B.TECH.
IN
ELECTRICAL ENGINEERING

CURRICULUM AND SYLLABUS
(Applicable from Academic Year 2024-25 onwards)

Department of Electrical Engineering
NATIONAL INSTITUTE OF TECHNOLOGY MANIPUR
Langol Road, Lamphelpat, Imphal, Manipur - 795004

COURSE STRUCTURE OF B.TECH IN ELECTRICAL ENGINEERING

Sl. No.	Course Components	No. of Course	Credits
1.	Basic Science Courses (BSC)	06	20
2.	Engineering Science Courses (ESC)	07	26
3.	Departmental Core Courses (DCC)	20	77
4.	Departmental Elective Courses (DEC)	04	12
5.	Open Elective Courses (OEC)	02	06
6.	Skill Enhancement Courses (SEC)	02	06
7.	Ability Enhancement Mandatory Course (AEMC)	05	14+8*
8.	Value Addition Courses (VAC)	03	0
	Total	49	161+8*

PROGRAMME STRUCTURE

Semester I

Sl. No.	Course Code	Course Name	Course Category	L	T	P	Credits
1.	CH 1101	Engineering Chemistry	BSC-1	3	0	2	4
2.	ME 1101	Engineering Mechanics	ESC-1	3	1	0	4
3.	ME 1102	Engineering Drawing	ESC-2	1	2	0	3
4.	MA 1101	Engineering Mathematics-I	BSC-2	3	0	0	3
5.	PH 1101	Engineering Physics-I	BSC-3	3	0	2	4
6.	HS 1101	Professional Communication Skills	SEC-1	3	0	0	3
7.	HS1191	Induction Programme*	VAC-1	0	0	0	0
8.	HS 1192	Extra Academic Activity-I*	VAC-2	0	0	0	0
		Total		16	3	4	21

Semester II

Sl. No.	Course Code	Course Name	Course Category	L	T	P	Credits
1.	CS 1201	Introduction to Computing	ESC-3	3	0	4	5
2.	EE 1201	Basic Electrical Engineering	ESC-4	3	0	2	4
3.	MA 1201	Engineering Mathematics-II	BSC-4	3	0	0	3
4.	EC 1201	Basic Electronic Circuits	ESC-5	3	0	2	4
5.	CE 1201	Environmental Engineering	ESC-6	3	0	0	3
6.	ME 1201	Engineering Workshop	ESC-7	1	0	4	3
7.	HS 1291	Extra Academic Activity-II	VAC-3	0	0	0	0
		Total		16	0	12	22

*Value Addition Courses (VAC) will be floated by Department of Humanities and Social Sciences (HSS).

Semester III

Sl. No.	Course Code	Course Name	Course Category	L -T-P	CREDIT
1.	EE2301	Network Analysis	DCC-1	3-0-2	4
2.	EE2302	Semiconductor Devices and Circuits	DCC-2	3-0-2	4
3.	EE2303	Electrical Engineering Material	DCC-3	3-1-0	4
4.	EE2304	Energy Science & Technology	DCC-4	3-0-0	3
5.	EC2331	Analog Electronic Circuits	IDCC-1	3-0-2	4
6.	MA2301	Engineering Mathematics –III	BSC-5	3-0-0	3
		Total		**18-1-6**	**22**

Semester IV

Sl. No.	Course Code.	Course Name	Course Category	L - T - P	CREDIT
1.	EE2401	Electrical Machines –I	DCC-5	3-0-2	4
2.	EE2402	Measurement and Instrumentation	DCC-6	3-0-2	4
3.	EE2403	Signals and Systems	DCC-7	3-1-0	4
4.	EE2404	Power Systems-I	DCC-8	3-1-0	4
5.	EC2431	Digital Electronics & Computer Organization	IDCC-2	3-0-2	4
6.	MA 2402	Numerical Methods	BSC-6	3-0-0	3
7.	*EE2439	Minor Project	AEMC-1	0-0-16	8
		Total		**18-2-(6+16*)**	**23+8***

*NOTE: Minor Project (EE2439) is to be opted by the students who want to leave the program after IV Semester with UG Diploma in Electrical Engineering.

Semester V

S. No.	COURSE NO.	COURSE NAME	Course Category	L - T – P	CREDIT
1.	EE3501	Power Electronics	DCC-9	3-0-2	4
2.	EE3502	Electrical Machines-II	DCC-10	3-0-2	4
3.	EE3503	Power Systems-II	DCC-11	3-0-2	4
4.	EE3504	Control System	DCC-12	3-0-2	4
5.	EC3531	Electromagnetic Field Theory	IDCC-3	3-1-0	4
6.	EE35XY	Department Elective-I	DEC-1	3-0-0	3
		Total		**18-1-8**	**23**

Semester VI

S. No.	COURSE NO.	COURSE NAME	Course Category	L - T – P	CREDIT
1.	EE3601	Microprocessor and Micro-controller	DCC-13	3-0-2	4
2.	EE3602	Switchgear and Protection	DCC-14	3-0-2	4
3.	EE3603	Advance Control System	DCC-15	3-1-0	4
4.	EE3604	Renewable Energy Resources	DCC-16	3-0-0	3
5.	EE36XY	Department Elective-II	DEC-2	3-0-0	3
		Total		**15-1-4**	**18**

Semester VII

S. No.	COURSE NO.	COURSE NAME	Course Category	L - T - P	CREDIT
1.	EE4701	Principles Of Industrial Instrumentation	DCC-17	3-0-0	3
2.	EE47XY	Department Elective-III	DEC-3	3-0-0	3
3.	HS 4701	Managerial Economics and Financial Accountancy	SEC-2	3-0-0	3
4.	EE4739	Project Work - I	AEMC-2	0-0-8	4
5.	EE4738	Summer Internship/Industrial Training/Research work**	AEMC-3	0-0-6	3
6.	EE47XY	Open Elective-I	OEC-1	3-0-0	3
		Total		**12-0-14**	**19**

** Students will undertake this course after completing Semester VI, during the summer vacation. Moreover, the evaluation will commence at the beginning of Semester VII. Also, as per the approval of 37th Senate, a provision has been made to offer 1 credit-based courses based on Industry, Entrepreneurship, Design thinking, Health and wellness, Yoga, etc., as separate basket and offer at any time from eminent external experts, and total number of such 1-credit courses is equivalent to Summer Internship/Industrial training/Research work and it is to be monitored by the Humanities and Social Sciences Department.

Semester VIII

S. No.	COURSE NO.	COURSE NAME	Course Category	L - T - P	CREDIT
1.	EE48XY	Department Elective-IV	DEC-4	3-0-0	3
2.	EE48XY	Open Elective-II	OEC-2	3-0-0	3
3.	EE4837	Seminar	AEMC-4	0-0-2	1
4.	EE4839	Project Work - II	AEMC-5	0-0-12	6
		Total	**6-0-14**		**13**

For students undergoing Industrial Training/Project in Industry/Organization through the Institute Placement

S. No.	COURSE NO.	COURSE NAME	L - T - P	CREDIT
1.	EE4840	Industrial Project	0-0-8	4
2.	EE4841	Project Seminar	0-0-10	5
3.	EE4842	Comprehensive viva	0-0-8	4
		Total	0-0-26	13

OPEN ELECTIVE-1 (7th SEM)

S. No.	COURSE NO.	COURSE NAME	L-T-P	CREDIT
1.	EE2351	Electromechanical Energy Conversion and Transformers	3-0-0	3
2.	EE2352	Introduction to Information Technology	3-0-0	3
3.	EE2353	Transducers & Signal Conditioning	3-0-0	3
4.	EE2354	Energy Efficiency & Conservation	3-0-0	3
5.	EE2355	Utilization of Electrical Energy	3-0-0	3
6.	EE2356	Electric vehicle and charging technology	3-0-0	3
7.	EE2357	Modern electric traction and drives	3-0-0	3
8.	EE2358	Illumination and LED Drives	3-0-0	3

OPEN ELECTIVE-I1 (8th SEM)

S. No.	COURSE NO.	COURSE NAME	L-T-P	CREDIT
1.	EE2451	Power Generation Systems	3-0-0	3
2.	EE2452	Electrical Safety	3-0-0	3
3.	EE2453	Power Systems Engineering	3-0-0	3
4.	EE2454	Solid State Devices & Circuits	3-0-0	3
5.	EE2455	Power system operation in Restructure Markets	3-0-0	3
6.	EE2456	Smart grid and its challenges	3-0-0	3
7.	EE2457	Electric and hybrid vehicle	3-0-0	3

DEPARTMENT ELECTIVE-I (5th SEM)

S. No.	COURSE NO.	COURSE NAME	L-T-P	CREDIT
1.	EE 3571	Renewable Power Generation Systems	3-0-0	3
2.	EE 3572	Switched Mode Power Conversion	3-0-0	3
3.	EE 3573	Flexible AC Transmission	3-0-0	3
4.	EE 3574	Power System Harmonics	3-0-0	3
5.	EE 3575	Advanced Power Converters	3-0-0	3
6.	EE 3576	Digital Signal Processing	3-0-0	3
7	EE 357X	NPTEL/SWAYAM/MOOCS	3-0-0	3

DEPARTMENT ELECTIVE-II (6th SEM)

S. No.	COURSE NO.	COURSE NAME	L-T-P	CREDIT
1.	EE 3671	LT & HT Distribution Systems	3-0-0	3
2.	EE 3672	Software-based System Design	3-0-0	3
3.	EE 3673	Electric Power Quality and Management	3-0-0	3
4.	EE 3674	Data Acquisition and Signal Conditioning	3-0-0	3
5.	EE 3675	Advanced Digital Signal Processing	3-0-0	3
6.	EE 3676	Wind Energy Conversion Systems and its Challenges	3-0-0	3
7	EE 367X	NPTEL/SWAYAM/MOOCS	3-0-0	3

DEPARTMENT ELECTIVE-III (7th SEM)				
S. No.	COURSE NO.	COURSE NAME	L-T-P	Credit
1.	EE 4771	High Voltage Engineering	3-0-0	3
2.	EE 4772	Power Station Engineering	3-0-0	3
3.	EE 4773	EHV AC Transmission	3-0-0	3
4.	EE 4774	Neural Network, Fuzzy Logic And Evolutionary Algorithm	3-0-0	3
5.	EE 4775	Discrete And Non-Linear Control Theory	3-0-0	3
6.	EE 4776	Illumination Engineering	3-0-0	3
7.	EE 4777	Computer Methods In Power Systems	3-0-0	3
8	EE 477X	NPTEL/SWAYAM/MOOCS	3-0-0	3

DEPARTMENT ELECTIVE-IV (8th SEM)				
S. No.	COURSE NO.	COURSE NAME	L-T-P	Credit
1.	EE 4871	Surge And Lightning Protection And Safety Devices	3-0-0	3
3.	EE 4872	Solar and Wind Power	3-0-0	3
4.	EE 4873	Modern Control System	3-0-0	3
5.	EE 4874	Solid State Drives	3-0-0	3
6.	EE 4875	Digital Control System	3-0-0	3
7.	EE 4876	Power System Operation and Control	3-0-0	3
8	EE 487X	NPTEL/SWAYAM/MOOCS	3-0-0	3

INTERDEPARTMENTAL COURSES Offered By ECE

INTERDEPARTMENTAL COURSES					
S. No.	COURSE NO.	COURSE NAME	Course Category	L-T-P	CREDIT
1.	EC2331	Analog Electronic Circuits	IDCC-1	3-0-2	4
2.	EC2431	Digital Electronics & Computer Organization	IDCC-2	3-0-2	4
3.	EC3531	Electromagnetic Field Theory	IDCC-3	3-1-0	4

INTERDEPARTMENTAL COURSES Offered to ECE

INTERDEPARTMENTAL COURSES					
S. No.	COURSE NO.	COURSE NAME	Course Category	L-T-P	CREDIT
1.	EE2331	Network Analysis and Synthesis	IDCC-1	3-0-2	4
2.	EE2431	Control System Engineering	IDCC-2	3-0-2	4
3.	EE3531	Industrial Electronics	IDCC-3	3-0-0	3

EE2301	NETWORK ANALYSIS AND SYNTHESIS	[L-T-P:3-0-2], Credit: 4

UNIT-I: Network Graphs
Matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Solution methods: nodal and mesh analysis.
UNIT-II: Network theorems: superposition, Thevenin and Norton's maximum power transfer, Wye-Delta transformation. Steady State sinusoidal analysis using phasors. Linear constant coefficient differential equations: time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits.
UNIT-III: 2-port network
2-port network parameters: driving point and transfer functions. State equations for network, Transient analysis using transform methods.
UNIT-IV: Filters
Low pass, high pass, band pass, band stop, all pass filters and frequency dependent negative resistors, Applications of active networks (op-amp, BJT, FET, tunnel diode etc.) and systems, Non-linear network analysis and systems.
UNIT-V: Network Synthesis
Elementary Synthesis Operations, LC Network Synthesis, RC and RL networks.

