles”, Wiley 2018.
2.	Wei Liu, “Introduction of Hybrid Vehicle System Modelling and Control”, Wiley student edition 2013.
3.	Mehradad Eshani, Yimin Gao and Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory and Design”, Second Edition, CRC Press, Taylor and Francis Group, 2010.
4.	James Larminie and John Lowry, “Electric Vehicle Technology Explained”, Second Edition, Wiley, 2012.
5.	Ali Emadi, Mehrdad Ehsani and John M. Miller, “Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles”, CRC Press, 2003.

6.	Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2nd Edition, 2003.
Reference Books:	
1.	RiK De Doncker, "Advanced Electric Drives – Analysis, Modeling, Control", Springer Publications, 2010.
2.	De Doncker, Rik, Pulle, Duco W.J., Veltman, Andre, "Advanced Electrical Drives", First Edition, CRC Press, Taylor and Francis Group, 2011.
3.	Ned Mohan, "Power Electronics Convertor, Applications, and Design", Third Edition, Wiley, 2002.
4.	Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals", Second Edition, CRC Press, Taylor and Francis Group, 2011.
5.	Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2002.
6.	Chris Mi, M. Abul Masrur, and David Wenzhong Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", Wiley, 2011.
E-References:	
1.	https://nptel.ac.in/courses/108/106/108106170/
2.	https://nptel.ac.in/courses/108/102/108102121/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Plan the selection of electrical machines for hybrid and electric vehicles.	L3: Applying
CO2	:	Analyze the drive-train topologies and advanced propulsion techniques	L4: Analyzing
CO3	:	Understand the concepts of electric vehicles, hybrid electric vehicles and their impact on environment	L2: Understanding
CO4	:	Evaluate modelling and simulation of EV	L5: Evaluating
CO5	:	Demonstrate the power system of various vehicular system.	L6: Creating

23PTEEE74	BATTERY MANAGEMENT SYSTEMS		SEMESTER			VIII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Basics of Electrical Engineering, Electric Circuit theory, Chemistry and Physics		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Objectives:						
To understand different techniques of digital relaying - their constructions, working principles, applications and limitations along with introduction to Wide Area Measurement System and network protection.						
UNIT I	**INTRODUCTION**		**9**	**0**	**0**	**9**
Introduction to Battery Management System (BMS), Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging						
UNIT II	**BATTERY-MANAGEMENT-SYSTEM REQUIREMENTS.**		**9**	**0**	**0**	**9**
Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of charge estimation.						
UNIT III	**BATTERY STATE OF CHARGE AND STATE OF HEALTH ESTIMATION**		**9**	**0**	**0**	**9**
Preliminary definitions. - Battery state of charge estimation (SOC)- voltage-based methods to estimate SOC , Model- based state estimation - Battery State of Health Estimation (SOH) - Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode						
UNIT IV	**MODELLING AND SIMULATION.**		**9**	**0**	**0**	**9**
Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, simulating an electric vehicle, Vehicle range calculations, Simulating constant power and voltage, Simulating battery packs.						
UNIT V	**DESIGN OF BMS**		**9**	**0**	**0**	**9**
Design of battery BMS: Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system						
Total (45L + 0T) = 45 Periods						
Text Books:						
1.	Gregory L Plett, "Battery Management Systems, Volume I: Battery Modeling", Artech House, 2015.					
2.	G. Plett, "Battery Management Systems: Volume II, Equivalent-Circuit Methods", Artech House, 2015					
3	H.J. Bergveld, W.S. Kruijt and P.H.L. Notten, "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002.					
Reference Books:						
1.	Davide Andrea, "Battery Management Systems for Large Lithium-ion Battery Packs", Artech House, 2010.					
2.	Pop, Valer, et al., "Battery Management Systems: Accurate State-of-Charge Indication for Battery-Powered Applications", Vol. 9. Springer Science & Business Media, 2008.					

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the role of battery management system	L1: Remembering
CO2	:	Identify the requirements of Battery Management System w.r.t application	L2: Understanding
CO3	:	Analyze the concept associated with battery charging / discharging process	L4: Analysing
CO4	:	Assess the various parameters of battery and battery pack	L3: Applying
CO5	:	Design the battery pack model.	L4: Analysing

23PTEEE75	ENERGY STORAGE SYSTEMS AND APPLICATIONS		SEMESTER		VIII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**	**3**
Electrical Engineering		**Hours / Week**	**L**	**T** / **P**	**TH**
			3	**0** / **0**	**3**

Course Objectives:

1.	To understand the various types of energy storage technologies.
2.	To analyze thermal storage system.
3.	To analyze different battery storage technologies.
4.	To model the Lithium-ion batteries.
5.	To study the various applications of energy storage systems.

UNIT I	INTRODUCTION	9	0	0	9

Necessity of energy storage – Types of energy storage – Comparison of energy storage technologies – Demand functions of energy storage technology in power system, application outlook and challenges of energy storage technology in power system.

UNIT II	THERMAL STORAGE SYSTEM	9	0	0	9

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – Pressurized water storage system – Modeling of phase change storage system – Simple units, packed bed storage units – Modeling using porous medium approach – Use of TRNSYS.

UNIT III	ELECTRICAL ENERGY STORAGE	9	0	0	9

Fundamental concept of batteries – Measuring battery performance, charging and discharging, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide, Li-ion batteries – Mathematical modeling of Lead Acid batteries – Flow batteries.

UNIT IV	LITHIUM-ION BATTERY MODELING	9	0	0	9

Analysis on charge and discharge temperature characteristics of Lithium-ion batteries – Electrothermal coupling Modeling - Modeling and Optimization of Air Cooling Heat Dissipation of Lithium-ion Battery Packs.

UNIT V	ALTERNATE ENERGY STORAGE TECHNOLOGIES	9	0	0	9

Flywheel, Supercapacitors, Principles and methods – Applications, Compressed air energy storage, Concept of Hybrid storage – Applications, Pumped hydro storage – Applications.

Total (45L + 0T) = 45 Periods

Text Books:

1.	Ibrahim Dincer and Mark A. Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley & Sons, 3rd Edition, 2021.
2.	Ru-shi Liu, Lei Zhang and Xueliang Sun, “Electrochemical Technologies for Energy Storage and Conversion”, Wiley publications, 2nd Volume set, 2012.
3.	Junqiu Li, “Modeling and Simulation of Lithium-Ion Power Battery Thermal Management”, Springer, 2020.

Reference Books:

1.	V.J. Lunardini, “Heat Transfer in Cold Climates”, John Wiley and Sons, 1st Edition, 1981.

2.	F.W. Schmidt and A.J. Willmott, “Thermal Energy Storage and Regeneration”, Hemisphere Publishing Corporation, 1st Edition, 1981.
E-References:	
1.	Prof. Subhasish Basu Majumder, “Electrochemical Energy Storage”, NPTEL Course, https://nptel.ac.in/courses/113105102
2.	Prof. P.K. Das, “Energy Conservation and Waste Heat Recovery”, NPTEL Course, https://nptel.ac.in/courses/112105221.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand different types of storage technologies.	L2: Understanding
CO2	:	Model a thermal battery energy storage system	L1: Remembering
CO3	:	Analyze the modeling of Lithium-ion batteries.	L4: Analyzing
CO4	:	Analyze the appropriate storage technologies for different applications.	L3: Applying
CO5	:	Explore the alternate energy storage technologies.	L2: Understanding