Texts:
1. Network Analysis, Van Valkenburg, PHI Pbs, 2010
2. Circuit Theory, Kuriakose-PHI Pbs, 2005

References:
1. Network Analysis, Bakshi & Bakshi, Technical Publications, 2009
2. Network Analysis and Synthesis, Wadhwa, New Age Publications, 2008

EE2302	SEMICONDUCTOR DEVICE AND CIRCUITS	[L-T-P:3-0-2], Credit: 4

UNIT-I: Semiconductor Fundamentals
Energy Bands in Silicon, intrinsic and extrinsic silicon. Carrier transport in Silicon: diffusion current, drift current, mobility and resistivity. Generation and recombination of carriers.
UNIT-II: Semiconductor devices
P-n junction diode, Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED, p-I-n and avalanche photo diode, Basics of LASERs.
UNIT-III: Device technology
Integrated circuits fabrication process, oxidation, diffusion, ion implantation, photolithography, n-tub, p-tub and twin tub CMOS process 1-D, 2-D, 3-D and 0-D nanostructures, influence of external fields on the nano-devices, quantized systems (magnetic quantization, magneto size quantization, magneto inversion layers), scattering mechanisms for bulk, 0-D, 1-D, 2-D and 3-D systems

Texts:
1. Solid State Electronic Devices by Streetman & Banerjee

References:
1. Semiconductor Devices: Jasprit Singh
2. Integrated Electronics: Millman & Halkis
3. Semiconductor Physics and Devices: Donald Neaman
4. Semiconductor Devices: Kanan Kano
5. Semiconductor Optoelectronic Devices: Pallab Bhattacharaya

EE2303	ELECTRICAL ENGINEERING MATERIAL	[L-T-P:3-0-0], Credit: 3

UNIT-I: Conducting Materials
Resistivity, factors affecting resistivity Classification of conducting materials into low-resistivity and high resistivity materials, and their applications. (Copper, Silver, Gold, Aluminum, Steel) Stranded conductors Bundled conductors copper alloys their Applications (Tungsten, Carbon, Platinum, and Mercury) Superconductivity, Superconducting materials, Application of superconductor materials.
UNIT-II: Semiconducting Materials
Semiconductors, Electron Energy and Energy Band Theory, Excitation of Atoms, Semiconductor Materials, Intrinsic Semiconductors, Extrinsic Semiconductors, N-Type Materials, P-Type Materials, Minority and Majority Carriers, Semi-Conductor Materials, Applications of Semiconductor materials, Rectifiers, Temperature-sensitive resisters or thermistors, Photoconductive cells, Photovoltaic cells, Varisters, Transistors, Hall effect generators, Solar power.
UNIT-III: Insulating Materials:
Insulating Materials – Classification, properties, applications, Ageing, commonly used insulating gases.

UNIT-IV: Dielectric Materials
Dielectric Constant of Permittivity, Polarization, Dielectric Loss, Electric Conductivity of Dielectrics and their Break Down, Properties of Dielectrics, Applications of Dielectrics.
UNIT-V: Magnetic Materials:
Classification, Diamagnetism, Para magnetism, Ferromagnetism, Magnetization Curve, Hysteresis Eddy Currents Curie Point, Magneto-striction Soft and Hard magnetic Materials, Soft magnetic materials, Hard magnetic materials.
Materials for Special Purposes-Structural Materials Protective Materials, Lead, Steel tapes, wires and strips Other Materials, Thermocouple materials, Bimetals, Soldering Materials, Fuse and Fuse materials, Dehydrating material.

Text Books:
1. Electrical Material Engineering & Electronic components, Authors: K.B.Raina,S.K. Bhattacharya, T. Joneja, Publisher: S. K. Kataria & Sons
2. An Introduction to Electrical Engineering Materials, Authors: C.S.Indulkar, S.Thiruvengadam, Publisher: S. Chand
3. Electrical Engineering Materials, Author: R.K.Shukla, Archana Singh, Publisher: Mc Graw Hill

EE2304	ENERGY SCEINCE AND TECHNOLOGY	**[L-T-P:3-0-0], Credit: 3**

UNIT-I: Perspective: Energy systems: Past, present, and future – Global energy and development, Energy and environment, Climate change, Energy transitions; Indian energy scenario – Challenges and opportunities; Energy Access, Energy security
UNIT-II: Tools and techniques: Foundation for Energy science, Foundation for Energy engineering, Environmental impacts of energy use, Sustainability and life cycle analyses, Energy economics, Energy planning and policy, Pinch analysis and process integration, Modelling, simulation, and optimization, Heat transfer and computational fluid dynamics, Analytical techniques for experimentation
UNIT-III: Technologies and systems: Clean coal and CCS, Unconventional oil and gas, Advanced nuclear energy systems, Micro grid, Smart grids, Wind and hydro energy, Wave, tidal and ocean energy, Solar photovoltaic systems, Silicon cells, PV modules and systems, Solar thermal systems, Thermal energy storage, Advanced bioenergy systems, Waste to Energy, Fuel cells, Hydrogen Energy
UNIT-IV: Energy Management System: Energy Management, Energy Auditing, Energy and Carbon Benchmarking, Zero energy and energy-positive buildings, Demand side management, Demand response
Text and Reference: 1. Sri Sivakumar, Umesh Chandra Sharma and Ram Prasad. Energy Science and Technology. All Volumes; Studium Press LLC.
2. John Andrews and Nick Jelley. Energy Science – principles, technologies and impacts. Oxford Univ. Press.
3. Zhigan Fang. Energy Science and Applied Technology. CRC Press.
4. Hatim Machrafi. Green Energy and Technology. Bentham e-Books.

EC2331	**ANALOG ELECTRONIC CIRCUITS**	**[L-T-P:3-0-2], Credit: 4**

UNIT-I: Diode Circuits
Small signal equivalent circuits of diode, Simple diode circuits, clipping, clamping, rectifier, Voltage multiplier, Zener diode and voltage regulator.
UNIT-II: BJT Circuits
Review of BJT operation and its characteristics, need of biasing and different types of biasing circuits for BJT & FET, stability analysis, small signal Amplifier analysis of BJT & FET, estimation of voltage gain, input resistance, output resistance etc.,
UNIT-III: Feedback Amplifier
Feedback concept, Feedback amplifier topologies, General characteristics of negative feedback amplifier, input and output resistance with negative feedback, Method of analysis of feedback amplifiers with practical examples.
UNIT-IV: Power Amplifier
Definition of class A, B and C power amplifiers, Distortion analysis, Series fed and transformer coupled power amplifier, Push-pull amplifiers, Conversion efficiency, Basic operation of differential Amplifier, Different configuration of differential Amplifier, Calculation of gain, impedance etc. Biasing of differential Amplifier, calculation of differential gain, common mode gain, CMRR.
UNIT-IV: Oscillators
Review of the basic concept for oscillation, Barkhaussen criterion, LC Oscillators, RC phase shift oscillator and Wien bridge oscillator, Colpitts, Hartley and Crystal oscillator, PLL as negative feedback system, building blocks of PLL, applications of PLL.

Texts:
1. *Microelectronic Circuits Theory and Application,* by Sedra and Smith, Oxford Publications, 7th Edition
2. *Electronic Circuit Analysis and Design*, by Donald A. Neamen, Irwin Publications, 3rd Edition

References:
1. *Design with Operational Amplifiers and Analog Integrated Circuits,* by Sergio Franco, Tata McGraw Hill Book Company, 3rd Edition

MA2301	**MATHEMATICS-III**	**[L-T-P:3-0-0], Credit: 3**

UNIT-I: Matrices
Matrices: Types of Matrices, Symmetric; Hermitian; Skew-symmetric; Skew-Hermitian; orthogonal matrices; Unitary Matrices; rank of a matrix by Echelon form and Normal form, Inverse of Non-singular matrices by Gauss-Jordan method; **Eigen values and Eigen**

vectors: Linear Transformation and Orthogonal Transformation: Eigen values and Eigenvectors and their properties: Diagonalization of a matrix; Cayley-Hamilton Theorem (without proof); finding inverse and power of a matrix by Cayley-Hamilton Theorem; Quadratic. **Sequences & Series:** Sequence: Definition of a Sequence, limit; Convergent, Divergent and Oscillatory sequences. Series: Convergent, Divergent and Oscillatory Series; Series of positive terms; Comparison test, p-test, D-Alembert's ratio test;. **Calculus:** Mean value theorems: Rolle's theorem, Lagrange's Mean value theorem with their Geometrical Interpretation and applications, Cauchy's Mean value Theorem. Taylor's Series. Applications of definite integrals to evaluate surface areas and volumes of revolutions of curves (Only in Cartesian coordinates), Definition of Improper Integral: Beta and Gamma functions and their applications.

Texts:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010
2. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons,2006.
3. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.

References:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
2. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11thReprint, 2010.

EE2401	ELECTRICAL MACHINES –I	[L-T-P:3-0-2], Credit: 4

UNIT-I: D.C. Generator

Principle of Operation, Construction of D.C. Machines, E.M.F. equations, Armature reaction, Commutation, interpoles and compensating winding, Types of Generator, Characteristics of self-excited generator and separately excited generators-applications.

UNIT-II: D.C. Motor

Principle of operation, back E.M.F. torque and speed equations, characteristics of D.C Motors, speed control of series and shunt motors by flux control, armature control and voltage controlled methods- applications, Swinburn's test, brake test, DC motor 3-point starters.

UNIT-III: Transformer

Construction and principle of operation, E.M.F. equations, phasor diagram, actual and approximate equivalent circuits, open and short circuit tests, voltage regulations, losses and efficiency, Sumpner's test, parallel operation and load sharing. Autotransformer, 3 phase transformer- Scott connection of transformers for phase conversion, on –load and off-load tap changers, induction regulators.

Text Books:

1. Nagrath I. J and Kothari D. P. "*Electric Machines"*, Tata McGraw Hill Publishing Company Ltd,1990.
2. P.S. Bimbhra, "*Electrical Machinery"*, Khanna Publishers, 2003.

References:

1. Fitzgerald. A.E., Charles KingselyJr, Stephen D. Umans, *"Electric Machinery"*, McGraw Hill Books Company, 1992.
2.Hill Stephen, Chapman.J, "*Electric Machinery Fundamentals"*, McGraw Hill Book Co., New Delhi, 4th edition 2005.

EE2402	MEASUREMENT & INSTRUMENTATION	[L-T-P:3-0-2], Credit: 4

UNIT-I: Basic Measurement Techniques

Construction and principle of operation of Moving coil, Moving Iron, dynamometer, Wattmeter, Electro-static Instruments, Thermal and Rectifier type deflecting instruments, extension of instrument ranges using shunts, multipliers and instrument transformers.

UNIT-II: Errors in Measurement

Definition of accuracy, precision, Fidelity, speed of response, non-linearity, techniques of linearization, classification of errors. Statistical analysis.

UNIT-III: Measurements of Resistances, Inductances and capacitances

Measurement of low, medium and high resistances, Kelvins double bridge, multimeters, megger, D.C. and A.C. potentiometers.
AC Bridges: measurement of inductances, capacitance and frequency by A.C. Bridges-Maxwell, Schering, Anderson, De-Sauty, Wien. Murray and Varley loop methods.

UNIT-IV: Measurement of power and energy: Measurements of power in polyphase circuits, various wattmeter connections. A.C. and D.C. energy meters. *Cathode Ray Oscilloscope*: C.R.O. construction & principle of operation.

UNIT-V: Digital Instrumentation

Block diagram of Instrumentation schemes, DVM, DMM, frequency counter. **Frequency domain instruments:** Wave analyzer, spectrum analyzer. **Special Purpose Instruments**: Signal generators, Q-meter.

Text Books:

1. A. Bell David, '*Electronic Instrumentation & Measurement'*, Reston Publishers, 2003.

References:

1. H.S. Kalsi, "*Electronic Instrumentation*", Tata Mc-Graw Hill, 2010.
2. Sawhney A K, "A *course in Electrical & Electronic Measurements & Instruments*", Dhanpat Rai & Co,1994.
3. Golding E.W. & Wides F.C, "*Electrical Measuring Instruments & Measurements"*, Wheeler.
4. S. K. Singh, "*Industrial Instrumentation & Control"*, Tata McGraw Hill, New Delhi, 2007.

EE2403	SIGNALS AND SYSTEMS	[L-T-P:3-1-0], Credit: 4

UNIT-I: Laplace, Fourier and z- Transforms: Definitions and properties of Laplace transform, continuous time and discrete time Fourier series, continuous-time and discrete-time Fourier Transform, DFT and FFT, Z-transform. Sampling theorem.

UNIT-II: Linear Time-Invariant (LTI) Systems: Definitions and properties; causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay.
UNIT-III: Signal transmission through LTI systems.

Text Books:
1. M.J Roberts, "*Fundamentals of Signals and Systems*", Tata McGraw Hill, 2007.

References:
1. A.V. Oppenheim, A.S. Willsky and H.S. Nawab, "*Signals and Systems*", Prentice Hall of India, 2006.
2. P. Lathi, "*Signal Processing and Linear Systems*", Oxford University Press, 1998.
3. R.F. Ziemer, W.H. Tranter and D.R. Fannin, "*Signals and Systems - Continuous and Discrete*", Prentice Hall of India, 1998.
4. Simon Haykin, Barry van Veen, "*Signals and Systems*", John Wiley and Sons, 1998.

EE2404	POWER SYSTEMS-I	[L-T-P:3-0-0], Credit: 3

UNIT-I: Introduction to various Power Plants: Introduction to conventional sources and non-conventional sources of energy, their scopes for energy conversion. Overview of different conventional and non-conventional power generation plants. Per unit quantities, per unit values for steady state condition, single line diagram, problems.
UNIT-II: Economics of Power Systems: Definitions of Load, connected load, Base load, Peak load, Demand, Demand intervals, Demand factor, Average load, Load factor, Diversity factors, Utilization factor, Capacity factor and Load curve. Economics of power factor improvement, tariff structures. Problems.
UNIT-III: Transmission Systems: Introduction, transmission voltages, classification of transmission system, advantages of high voltage transmission, comparison of overhead and underground supply system. Comparison of AC and DC transmission system, economic choice of conductor size, Kelvin's law, problems.
UNIT-IV: Overhead Line Insulators and Underground Cables: Overhead line insulators and its types, voltage grading of insulators, string efficiency, methods of improving string efficiency, grading. Sag in overhead line, calculation of sag, ice and wind loading, Stringing chart. Underground cables, general construction, classification of cables, capacitance of a single core cable, capacitance of three core cables, most economical size of conductor, grading of cables, types of grading, breakdown voltages. Problems.
UNIT-V: Distribution Systems (DS): Introduction, classification of DS, feeders, distributors, service mains of a typical DS, primary AC DS - radial feeders, parallel feeders, loop feeders and interconnected network system. Secondary AC DS - three phase four wire system and single phase two wire DS, methods of calculation of AC DS, current loading and voltage drop diagram. Problems

EC2431	DIGITAL ELECTRONICS & COMPUTER ORGANIZATION	[L-T-P:3-0-2], Credit: 4

UNIT-I: Number System and Boolean Algebra
Introduction to number systems, binary, Integer and floating-point- numbers, octal, hexadecimal and decimal number system and their conversion. Arithmetic Operations: Binary addition & subtraction; 1's and 2's complement, subtraction using 2's complement; binary codes, addition and subtraction operations on binary-coded numbers; Algorithms for performing multiplication and division.
UNIT-II: Combinational Logic Circuits
Basic Logic Operations, AND, OR, NOR, NAND, EX-OR, EX-NOR Gates, Boolean expressions and their minimization using algebraic identities; Karnaugh map representation and minimization of Boolean functions using K-map; Don't care conditions, NAND and NOR logic implementations, two-level realizations using gates – AND-OR, OR-AND, NAND-NAND and NOR-NOR structures. Combinational Circuits using MSI Modules: Adders, subtractors, BCD arithmetic, serial adder, carry look-ahead adder, Multi-bit adder, Multiplexers, De-multiplexers, Decoders, Multiplexer-based realization of K-maps; Combinational circuit design using multiplexers and gates
UNIT-III: Sequential Logic Circuits
Latches and Flip-flops; Ripple counters using T flip-flops; Synchronous counters; Shift Registers; Ring and MLS counters; Sequence generator using J-K / D flip-flops, Finite state machines, propagation delay, setup and hold time, critical path delay
UNIT-IV: Memories and Programmable Logic: ROM, SRAM, DRAM, PLA, PAL Logic Families: ROM, SRAM, DRAM, PLA, PAL

Texts:
1. *Digital Electronics,* by WH Gothmann, PHI, 2nd Edition

References:
1. *Digital Logic & Computer Design,* by M Morris Mano, Pearson, 5th Edition 2011
2. *Digital Design, Principles and Practices*, by J.F. Wakerly, Pearson Education, 4th Edition 2005

MA2401	NUMERICAL METHODS	[L-T-P:3-0-0], Credit: 3

UNIT-I: Definition and source of errors, propagation of errors, solutions of algebraic and transcendental equations by bisection method, iteration method, Secant method, Newton-Raphson method, Solution of Simultaneous linear equations by Gauss Elimination, Gauss-Jacobi and Gauss-Seidal method.

UNIT-II: Interpolation: Concept of interpolation, difference operators, divided difference interpolation, Newton's forward, backward interpolation, Lagrange's interpolation, Starling and Bessel's interpolation, spline interpolation.

UNIT-III: Numerical differentiation (1st and 2nd order), Numerical integration (Trapezoidal, Simpson's one-third, Weddle's rule), Gaussian quadrature.

UNIT-IV: Numerical Solutions of Ordinary differential equations: IVP: Taylor's method, Picard's method, Runge-Kutta's method, Euler's method and Euler's modified method, Predictor-corrector method. BVP: Shooting method, Finite difference method.

Texts

1. Jain, Iyengar and Jain "Numerical Methods for Engineers and Scientists", Wiley Eastern
2. Richard L Burden, J Douglas Faires ,"Numerical Analysis", Brooks/Cole, Cengage Learning
3. Atkinson, Kendall E, "An Introduction to Numerical Analysis" John wiley & sons

Reference Books:

1. S. D. Conte and Carl de Boor, "Elementary Numerical Analysis – McGraw Hill
2. Gerald and Wheatley ," Applied Numerical Analysis", Addison – Wesley

EE3501	POWER ELECTRONICS	[L-T-P:3-0-2], Credit: 4

UNIT-I: General Introduction

Introduction on Power Electronics, Scope and Application,

UNIT-II: Power Semiconductor Devices Power diodes

Power transistors - SCRs - Triac - GTO - Power MOSFETs - IGBTs- Principles of operation and characteristics, device specifications and ratings, methods of turning on SCR- gate triggering circuit, methods of turning off SCR commutation circuits. Protection and gate drive circuits.

UNIT-III: Control rectifiers (AC to DC converter)

Single phase converters: Principle of phase control, half wave-controlled rectifier load, fully controlled bridge converter, half controlled (semi) converter, Effect of single-phase full converter with source inductance, Dual converter, 3-phase half wave controlled rectifier, 3-phase fully controlled bridge converter, 3-phase semi converter.

UNIT-IV: Inverter

Series inverter, parallel inverter, single phase bridge inverter, concept of VSI and CSI, 3-phase bridge inverter (120° and 180° conduction mode), concept of PWM inverter.

UNIT-V: D.C. Choppers and Cycloconverter

Principle of operation, control techniques, transient analysis of step down chopper, buck, boost & buck-boost regulator, voltage commutated chopper, current commutated chopper, load commutated chopper, jones chopper.

Cyclo converters-Single- phase mid-point type and bridge type cyclo converter, Applications: HVDC transmission, UPS, Zero voltage switch, Zero current switch.

Text Books:

1. P.S. Bimbhra, "*Power Electronics"*, Khanna Publication, 2012.
2. M.H. Rashid, "*Power Electronics"*, Pearson Publication, 2003.

References:

1. P.C. Sen, "*Power Electronics"*, Tata McGraw-Hill, 1987.
2. V.R. Moorthi, "*Power Electronics"*, Oxford University Press, 2005.
3. M.D. Singh & K.B. Khanchandani, "*Power Electronics"*, Tata McGraw-Hill, 2007.

EE3502	ELECTRICAL MACHINES-II	[L-T-P:3-0-2], Credit: 4

UNIT-I: Synchronous Generator

Constructional details – Types of rotors – emf equation – Synchronous reactance –Armature reaction – Voltage regulation – EMF, MMF, ZPF and A.S.A method – Synchronizing and parallel operation – Synchronizing torque - Change of excitation and mechanical input – Two reaction theory – Determination of direct and quadrature axis synchronous reactance using slip test – Operating characteristics - Capability curves.

UNIT-II: Synchronous Motor

Principle of operation – Torque equation – Operation on infinite bus bars -V-curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power developed.

UNIT-III: Three Phase Induction Motor

Constructional details – Types of rotors – Principle of operation – Slip – Equivalent circuit – Slip torque characteristics - Condition for maximum torque – Losses and efficiency – Load test - No load and blocked rotor tests - Circle diagram – Separation of no load losses – Double cage rotors –Induction generator – Synchronous induction motor. Single phase induction motor, single phase synchronous motor, single phase commutator motors. Special purpose Machine.

Text Books:

1. D.P. Kothari and I.J. Nagrath, "*Electric Machines"*, Tata McGraw Hill Publishing Company Ltd 2002.
2. P.S. Bhimbhra, "*Electrical Machinery"*, Khanna Publishers, 2003.

References:

1. A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, "*Electric Machinery"*, Tata McGraw Hill publishing Company Ltd, 2003.
2. J.B. Gupta, "*Theory and Performance of Electrical Machines"*, S. K. Kataria and Sons, 2002.
3. K. Murugesh Kumar, "*Electric Machines"*, Vikas Publishing House Pvt. Ltd, 2002.

EE3503	POWER SYSTEMS-II	[L-T-P:3-0-0], Credit: 3

UNIT-I: INTRODUCTION

Structure of electric power systems – one-line diagram – Two wire DC, AC single phase and three phase systems- Recent Trends in transmission systems, comparison of EHVAC and HVDC systems.

UNIT-II: Performance of transmission lines

Transmission line parameters-Resistance, inductance and capacitance of single-phase transmission lines –stranded and bundled conductors – symmetrical and unsymmetrical spacing –transposition of conductors– Double circuit line Application of self and mutual GMD – Skin and Proximity effect –Corona loss.

Performance of lines-Equivalent circuits for short, medium and long lines – transmission efficiency and voltage regulation – Real and reactive power flows in lines –power angle diagram – power circle diagrams for receiving and sending end, limiting factors for transmission line load ability– Ferranti effect. Mechanical design of Transmission line**-**Factors affecting mechanical design, line supports, sag.

UNIT-III: POWER SYSTEM STABILITY

Introduction to stability studies, Swing equation, Swing curve, Equal area criterion, Critical clearing angle and time, Modified Euler's method, Fourth order Runge-Kutta method, Multi-machine transient stability.

UNIT-IV: POWER FLOW ANALYSIS

Bus classification, Formulation of Power Flow problems, Power flow solution using Gauss Seidel method, Handling of Voltage controlled buses, Power Flow Solution by Newton Raphson method, Fast Decoupled Power Flow Solution.

UNIT-V: Economic operation of Power plant: Introduction; Methods of loading turbo - generators, Thermal plant cost modelling, Input - output curves, incremental cost, cost curve: Linear and quadratic, method of Lagrangion multiplier, Equality constraints and inequality constraints, transmission loss, optimum generator allocation with and without transmission loss; Penalty factors, iterative procedure to solve co-ordination equation. Advantages of combined operation with hydro plants, Introduction with a schematic diagram having cost and load curve.

Text Books:

1. C.L.Wadhwa, *"Electrical Power System"*, New Age International Pvt. Ltd., 2007.
2. J Nagrath and D P Kothari, "*Power System Engineering"*, Tata McGraw Hill

References:

1. J Nagrath and D P Kothari, "*Power System Engineering"*, Tata McGraw Hill
2. B R Gupta, "*Power System Analysis and Design"*, Wheelers Publishers
3. Ashfaq Hussain, "*Electrical Power Systems"*, CBS publishers and distributor.
4. S.N. Singh, "*Electric Power*

EE3504	CONTROL SYSTEM	[L-T-P:3-0-2], Credit: 4

UNIT-I: Models and physical systems

Feedback and its effects-linearization Mathematical Modelling of Physical Systems- Block diagram Concept and use of Transfer function. Signal Flow Graphs Mason's gain formula.

UNIT-II: Time Domain Analysis of Control Systems

BIBO and absolute stability, Routh-Hurwitz Criterion. P, PI and PID controllers, State Variable Analysis of Linear Dynamic Systems-controllability and observability Root Locus Techniques- zero and pole.

UNIT-III: Frequency Domain Analysis of Control Systems

Polar plots, Nyquist stability criterion, Bode plots, application M&N circles, Nichols charts Design of Compensators.

Text Books:

1. I .J. Nagrath, M. Gopal, "*Control Systems Engineerin*g", New Age International Publishers, 2008.
2. K. Ogata, "*Modern Control Engineering"*, Prentice Hall, 2010.

References:

1. Samarjit Ghosh, "*Control System: Theory & Applications"*, Pearson Education, 2007.

2. B. C. Kuo, Farid Golnaraghi, "*Automatic Control Systems"*, John Wiley and Sons, 2003
3. D. Roy Choudhury, "*Modern Control Engineering"*, Prentice Hall, 2005.

EC3531	ELECTROMAGNETIC FIELD THEORY	[L-T-P:3-0-0], Credit: 3

UNIT-I: Vector Calculus
Basics of Vectors, Definition of potential difference and potential, Potential of point charge and system of charges. Potential gradient, Energy density in electrostatic field. Poisson's and Laplace's equations. Poynting Vector, Boundary conditions at Media Interface. Coordinate Systems and Transformation: Cartesian, Cylindrical and Spherical Coordinates.
UNIT-II: Electrostatic and Magnetostatic Fields
Introduction, Electric Fields due to Continuous Charge Distributions, An Electric Dipole and Flux Lines, Energy Density in Electrostatic Fields, Maxwell's Equations for Static EM Fields, Gauss's law, Biot- Savart, Stoke's theorem and Amperes circuital laws and their applications. Significance of curl and divergence. Magnetic flux density, Scalar and Vector magnetic potential.
UNIT-III: Magnetics, Materials and Field Distributions
Properties of Materials, Convection and Conduction Currents, Polarization in Dielectrics, Dielectric Constant and Strength, Isotropic, and Homogeneous Dielectrics, A Magnetic Dipole, Magnetization in Materials, Classification of Magnetic Materials and Magnetic Boundary Conditions, Magnetic Energy, Force on Magnetic Materials, Current Continuity.
UNIT-IV: Wave Propagation Characteristics
Wave Propagation in Lossy Dielectrics, Plane Waves in Lossless Dielectrics, Free Space and in Good Conductors. Power and the Poynting Vector, Reflection of a Plane Wave at Normal Incidence and at Oblique Incidence.
Texts:
1. *Principle of Electromagnetics,* by M.N.O. Sadiku and S.V. Kulkarni, Oxford, 6th Edition
2. *Microwave Engineering*, by David. M. Pozar, John Wiley, 4th Edition

References:
1. *Electromagnetic Waves,* by R.K. Shevgaonkar, Tata McGraw Hill, 1st Edition
2. *Electromagnetic waves & Radiating Systems*, by E.C. Jordan & K.G. Balmain, Prentice Hall, 2nd Edition

EE3601	MICROPROCESSOR AND MICRO-CONTROLLER	[L-T-P:3-0-2], Credit: 4

UNIT-1: Microprocessors
Addressing mode, instruction set, Overview/concept of peripheral interfacing devices-8251, 8253, 8255 and 8279, 8085-architecture, control signal generation for external operations- fetch, operation, pin configuration and functions, bus organization,10/M, read/write, machine cycles and bus timings.
Unit II. Microcontrollers
Timer/Counter programming for time delay generation and waveform generation. Interfacing with ADC, DAC, LEDs and seven segment display, addressing modes, instruction sets, instruction classification, 8051-architecture, operation, pin configuration and functions, memory organization, register, 1/0 ports, Assembly language programming, Interrupts in 8051.
Unit III. IoT application using Arduino and Raspberry Pi
Arduino- Playing tones and a melody, Raspberry Pi -controlling LED, interfacing an LED and Switch, Interfacing a Light Sensor (LDR), camera interfacing etc., alphanumeric LCD display, speed and direction control, temperature and humidity sensor interfacing.
Unit IV. Raspberry Pi: Introduction to the Raspberry Pi, setting and configuring the board, programming on Raspberry Pi, Protocol pins, RPi, GPIO library, basic functionality of the Raspberry Pi board and its processor, python programming environment, python expressions, general purpose 10 pins, communicating with devices and sensors.
Unit V. Arduino: Introduction to the Arduino ,Arduino Libraries, Analog and Digital Interfacing, Adding Interrupts, communicating with devices and sensors, creating an Arduino programming Environment, Arduino IDE, creating an Arduino program.

Recommended Books:
Text Books:
1. R. S. Gaonkar, "*Microprocessor Architecture, Programming and Applications with the 8085*",
Penram International Publishing (India), 2000.
2. A.K. Roy & K.M. Bhurchandi, "*Advanced Microprocessor and Peripherals (Architecture, Programming & Interfacing"*, Tata McGraw-Hill Publication,
Reference Books:

1. "Arduino for beginners: Essential Skills Every Maker Needs", John Baichtal, Person Education, Inc., 1st Edition.
2. "Programming with Raspberry Pi: Getting Started with Python", Simon Monk, January 2012, McGraw Hill Professional.
3. "Arduino Cookbook", Michael Margolis, O'Reilly Media, Inc., 1st Edition.
4. "8085 Microprocessors Architecture Application and Programming", Ramesh S. Goankar, Penram International, 5th Edition
5. "Raspberry Pi User Guide", Eben Upton and Gareth Halfacree, August 2016, 4th Edition, John Wiley & Sons.
6. "The 8051 Microcontroller", Kenneth J. Ayala, Cangage learning, 3rd Edition.

EE3602	SWITCHGEAR AND PROTECTION	[L-T-P:3-0-2], Credit: 4

UNIT-I: Symmetrical fault and Unsymmetrical Faults
Causes of faults, types of faults, importance of fault analysis in electrical power systems, fault analysis for generators, transmission lines, Concepts of symmetrical components, sequence impedances and sequence networks for generators, transformers, transmission lines etc, Symmetrical fault (LLL and LLL-G) analysis, unsymmetrical fault (L-G, L-L, LL-G) analysis, fault analysis for generators, transmission lines, current limiting reactors, types, functions.
UNIT-II: Circuit Breakers: Function, importance, arc phenomenon, arc interruption theories, CB types and description, Circuit breaking transients, restriking and recovery voltages, CB ratings, testing of CB's.
UNIT-III: Protection Relays
Operating principle, classification, Electromagnetic type relays theories for torque generation, concepts of protective zones, Introduction to numerical and solid state relays. Over Current relay characteristics, Directional relay torque generation, feeder protection, time grading & current grading, Distance protection philosophies, Distance relays and their characteristics, differential protections, Protection of Transmission lines, generator and transformers, Transley relay, negative sequence relay, Fuses.
UNIT-IV: Sub-Stations: Function of sub-station, necessity, types and arrangement of sub-station equipment's, single line diagram with different busbar arrangement including reactors, bus-tie breakers, substation grounding, surge protection
UNIT-V: Lightning Arrester: Function, types, working principles and surge absorbers.
UNIT-VI: Neutral Grounding: Fundamentals of neutral grounding, ungrounded system analysis, arcing ground, solid grounding, types of grounding, resistance, reactance and resonant grounding, generator neutral breaker, grounding practice.
Text Books:
1. Badriram & Vishwakarma, "*Power System Protection*", Tata McGraw-Hill Education, 2011.
2. Paithankar Y. G., S. R. Bhide., "*Fundamentals of power system protection*", PHI Learning Pvt. Ltd., 2004.
References:
1. Ravindra Nath.B, and Chandar.M, "*Power systems protection and switchgear*", New age international (P) Ltd. 2005.
2. Rao Sunil.S, "*Switchgear and protection".* Khanna Publishers, 1999.
3. Paithankar.Y.G," *Transmission Network Protection: Theory and Practice*", Marcel Deicker, Inc.1998.

EE3603	ADVANCE CONTROL SYSTEM	[L-T-P:3-1-0], Credit: 4

UNIT-I: Linear control systems:
Introduction, concept of state, state variables and state Model, state modeling of linear systems, linearization of state equations.
UNIT-II: State space analysis:
State space representation using physical variables, phase variables & canonical variables. Derivation of transfer function from state model, diazotization, Eigen values, Eigen vectors, generalized Eigen vectors. Solution of state equation: state transition matrix and its properties, computation using Laplace Transformation, power series method, Cayley-Hamilton method, concept of controllability & observability, methods of determining the same.
UNIT-III: Frequency response design
Design of lag, lead, lag-lead and PID controllers, the Nyquist criterion, analysis and design, relative stability and the Bode diagram, closed-loop response, sensitivity, time delays;
UNIT-IV: Root locus design
Construction of root loci, phase-lead and phase-lag design, PID controller design; Modern design: controllability and observability, state feedback with integral control, reduced order observer.
UNIT-V: Digital controllers
Use of z-transform for closed loop transient response, stability analysis using bilinear transform and Jury method, deadbeat control, Digital control design using state feedback.
Text Books:
1. M. Gopal, "*Digital Control and State Variable Methods*", Tata McGraw Hill, 2003.
2. M. Gopal, "*Control Systems*", Tata McGraw Hill, 2008.
References:
1. G. F. Franklin, J. D. Powel and A. E. Emami-Naeini, "Feedback *Control of Dynamic Systems*", Prentice Hall Inc. 2002.
2. K. J. Astrom and T. Hagglund, "*Advanced PID Control*", ISA, Research Triangle Park, NC 27709, 2005.

EE3604	RENEWABLE ENERGY RESOURCES	[L-T-P:3-0-0], Credit: 0

UNIT-I: Introduction
Fossil fuel-based systems, Impact of fossil fuel-based systems, non-conventional energy – seasonal variations and availability.
UNIT-II: Renewable energy sources
Sources and features, Hybrid energy systems, Distributed energy systems and dispersed generation (DG), Other sources of energy-Solar energy, Wind energy system, Wave energy, Energy from biomass, Energy from OTEC, Geothermal energy system.
UNIT-III Solar energy:
The Sun, The Solar constant, Solar radiation spectrum, Solar radiation measurement, Solar radiation at earth's surface, Solar radiation data, radiation geometry, empirical relations predicting availability of solar radiation, radiation on horizontal and tilted surface, Flat plate collectors, Basic energy balance equation and its principle, concentrating collectors, It's classification and working principle, Application of solar thermal technologies-Heating, cooling, Drying, Distillation, Power generation, Solar PV system, it's principle and application,
UNIT-IV: Wind Energy
Introduction, Basic principle of wind energy conversion, wind data and energy estimation, site selection, basic component of wind

energy conversion system, wind turbines and their analysis, wind-electrical generation. Stand-alone and grid connected wind-electrical power system, various applications of wind energy.

Text books

1. Rai.G.D, "*Non-conventional resources of energy*", Khanna publishers, Fourth edition, 2010.
2. Khan.B.H, "*Non-Conventional Energy Resources*", The McGraw Hills, Second edition, 2009.
3. S.P. Sukhatme, "Solar energy: Principles of Thermal storage", Tata McGraw Hill.

References:

1. Godfrey Boyl, *"Renewable Energy: Power sustainable future*", Oxford University Press, Third edition, 2012.
2. Rao.S. & Parulekar, *"Energy Technology"*, Khanna publishers, Fourth edition, 2005.

EE4701	PRINCIPLES OF INDUSTRIAL INSTRUMENTATION 3-0-0-3	[L-T-P:3-0-0], Credit: 3

Unit-1: Characteristics of Measurement System: Functional Units, Classification and Performance characteristics, Dynamic Calibration, Errors: An Overview, Statistical Error Analysis and Reliability.

Unit-2: Pressure, Temperature and Flow Measurement: Pressure Measurement: Electrical types, Vacuum Measurement, Sound pressure level measurement, Temperature Measurement: Electrical Types temperature sensors. Flow Measurement: Electrical type flow meters, Open Channel flow measurement; Level Measurement: Hydrostatic type, Thermal effect type, Solid level measurement.

Unit-3: Instruments for Analysis: Introduction, Gas Analysers, Liquid Analysers, X-ray Methods, Chromatography, Mass spectrograph. Telemetry: Introduction, Pneumatic Means, Electrical Means, Frequency Telemetering, Multiplexing, Modulation, Modulation of Digital Data, Transmission Channels, Briefing of a Telemetry System in Operation.

Unit-4: Power Plant Instruments: Introduction, Power Plant Scheme, Vibration and Expansion, Analysis, Flue Gas Analysis. Turbine–Monitoring and Control: Turbine measurements: electrical, mechanical and process parameters. Turbine control systems: safety and process. Lubrication system for Turbo Alternator and its control. Turbo Alternator cooling system.

Display, Recording, Alarm: Introduction, Display methods, Recorders, Alarm annunciation, Data logging system.

Text Book

1. Principles of Industrial Instrumentation, D Patranabis, Third Edition, Tata McGraw Hill Education Private Limited, New Delhi
2. Power Plant Instrumentation – K.Krishnaswamy, M.Ponnibala, PHI publications,2009.

Reference Book

1. Power Plant Engineering - P.K Nag, Tata McGraw-Hill,2010.

HS 4701	MANAGEMENT PRINCIPLE AND PRACTICES	[L-T-P:3-0-0], Credit: 3

UNIT-I: Management theory & Practice

Function of management, Hawthorne experiment, Leadership styles & Motivation theories.

UNIT-II: Marketing Management

Process, Product life cycle and Marketing strategies. Operation Management: Productivity & Work study, Operational strategy.

UNIT-III: Project Management

Project planning & Feasibility analysis, Project scheduling methods.

UNIT-IV: Microeconomics, Monetary & Fiscal policy

Globalization, Credit creation by commercial bank.

Entrepreneur & its functions, Demand forecasting, Sustainable development & its strategies.

UNIT-V: Indifference curve analysis

Market and its structures.

TEXT BOOKS

1. A. Koutsoyiannis , Modern Microeconimocs, 2nd edition, Macmillan.
2. Robert, S Pindu, D. Rubinfield, PL Mehta, Microeconimics 2009
3. Marketing management by Philip Kotler
4. Production and operations management by Aswathappa and Shridhara Bhatt

EE3XY	DEPARTMENTAL ELECTIVE-I (5th Sem)	[L-T-P:3-0-0], Credit: 3

EE 3571 Renewable Power Generation Systems 3-0-0-3

UNIT-I: Environmental aspects of electric power generation from conventional sources

Limitation of fossil fuels - Atmospheric pollution – effects of hydro-electric projects – disposal of nuclear waste – GHG emission from various energy sources and its effects – need for renewable energy sources.

UNIT-II: Solar Photo-Voltaic system

Solar radiation and its measurement – Angle of sun rays on solar collector – optimal angle for fixed collector – sun tracking, an introduction to solar cell, solar PV module, PV system design and applications – stand-alone and grid connected systems, environmental impacts.

UNIT-III Wind power generation

Wind energy, classification of wind turbines – aerodynamic operation of wind turbine, extraction of wind turbine power, wind turbine power curve, horizontal axis wind turbine generator – modes of wind power generation – stand-alone and grid connected system, environmental impacts.

UNIT-IV: Fuel cell system

Principle of operation of fuel cell, technical parameters of fuel cell, Type of fuel cell – advantages of fuel cell power plants, energy output, efficiency and emf of fuel cell – operating characteristics, applications and environmental impacts.

UNIT-V: Hybrid energy systems

Need for hybrid systems, types, configuration and coordination, electrical interface – PV- Diesel, Wind-diesel, wind-PV, wind-PV- fuel cell.

Reference Books:

1. D P Kothari, K C Singal and Rakesh Ranjan, 'Renewable Energy Sources and Emerging Technologies' 2nd Edition, 2012.
2. C S Solanki, 'Solar Photo-voltaics – Fundamentals, Technologies and Applications', PHI Pvt., Ltd., 2nd Edition, 2011.
3. S N Bhadra, D Kastha and S Banerjee, 'Wind Electric Systems', Oxford Publications, 2nd Edition, 2007

EE 3572 Switched Mode Power Conversion [3-0-0-3]

UNIT-I: Introduction to Power Electronic Switches and reactive components

A brief review of the characteristics of power semiconductor devices (Diode, MOSFET, IGBT), approximate / Equivalent representation of these switches in the on and off-state, realization of composite switches and characteristics in VI quadrants. Losses in Switches: Conduction loss, review of rms and average calculations of a waveform, conduction loss calculations for different devices, Device switching characteristics, Introduction to device datasheets, Switching Loss, Heat sink and thermal equivalent circuit. Basics of gate driver circuits and snubbers: Drive requirement, Effects of gate resistance, effect of parasitic inductance, turn-off snubber, turn-on snubber. Reactive Components: basics of inductor and Transformer design, Selection of capacitors, equivalent series resistor and inductance (ESR and ESL). Basics of current second and volt second balance.

UNIT-II: DC-DC Linear regulator

Series controlled regulator, Shunt controlled regulator Non-Isolated DC-DC converter: buck, boost, buck-boost, Cuk, Sepic continuous conduction mode and discontinuous conduction mode analysis in steady state Effect of non-idealities in the voltage gain and efficiency. Isolated DC-DC Converter: Steady state Analysis of flyback, forward, half bridge and full bridge converter.

UNIT-III: Dynamic Modeling of DC-DC converters

State space representation and Circuit Averaging technique for modelling basic switching converters like Buck, Boost, Buck-Boost converters. Audio Susceptibility, Input Admittance, Output Impedance, Transfer function analysis and dynamic performances of switching power converters.

UNIT-IV: Control of DC-DC Converter

Pulse width modulation, Controller basics: controller structure, (P, PI, PID) controller, design principles, Implementation of PID controller, Voltage and Current Control Method, Closed-loop control of switching power converters.

Module 5: Soft Switching Converter: Motivation, Hard-switching vs soft-switching. Introduction to resonant power converters and their characteristics. Topologies, control and analysis of various resonant/soft-switching dc-dc converters.

References:

•Erickson, Robert W., Fundamentals of Power Electronics, Springer, 2001

•Philip T. Krein, Elements of Power Electronics, Oxford University Press,2015

•V. Ramanarayanan, Course Material on Switched Mode Power Conversion, Department of Electrical Engineering, Indian Institute of Science, , Bangalore,2007 , (https://ee.iisc.ac.in/wp-content/uploads/2023/01/SMPC_VRamnarayanan.pdf)

•L Umanand, Power Electronics: Essentials & Applications, Wiley India Pvt. Limited, 2009

EE3573 FLEXIBLE AC TRANSMISSION [3-0-0-3]

UNIT-I: FACTS concepts and general system considerations

Power flow in AC systems - Real and Reactive Power flow control Definition of FACTS - Power flow control -Constraints of maximum transmission line loading - Benefits of FACTS Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control.

UNIT-II: Static Compensators-Static shunt compensators

SVC and STATCOM - Operation and control of TSC, TCR and STATCOM - characteristics and control, Compensator control - Comparison between SVC and STATCOM.

UNIT-III: Static series compensation

GCSC, TSSC, SSSC -Static voltage and phase angle regulators - TCVR and TCPAR Operation and Control –Applications- Modeling and Simulation.

UNIT-IV: Unified and Interline Power Flow Controllers

Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC- Basic Principle of P and Q control- independent real and reactive power flow control- Applications - Introduction to interline power flow controller- comparison with other FACTS

devices -Applications-Modeling and Simulation.

UNIT-V: Special Purpose FACTS Controllers Special purpose FACTS controllers

Thyristor controlled voltage limiter - Thyristor controlled voltage regulator - Thyristor controlled braking resistor - Thyristor controlled current limiter Custom Power - Compensation Devices - STS - SSC - SVR -Backup energy supply devices, DVR, D-STATCOM and UPQC.

References:

1. N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press, 2000.
2. T.J.E Miller, Reactive Power Control in Electric Systems, John Wiley & Sons, 2010.
3. N. Mohan et.al., Power Electronics, 3rd ed., John Wiley and Sons, 2002.
4. K. R. Padiyar, FACTS controllers in power transmission and distribution, New Age International (P) Ltd, 2008.
5. X.P.Zhang, C.Rehtanz, B.PalFlexible AC Transmission System Modelling and Control, Springer,2006

EE 3574 Power System Harmonics [3-0-0-3]

UNIT-I: Power system harmonics

Power electronic converters, transformers, rotating machines, arc furnaces, fluorescent lighting. Harmonic effects within power system-resonances, harmonic torques, static power plant, control systems, power system protection, consumer equipment, measurements, and on power factor. Harmonic effects related to communication interference: telephone circuit susceptiveness, harmonic weights, I-T and kV-T products, shielding. Harmonic effects related to biological effects. Power theory, single and three-phase, non -sinusoidal conditions, Fryez and Budeno's methods.

UNIT-II: Power quality parameters

Transducers and data transmission, Hall effect voltage and current sensors.

UNIT-III: Harmonic mitigation techniques

Passive filters, active filters. Algorithms for extraction of harmonic current in the line.

References:

1. J. Arrillaga, Power System Harmonics, IEE Press.

EE 3575 Advanced Power Converters 3-0-0-3

UNIT-I: Voltage and current source inverters

Analysis and modes of operation of Single-phase half-bridge inverters, Single- phase full- bridge inverters, Three-phase full-bridge VSI. 120 degree and 180 degree operation of three- phase full-bridge inverter. Harmonic analysis. Filter design and simulation practice. Current source inverters, Three phase full bridge current source inverters, Boost type CSI, Comparison between VSI and CSI, Filter design Applications and simulation practices.

UNIT-II: Modulation Techniques for DC-AC Power Conversion

Single-phase and three-phase H-bridge inverter. Various of topologies for DC-AC power conversion- evolution and modes of operation. Purpose of pulse width modulation, Concept of over modulation, square wave operation of voltage source inverter, Selective harmonic elimination, Sine PWM and filter design. Space vector concept and transformation, Per-phase methods from a space vector perspective, Space vector-based modulation, Conventional space vector PWM, identification of sector, dwell time calculation, design of space vector PWM for conventional two level three phase inverter. Simulation practice.

UNIT-II Special type inverters: Impedance source inverters, Quasi-impedance source inverters, Equivalent circuit and operations, Circuit analysis and calculations, Simulation practice, Multilevel DC-AC inverters, Diode-clamped capacitor clamped multilevel inverters, Multilevel inverters using H-Bridges, Generalized multilevel inverters, Mixed level l multilevel inverters, Applications and simulation practices.

Soft-switching DC-AC inverters: Notched DC link inverters, Resonant circuits, Design considerations, Resonant pole inverter, Operating, principle, Transformer based resonant DC link inverters, Applications and simulation practices.

References:

1. F. L. Luo and H. Ye, Advanced DC/AC Inverters: Applications in Renewable Energy, CRC Press, 2013.
2. Seguier, Guy, Labrique and Francis, Power Electronic Converters- DC-AC Conversion, Springer, 1993
3. E. dos Santos, E. R. da Silva, Advanced Power Electronics Converters: PWM Converters Processing AC Voltages, Wiley, 2014.
4. A. Yazdani, Voltage–Sourced Converters in Power Systems: Modeling, Control, and Applications, Wiley, 2010
5. D. O. Neacsu, Switching Power Converters: Medium and High Power, CRC Press, 2017.

EE 3576 Digital Signal Processing 3-0-0-3

Unit 1: Introduction to DSP : Overview of DSP: Introduction, history, and applications. Discrete-Time Signals and Systems: Definitions, classifications, and examples. Basic Operations: Sampling, quantization, aliasing, and reconstruction.

Unit 2: Discrete-Time Fourier Transform (DTFT): Fourier Transform for Discrete-Time Signals: Definition, properties, and applications. Frequency Domain Representation: Magnitude and phase spectra. Inverse DTFT: Reconstruction of signals from frequency domain.

Unit 3: z-Transform: z-Transform: Definition, properties, and ROC. Inverse z-Transform: Methods and applications. Analysis of Linear Time-Invariant Systems: Using z-transform, system stability, and frequency response.

Unit 4: Discrete Fourier Transform (DFT): DFT and its Properties: Definition, computation, and properties. Fast Fourier Transform

(FFT): Radix-2 FFT algorithms, applications in signal processing. Circular Convolution: Linear convolution using DFT.
Unit 5: Multirate DSP: Multirate Signal Processing: Decimation, interpolation, and sampling rate conversion. Polyphase Decomposition: Applications in efficient filter design. Applications of Multirate DSP: Subband coding, filter banks.
Unit 6: DSP Processors and Applications: DSP Hardware: Introduction to DSP processors, architecture, and features. Programming DSP Processors: Basics of programming, development tools. Applications of DSP: Audio and speech processing, image and video processing, biomedical signal processing.

Textbooks:

1. "Digital Signal Processing: Principles, Algorithms, and Applications" by John G. Proakis and Dimitris K. Manolakis
2. "Discrete-Time Signal Processing" by Alan V. Oppenheim and Ronald W. Schafer

Reference Books:

1. "Digital Signal Processing: A Computer-Based Approach" by Sanjit K. Mitra
2. "Understanding Digital Signal Processing" by Richard G. Lyons

EE4XY	DEPARTMENTAL ELECTIVE-II (6th Sem)	[3-0-0-3]

EE 3671 LT & HT Distribution Systems [3-0-0-3]

Unit-1: Introduction: Distribution system structure, HT and LT distribution systems, Types of loads, load estimation, distribution substation
Unit-2: Modelling of Distribution System Components: Overhead lines, feeders and cables, single and three phase distribution transformers, distributed generators, VAr compensating devices
Unit-3: Distribution System Analysis: Power flow analysis in distribution system, load balancing, short circuit analysis, network reconfiguration
Unit-4: Performance Measurement: power loss calculation, voltage stability indices and reliability assessment
Unit-5: Operation and Control: Communication in distribution system, SCADA system, Active and reactive power control, demand side management.

Text and Reference:
1. Turan Gonen. Electric Power Distribution System Engineering. CRC Press
2. A.S. Pabla. Electric Power Distribution. McGraw-hill
3. S. Sivanagaraju, V. Sankar. Electrical Power Distribution and Automation. Dhanpat Rai & Co
4. Anthony J Pansini. Guide to electrical power distribution system. Penn Well Books
5. Stuart A. Boyer. SCADA-Supervisory Control and Data Acquisition. International Society of Automation

EE 3672 Software based System Design [3-0-0-3]

Unit-1: Introduction: Importance of Software-based system design, different software tools used for system modeling, simulation and analysis.
Unit-2: MATLAB/Simulink®: Introduction to MATLAB Basics, Simulink and Simscape Electrical, Control systems and other toolboxes as per need of design. Design and simulate electrical and electromechanical systems in Simscape Electrical, Validation of characteristics of a DC motor, generation of PWM pulses for different power converters, open-loop and closed-loop position control of DC Motor, speed control of a squirrel cage induction motor, multilevel converters, modeling of a wind generator system, Modeling of a Solar PV System, implementation of a DC/AC microgrid
Unit-3: LabVIEW: Introduction to basics of LabVIEW, simulation of LTI systems, PID controller design, Filter design, Speed control of SeparatelyExcited DC motor, Design and Simulate a Buck and Boost converter. Other design problems considered using MATLAB may also be done here.
Unit-4: PSpice: Introduction to PSpice, Linear and non-linear AC/DC circuit design and analysis, Converter design, Digital circuit design, transient analysis of DC and AC circuits. Circuit implementation of controllers design using MATLAB or LabVIEW in PSpice.
Unit-5: Automation Studio: Introduction to Automation Studio. Design of hydraulics and pneumatics control of off-highway vehicles, Electrical system design and analysis using PLC, etc
Unit-6: Adam Multibody Simulator, Adam car simulator, Easy 5 and VI Rail: Design various mechanical and electromechanical control systems, cosimulation between Adams and MATLAB® Simulink. Building a model of railway vehicle & car, and analyze their dynamics.
Unit-7: ETAP and PSIM: Design and analysis of 11/ 33 bus systems,generation of PWM pulses for different power converters, design of control strategies for power converters (renewable application), multilevel converters.

Text and Reference:
1. Manual of the software
2. Recently published papers
3. Ronald W. Larsen. LabVIEW for Engineers. Prentice-Hall
4. Harold Klee. Simulation of Dynamic Systems with MATLAB and Simulink. CRC Press

EE 3673 Electric Power Quality and Management [3-0-0-3]

Unit-1: Overview and definition of Power Quality (PQ), classification and characteristics of different PQ problems, Sources of

Pollution, International PQ standards and regulations, Power Acceptability curves- their necessity and utilization.
Unit-2: Voltage Sag, swell, transients, and interruptions. – Characteristics, causes, effects and methods of mitigation. Voltage sag performance evaluations for transmission and distribution systems. Role of energy storage devices in mitigating poor voltage quality. Reliability indices and their importance.
Unit-3: High voltage transients in power systems- their causes, effects and methods of reduction. Ferro-resonance, its effect, mitigation and ways of detection of its occurrence. Devices for overvoltage protection and electrical noise.
Unit-4: Harmonics – Causes, effects, methods of quantitative analysis of voltage and current harmonics contamination in their respective waveforms. Relation between true power factor, displacement power factor and distortion factor and harmonic phase sequences. Waveform analysis of harmonic injection due to different non-linear loads. Harmonic Resonance – their causes, effects and mitigation. Effects of harmonics on different power system components.
Unit-5: Applied Harmonics – Choice of PCC, harmonic evaluations on utility systems, principles for controlling harmonics in utility distribution systems and end-user facility. PQ standards regarding harmonics in particular and PQ benchmarking
Text and Reference:
1. Math H. J. Bollen. Understanding Power Quality Problems. IEEE Press
2. Roger C. Dugan et.al, Electrical Power Systems Quality. McGraw Hill
3. Arindam Ghosh and Gerard Ledwich. Power Quality Enhancement Using Custom Power Devices. Springer
4. M. A. S. Masoum E. F. Fuchs. Power Quality in Power Systems and Electrical Machines. Academic Press, Elsevier

EE 3674 Data Acquisition and Signal Processing [3-0-0-3]

Unit-1: Introduction to Operational Amplifiers and its Characteristics: Introduction, schematic of an Op-amp, Power supply connections, Characteristics of an Ideal OP-AMP, Inverting Amplifier, Non-inverting Amplifier, Voltage follower, Differential Amplifier, PSRR. DC characteristics – Input bias current, Input offset current, Input offset voltage, Total output offset voltage, Thermal drift. AC characteristics – Frequency response, Slew rate, CMRR.
Unit-2: Applications of Operational Amplifier: Scale changer/Inverter. Summing amplifier: Inverting summing amplifier, Non-inverting Summing amplifier, Subtractor, Instrumentation Amplifier. V – I and I – V converter, Op-amp circuit using diodes, sample and hold circuit, Differentiator and Integrator. Comparator, Regenerative comparator (Schmitt Trigger), Astable mutivibrator, Monostable multivibrator and Triangular waveform generator. Phase shift oscillator, Wien bridge oscillator.
Unit-3: Voltage Regulators: Introduction, Series Op-amp regulator, IC voltage regulators, 723 general purpose regulators, switching regulator.
Unit-4: Active filters: First and Second order LPF, First and Second orders HPF, Band Pass Filters, Band Reject filters.
Unit-5: 555 Timer: Description of Functional Diagram, Monostable operation, Applications of Monostable Multivibrator: Frequency Divider & Pulse Width Modulation. Astable operation, Applications of Astable Multivibrator: FSK Generator and Pulse Position Modulation.
Unit-6: Data Acquisition Systems: Types of instrumentation systems, Components of analog data acquisition system, Digital data acquisition system Analog Data Acquisition System- Transducer, signal conditioner, display device, graphic recording instruments, magnetic tape instruments. Digital Data Acquisition System- Transducer, signal conditioner, multiplexer, analog to digital converter, display device, digital recorder.
Unit-7: Data Converters: Digital to Analog Converters- Basic DAC techniques, Weighted Resistor DAC, R – 2R Ladder DAC, DAC 0800. Analog to Digital Converters: Functional diagram of ADC, Flash ADC, Counter type ADC, Successive approximation ADC, Dual slope ADC. ADC 0809, DAC/ADC specifications.

Text and Reference:
1. D.Roy Choudhury, Shail B. Jain. Linear Integrated Circuits. New Age International
2. R. A. Gayakwad. Op – Amps and Linear Integrated Circuits. PHI
3. A K Sawhney A course in Electrical & Electronic Measurements & Instrumentation. Dhanpat Rai Publications
4. Coughlin & Driscoll. Operational Amplifiers and Linear Integrated Circuits. PHI
5. S. Franco. Design with Operational Amplifiers and Analog Integrated Circuits. TMH

EE 3675 Advanced Digital Signal Processing [3-0-0-3]

Unit-1: A review of digital signal processing. Motivation for multiresolution/ multiscale analysis – Necessity of time-frequency analysis and wavelets. Introductory Examples: Image Compression, Wideband Correlation Processing, Magnetic Resonance Imaging, Digital Communication.
Unit-2: Piecewise constant approximation - the Haar wavelet. Building up the concept of dyadic Multiresolution Analysis (MRA).
Unit-3: Relating dyadic MRA to filter banks. Elements of multi-rate systems and twoband filter bank design for dyadic wavelets
Unit-4: Families of wavelets: Orthogonal and biorthogonal wavelets. Daubechies' family of wavelets in detail. Vanishing moments and regularity. Conjugate Quadrature Filter Banks (CQF) and their design. Dyadic MRA more formally. Data compression - fingerprint compression standards, JPEG-2000 standards
Unit-5: The Uncertainty Principle: and its implications: the fundamental issue in this subject - the problem and the challenge that Nature imposes. The importance of the Gaussian function: the Gabor Transform and its generalization; time, frequency and scale - their interplay. The Continuous Wavelet Transform (CWT). Condition of admissibility and its implications. Application of the CWT in wideband correlation processing.
Unit-6: Journey from the CWT to the DWT: Discretization in steps. Discretization of scale - generalized filter bank. Discretization of translation - generalized output sampling. Discretization of time/ space (independent variable) - sampled inputs.

Unit-7: Piecewise linear to piecewise polynomial. The class of spline wavelets - a case for infinite impulse response (IIR) filter banks.
Unit-8: Variants of the wavelet transform and its implementational structures. The wave packet transform. Computational efficiency in realizing filter banks - Polyphase components. The lattice structure, The lifting scheme.

Text and Reference:
1. Howard L. Resnikoff, Raymond O. Wells. Wavelet Analysis: The Scalable Structure of Information. Springer
2. K. P. Soman, K. I. Ramachandran. Insight Into Wavelets - From Theory to Practice. PHI
3. Michael W. Frazier. An Introduction to Wavelets Through Linear Algebra. Springer
4. P. P. Vaidyanathan. Multirate Systems and Filter Banks. Pearson Education

EE 3676 Wind Energy Conversion Systems and its Challenges [3-0-0-3]

Unit-1: Wind Energy Conversion System (WECS): Introduction: Components of WECS, WECS schemes, energy in wind, Power coefficient, aerodynamics of wind turbine, HAWT, VAWT, Power developed, rotor selection, rotor design considerations, braking systems, yaw control, pitch angle control, stall control,power curve, basic principles of wind energy conversion, power speed characteristics.
Unit-2: Fixed speed WECS: Types of WECS, choice of generators, deciding factors, constant speed constant frequency systems, squirrel cage induction generator: working principle, generator model for steady state and transient stability analysis, grid connected and standalone operation of SCIGs.
Unit-3: Doubly Fed Induction Generator (DFIG)based WECS: Need of variable speed systems, power-wind speed characteristics, DFIG: different operating modes, steady-state equivalent circuit, performance analysis, DFIG for standalone applications, operation of DFIGs with different power electronic converter configurations for standalone and grid connected operation, power control strategies, reactive power and voltage control, case studies on power control strategies.
Unit-4: Permanent Magnet Synchronous Generator (PMSG) based WECS: Operation of PMSGs, steady-state analysis, performance characteristics, operation of PMSGs with different power electronic converter configurations for standalone and grid-connected operation, power control strategies, case studies on power control strategies
Unit-5: Power quality issues with grid connected system: Wind interconnection requirements, Indian wind grid code, Low-Voltage Ride Through (LVRT), power quality issues associated with grid connected generators, current practices and industry trends, generator sizes, technology and location (off shore versus on shore), control strategies for power control under distorted grid conditions (case studies).

Text and Reference:
1. Marcelo Godoy Simoes and Felix A. Farret. Renewable Energy Systems: Design and Analysis with Induction Generators. CRC Press
2. Ion Boldea. Variable speed generators. CRC press
3. S.N. Bhadra, D.Kastha and S.Banerje. Wind Electrical Systems. Oxford University Press
4. Siegfried Heier, Rachel Waddington. Grid Integration of Wind Energy Conversion Systems. Wiley
5. Freries LL .Wind Energy Conversion Systems. Prentice Hall

EE4XY	DEPARTMENTAL ELECTIVE-III (7th Sem)	[3-0-0-3]

EE 4771 HIGH VOLTAGE ENGINEERING 3-0-0-3

UNIT-I: Breakdown Phenomenon

Breakdown in gases - Mechanism of breakdown in gases, breakdown theory. Breakdown in liquids - suspended solid particle mechanism, Cavitation and bubble mechanism, Stressed Oil volume mechanism, etc. Breakdown in solids - Intrinsic breakdown, Electromechanical breakdown, breakdown of solid dielectrics in practice, Chemical and Electrochemical deterioration and breakdown, breakdown due to treeing and tracking, breakdown due to internal discharges.

UNIT-II: Overvoltage phenomenon and Insulation Coordination in Electrical Power Systems

Overvoltage Phenomenon, Protection & Insulation Coordination Natural causes for overvoltage - lightning phenomenon, over voltage due to switching surges and due to arching ground. Line design based on lightning. Basic idea about protection against overvoltage - lightning arresters, surge absorbers, Ground wire, grounding practices etc. BIL, SIL of the equipments, V-T curve, Concepts of Insulation coordination.

UNIT-III: Generation of High AC & DC voltage

High AC voltage generation - Testing transformer and its cascaded connections. Single phase resonant circuits. High DC voltage generation - Single stage and Multi stage voltage multiplier circuits. Impulse Voltage and Current generation Measurement of High Voltage and Current High Voltage Testing.

Text Books:

1. High Voltage Engineering , 'C. L. Wadhwa ',New Age International Pub. (P) Limited, New Delhi.
2. High Voltage Engineering, 'M.S Naidu & V Kamaraju' , Tata Mc Graw Hill Publishing company, New Delhi,

References:

1. High Voltage Engineering Fundamentals, ' E. Kuffel & W. S. Zaengl' , Butterworth-Heinemann, 2000

EE 4772 Power Station Engineering 3-0-0-3

Unit-1: COAL BASED THERMAL POWER PLANTS Rankine cycle – improvisations, Layout of modern coal power plant, Super Critical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants – Fuel and ash handling,

Draught system, Feed water treatment. Binary Cycles and Cogeneration systems.
Unit-2: DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS Otto, Diesel, Dual & Brayton Cycle–Analysis & Optimisation. Components of Diesel and Gas Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle systems.
Unit-3: NUCLEAR POWER PLANTS Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, 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. Safety measures for Nuclear Power plants.
Unit-4: POWER FROM RENEWABLE ENERGY Hydro Electric Power Plants – Classification, Typical Layout and associated components including Turbines. Principle, Construction and working of Wind, Tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geo Thermal, Biogas and Fuel Cell power systems.
Unit-5: ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants. Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.

TEXT BOOKS:
1. A Course in Power Plant Engineering:/Arora and S.Domkundwar/Dhanpat Rai Publisher
2. Power Plant Engineering / P.C.Sharma / S.K.Kataria Publisher
3. A Text Book of Power Plant Engineering / R.K.Rajput / Laxmi Publications
REFERENCE BOOKS:
1. Power Plant Engineering/ P.K.Nag II Edition /TMH Publishers
2. An Introduction to Power Plant Technology / G.D. Rai/Khanna Publishers
3. Power plant Engg /Elanchezhian/I.K. International Publishers

EE 4773 EHV AC Transmission 3-0-0-3

UNIT-I: Necessity of EHV AC transmission – advantages and problems–power handling capacity and line losses- mechanical considerations – resistance of conductors – properties of bundled conductors – bundle spacing and bundle radius- Examples.Line and ground reactive parameters**:** Line inductance and capacitances – sequence inductances and capacitances – modes of propagation – ground return – Examples.
UNIT- II: E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages – Estimation at line and ground parameters-Bundle conductor systems-Inductance and Capacitance of E.H.V. lines – positive, negative and zero sequence impedance – Line Parameters for Modes of Propagation.
UNIT- III: Electrostatic field and voltage gradients – calculations of electrostatic field of AC lines – effect of high electrostatic field on biological organisms and human beings – surface voltage gradients and maximum gradients of actual transmission lines – voltage gradients on sub conductor.
UNIT- IV: Electrostatic induction in unenergized lines – measurement of field and voltage gradients for three phase single and double circuit lines – unenergized lines. Power Frequency Voltage control and over voltages in EHV lines: No load voltage – charging currents at power frequency-voltage control – shunt and series compensation – static VAR compensation.
UNIT – V: Corona in E.H.V. lines – Corona loss formulae- attention of traveling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits. Measurements of audio noise radio interference due to Corona – properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.
UNIT- VI: Design of EHV lines based on steady state and transient limits – EHV cables and their characteristics.

TEXT BOOKS:
- R. D. Begamudre, "EHVAC Transmission Engineering", New Age International (p) Ltd. 3rd Edition.
- K.R. Padiyar, "HVDC Power Transmission Systems" New Age International (p) Ltd. 2nd revised Edition, 2012.

REFERENCES:
- S. Rao "EHVAC and HVDC Transmission Engineering. Practice" Khanna publishers.
- Arrillaga. J "High Voltage Direct Current Transmission" 2nd Edition (London) Peter Peregrines, IEE, 1998.
- Padiyar. K.R, "FACTS Controllers in Power Transmission and Distribution" New Age International Publishers, 2007.
- Hingorani H G and Gyugyi. L "Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" New York, IEEE Press, 2000.

EE 4774 Neural Network, Fuzzy Logic And Evolutionary Algorithm 3-0-0-6

Unit-1: Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and-Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Historical Developments, Potential Applications of ANN Artificial Neuron Model, Operations of Artificial Neuron, Types of
Unit-2: Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application. Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem, Limitations of the Perceptron Model, Applications. Credit Assignment Problem, Generalized Delta Rule, Derivation of Backpropagation (BP)

Unit-3: Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions. Fuzzification, Membership value assignment, development of rule base

and decision making system, Defuzzification to crisp sets, Defuzzification methods Training, Summary of Backpropagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvement

Texts / References:

1. S. Haykin, Neural Networks: A Comprehensive Foundation, Prentice- Hall India, 2nd Edition, 1999.
2. J. S. R. Jang, C. T. Sun, and E. Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, 2nd Edition, Pearson Education, 2005.
3. J. A. Freeman and D. M. Skapura, Neural Networks: Algorithms, Applications, and Programming Techniques, 1st Edition, Pearson Education, 2007
4. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai – PHI Publication.

EE 4775 Discrete and Non-Linear Control Theory 3-0-0-6

Unit-1: Analysis of nonlinear systems using perturbation theory, phase plane trajectories, Describing functions, Lyapunov& Popov's methods.
Unit-2: Nonlinear control design techniques; Feedback linearization, input-state and input- output linearization, design issues for MIMO nonlinear systems. Variable structure control, sliding surface design, approximation of switching laws. Adaptive control:
Unit-3: Need for adaptive control, MIT rule, Model reference and self-tuning adaptive control techniques, Auto tuning, Gain scheduling. Stability, convergence and robustness issues in adaptive control. Adaptive control of nonlinear systems. Practical aspects, implementation and applications of adaptive control.

REFERENCES BOOK:

1. Slotine J.J.E and W. Li, "Applied nonlinear control", Prentice Hall Inc., 1991.
2. Mohler R.R., "Nonlinear systems: Dynamics and Control", Prentice Hall Inc., 1991.
3. M. Vidyasagar, "Nonlinear system analysis", Prentice Hall, 1993
4. Hassan K.Khalil,"Nonlinear Systems" PearsonIndia Education Pvt.Ltd. 2015
5. K.J. Astrom "Adaptive Control", Addison Wesley, 1983
6. Astrom K.J. and B. Wittenmark, "Computer Controlled Systems: Theory and Design", Prentice Hall of India, 1994.

EE 4776 Illumination Engineering 3-0-0-6

UNIT 1: Fundamentals of illumination engineering: Radiant energy, Nature of light, Plane angle, Solid angle, Relation between plane angle and solid angle, Luminous flux, Luminous intensity, Lumen, Candle power, Brightness or Luminance, Illumination, Uniform diffuse source, Mean horizontal candle power (M.H.C.P.), Mean spherical candle power (M.S.C.P.), Mean hemi-spherical candle power (M.H.S.C.P.), Reduction factor, Lamp efficacy, Specific consumption, Utilization factor, Space-height ratio, Coefficient of utilization, Maintenance factor, Depreciation factor, Waste light factor, Absorption factor, Beam factor, Reflection factor, Glare.
Unit-2: Measurement and analysis of artificial lighting: Laws of Illumination: inverse square law; cosine law; Lambert's law, Polar curves, Photometry: Photometer bench, Photometer heads, Lummer-bodhun photometer head, Flicker photometer, Integrating sphere, Illumination photometer, Energy radiation and luminous efficiency. Incandescent lamp: heat radiation; filament materials; filament dimension measurement; coiled-coil filament; lamp characteristics, Arc lamp: carbon arc lamps; flame arc lamps; magnetic arc lamps, electric discharge lamps: excitation; ionization; lamps characteristics, Hot cathode lamp, Cold cathode lamp, Neon lamp, Sodium vapour lamp, Mercury vapour lamp, Halogen lamps, Fluorescent lamp: phosphor; starters; chokes; stroboscopic effect; its operation on DC, LEDs, LEDs in communication.
Unit-3: Lighting fittings and schemes: Requirements of good lighting, symmetrical fittings: A type fitting; B type fitting; C type fitting; D type fitting; E type fitting, Asymmetrical fittings, Factory lighting, Flood lighting, Street lighting: diffusion principle; specular reflection principle, Recommended illumination levels for different purposes.
Text books:

1. D.C. Pritchard, "Lighting", 6th Edition, Routledge, 2016
2. Jack L. Lindsey, "Applied Illumination Engineering", PHI, 1991

EE 465 Introduction To Digital Signal Processing 3-0-0-6

EE 4777 Computers Methods in Power Systems 3-0-0-3

Unit-1: Elementary linear graph theory: Incidence and network matrices. Calculation of Z-Bus, Y-Bus, Z-Loop by singular and non-singular transformations. Algorithm for the calculation of Z-Bus of singular and three phase network. Short circuit studies using Z-Bus, Y-Bus.
Unit-2: Different methods of solution of Linear and non-linear algebraic equations: Gauss-Scidel, Gront relaxation, Newton-Raphson and iterative methods. Load flow studies by different methods, solution of the swing equations. Representation of off-load and on-load tap changing and phase-shifting transformers for the purpose of load flow studies.
Unit-3: Central Computer Control and Protection: Data collection and manipulation, supervisory control relay target logging, state

estimation program, Operating procedure recommendations, automatic fault study and relay setting, power system stability monitoring, corrective action for stability problem. Automatic generation control, economic dispatch, generation schedule, optimum unit commitment interchange negotiation, volt/ VAR dispatch, weather forecast analysis, load forecast – future, evaluation of proposed operation, system security, load flow calculations, environmental monitoring.
Reference books:

1. Stagg and Al Albiad, Computer Application in Power System, McGraw Hill
2. M.A. Pai., Computer Techniques in Power System Analysis, TMH
3. George L. Kusic, Computer aided power system analysis, PHI
4. Wood and Wollenberg, Power generation and Control, John Wiley

EE4XY	DEPARTMENTAL ELECTIVE-IV (8th Sem)	[3-0-0-3]

EE 4871 Surge and Lightening Protection and Safety Devices 3-0-0-3

UNIT 1: Modern Trends in Power System Protection, Need for Protective Systems, Nature and Causes of Faults, Types of Faults, Effects of Faults, Fault Statistics.
UNIT 2: Fuse Characteristics, Types of Fuses, Applications of HRC Fuses, Selection of Fuses, Discrimination.
UNIT 3: Protection Against Overvoltage, Causes of Overvoltage, Lightning Phenomena, Wave Shape of Voltage Due to Lightning, Overvoltage Due to Lightning, Klydonograph and Magnetic Link, Protection of Transmission Lines against Direct Lightning Strokes, Protection of Stations and Sub-stations from Direct Strokes, Protection Against Travelling Waves, Peterson Coil, Insulation Coordination, Basic Impulse Insulation Level (BIIL).
UNIT 4: Circuit Breakers, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Prestriking Voltage and Recovery Voltage, Resistance Switching, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers High Voltage DC (HVDC) Circuit Breakers, Rating of Circuit Breakers.
UNIT 5 : Relay Construction and Operating Principles, Electromagnetic Relays, Static Relay.

Reference Books:
1. Lewis Blackburn, J., 'Protective Relaying – Principles and Applications', Marcel Dekkar, INC, New York, 2006.
2. The Electricity Training Association, 'Power System Protection Vol-4', The IEE, U.K., 2005. 3. C. Russeil Mason, 'The art and Science of Protective Relaying', GE Publishers, 1962.
3. T. Johns and S. K. Salman, 'Digital Protection for Power Systems', Peter Peregrinus Ltd.,1997.
4.Arun G Padkye and James S Thorp, 'Computer Relaying for Power Systems', John Wiley publications, 2nd Edition, 2009.
5. P M Anderson, 'Power System Protection', IEEE Press, 2012.

EE 4872 Solar and Wind Power 3-0-0-3

Unit-1: Introduction to energy sources: Recent trends in energy consumption, world energy scenario, energy sources and their availability, conventional and renewable sources, need to develop new energy technologies, qualitative study of different types of dispatchable and non-dispatchable energy resources, different types of energy storage suitable of wind and solar.
Unit-2: Solar Photovoltaic (SPV) system: Introduction to solar energy, solar radiation and measurement, PVsolar cell, one diode and two diode modelling of PV cell, series and parallel connection of PV cell, P-V&IV characteristics, effect of change in insolation and temperature on PV cell, partial shading, blocking and bypass diode, modules, MPPT algorithms
Unit-3: Converter interface for solar PV system and battery storage: Introduction to buck, boost and fly back dc-dc converters, 1-phase and 3-phase inverters, control schemes: unipolar, bipolar, need for storage, different types of battery suitable for SPV, characteristics and parameters, charging schemes of battery, off-grid and grid connected SPV system, PLL and synchronization, single and double stage control for SPV system, power processing, grid connection issues.
Unit-4: Wind Energy Conversion Systems (WECS): Basic principle of wind energy conversion, Betz limit, aerodynamics principle, drag and lift force, phasor representation, power-speed characteristics, components of a wind energy conversion system (WECS), mechanical control, MPPT algorithm, off grid and grid connected WECS:self-excited induction generator, VSCsupported induction generators andgrid connected DFIG.
Unit-5: Applications: PV Power plant, water pumping, hybrid PV-wind system
Text and Reference:
1. Chetan Singh Solanki. Solar Photovoltaics: fundamentals, Technologies, and Applications. Prentice Hall of India
2. Remus Teodorescu, Marco Liserre, Pedro Rodriguez. Grid Converters for Photovoltaic and Wind Power Systems. Wiley Publications
3. Mukund R. Patel. Wind and Solar Power Systems: Design, Analysis, and Operation. CRC Taylor & Francis
4. D. Hart . Power Electronics. McGraw-Hill
5. S. N. Bhadra, D. Kastha& S. Banerjee. Wind Electrical Systems. Oxford university press
6. Mukund R. Patel. Wind and Solar Power Systems: Design, Analysis, and Operation. CRC Taylor & Francis
7. Ion Boldea. Variable speed generators. CRC press

EE 4873 Modern Control System 3-0-0-3

Unit-1: System representation-introduction to state and state variable- transformations- state transition matrix properties and methods of valuation - time response of linear systems - state diagrams.
Unit-2: Resolvent matrix controllability and observability-state variable feedback - pole placement-stability-
Unit-3: stability in the sense of lyapunov, stability of linear systems and non-linear systems-optimal control-formulation of the optimal control problem - use of Hamiltonian method - continuous time linear state regulator matrix riccati equation-state variable feedback design.

TEXTS:
1. Katsuhiko Ogata : Modern Control Engineering, 5th Edition, Prentice-Hall of India, 2010.
2. M. Gopal : Modern Control Systems Theory, 2nd Edition, New Age Intl. Pvt. Ltd., 1993.

EE 4874 Solid States Drives 3-0-0-3

Unit-1: DRIVE CHARACTERISTICS: Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, starting & stopping – typical load torque characteristics – Selection of motor,
Unit-2: CONVERTER / CHOPPER FED DC MOTOR DRIVE: Steady state analysis of the single and three phase converter fed separately excited DC motor drive– continuous conduction – Time ratio and current limit control – 4 quadrant operation of converter / chopper fed drive-Applications,
Unit-3: INDUCTION MOTOR DRIVES: Stator voltage control–V/f control– Rotor Resistance control-qualitative treatment of slip power recovery drives-closed loop control— vector control- Applications,
Unit-4: SYNCHRONOUS MOTOR DRIVES: V/f control and self-control of synchronous motor: Margin angle control and power factor control- Three phase voltage/current source fed synchronous motor- Applications,
Unit-5: DESIGN OF CONTROLLERS FOR DRIVES: Transfer function for DC motor / load and converter – closed loop control with Current and speed feedback–armature voltage control and field weakening mode – Design of controllers; current controller and speed controller- converter selection and characteristics.

Text books:
1. Gopal K.Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 1992.
2. Bimal K.Bose. Modern Power Electronics and AC Drives, Pearson Education, 2002.
3. R.Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson, 2001.

References:
1. Vedam Subramanyam, " Electric Drives Concepts and Applications ", 2e, McGraw Hill, 2016
2. Shaahin Felizadeh, "Electric Machines and Drives", CRC Press (Taylor and Francis Group), 2013.
3. John Hindmarsh and Alasdain Renfrew, "Electrical Machines and Drives System," Elsevier 2012

EE 4875 Digital Control System 3-0-0-3

Unit-1: Discrete-time system representations: modeling discrete-time systems by linear difference equations and pulse transfer functions, time responses of discrete systems; discrete state-space models, stability of discrete-time systems.
Unit-2: Finite settling-time control design: deadbeat systems, inter sample behaviour, time-domain approach to ripple-free controllers, limitations and extensions of the deadbeat controller.
Unit-3: State-feedback design techniques: linear system properties, state feedback using Ackermann's formula, tracking of known reference inputs.
Unit-4: Output-feedback design techniques: observer design, observer-based output feedback design.

Texts:
1. B. C. Kuo, Digital Control Systems; Oxford University Press, 2/e, Indian Edition, 2007.
2. K. Ogata, Discrete Time Control Systems; Prentice Hall, 2/e, 1995.
3. M. Gopal, Digital Control and State Variable Methods; Tata Mcgraw Hill, 2/e, 2003.
4. G. F. Franklin, J. D. Powell and M. L. Workman; Digital Control of Dynamic Systems; Addison Wesley, 1998, Pearson Education, Asia, 3/e, 2000.
5. K. J. Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design; Prentice Hall, 3/e, 1997.

EE 4876 Power System Operation and Control 3-0-0-3

Unit-1: Basic concepts of operation and control of power system - necessity of voltage and frequency regulation in power systems-real power-frequency and reactive power- voltage control loops-system load variation, load curves and basic concepts of load dispatching, load forecasting, unit commitment, load shedding and islanding.
Unit-2: Real power frequency control: Plant and system level control - basics of speed governing mechanisms and modeling-speed load characteristics-regulation of two generators in parallel-Concept of control area-LFC of single area system-static and dynamic analysis of uncontrolled and controlled cases- integration of economic dispatch controller with LFC-LFC of two area system-tie line

modeling-block diagram representation of two area system static and dynamic analysis-state variable model.
Unit-3: Reactive power voltage control: Basics of reactive power control- Excitation system requirement-elements of excitation system-static and dynamic analysis-stability compensation-generation and absorption of reactive power-methods of voltage control-control by tap changing transformer-shunt and series compensation, phase angle compensation.
Unit-4: Economic operation of power system:
Statement of economic dispatch problem-incremental cost curve-input and output characteristics of thermal and hydro plants-system constraints-hydrothermal. Scheduling of long and short terms-optimal operation of thermal units without and with transmission losses using penalty factor, incremental transmission loss, and transmission loss formula (no derivation)-base point and participation factors-Statement of unit commitment-constraints in unit commitment-solution methods using priority list and dynamic programming.
Unit-5: Computer control of power systems:
Concept of energy control centre and functions-need of computer control of power systems-system monitoring, data acquisition and controls-System hardware configurations-SCADA.

Text Books:
1. Olle.I.Elgerd, "Electric energy systems theory-An introduction", Tata McGraw Hill publishing Ltd, New Delhi, 2008.
2. Prabha Kundur, "Power system stability and control", Tata McGraw Hill publishing Ltd, New Delhi, 5th reprint, 2008.

References:
1. Allen J.Wood, Bruce F.Wollenberg, "Power Generation", Operation and Control", 2nd Edition, John Wiley and sons, 1996.
2. I.J.Nagrath and D.P.Kothari, "Power System Engineering", 2nd Edition, Tata McGraw Hill publishing Ltd, New Delhi, 2008.
3. S.Sivanagaraju, G.Sreenivasan, "Power System Operation and Control", Pearson Education, 2010

EE2XY	**OPEN ELECTIVE-I (7th Sem)**	**[3-0-0-3]**

EE 2351 Electromechanical Energy Conversion and Transformers 3-0-0-3

Unit-1: Introduction to Machinery Principles: Three phase circuits, Magnetic circuits
Transformers: Types and construction, Ideal transformer, Transformer equivalent circuits, Transformer analysis on a per unit basis, Voltage regulation & efficiency, Autotransformer.
Unit-2: AC Machinery Fundamentals: Rotating magnetic field, Induced voltage & torque in AC machine. Synchronous Generator: Construction, Speed & internal generated voltage, Equivalent circuit, Phasor diagram, Parallel operation. Synchronous Motors:
Unit-3: Basic principles of motor operation, Steady state operation, Starting of Synchronous Machine. Induction Motors: Construction, Basic concepts, Equivalent circuit, Power & Torque, Torque-speed characteristics, Speed control, determining circuit model parameters.
Unit-4: DC Machinery Fundamentals: Commutation, Internal generated voltage & induced torque equations of real DC machines. DC Motors & Generators: Introduction, Equivalent circuit, Magnetization curve of a DC machine, Different types of DC Machines.
Unit-5: Single Phase & Special-Purpose Motors: Universal motor, Introduction to single-phase induction motor, Starting and speed control of single-phase induction motor.

TEXTBOOK:
1. Electric Machinery Fundamentals by Stephen Chapman, 3rd edition, McGraw-Hill, 1999.

EE 2352 Introduction to Information Technology 3-0-0-3

Unit-1: Fundamentals of Computer: Scope of IT and its importance, Computer system concepts, characteristics, capabilities and limitations, Generations of computers, Types of computers, Personal computer (PCs), Configurations of PCs, PCs specifications, Computer system architecture, Basic components of a computer system, Input devices, Output devices, CPU and its components, Unit-
Unit-2: Memory: RAM, ROM, EPROM, PROM, Secondary storage device
Computer Software and Classification: Software and its need, Types of software, System Software, Utility Program, Programming languages, Assemblers, Compilers, Interpreter, Application Software, Programming languages machine, assembly, high Level, GL, Trends in software, Introduction to Disk Operating System: internal and external commands, File Allocation Table (FAT & FAT 32), Introduction to Window Operating System, GUI environments, Working with Files & Folders, Working with windows application programs, Customizing the taskbar and desktops, Customizing windows, Use of accessories, Working with control panel, Mobile Computing
Unit-3: Database Management System, Telecommunication and Computer Network, Internet Web and Emerging Technology, Security and Ethical Challenges.

Recommended Books:
1. Alexis Leon & Mathews Leon (2009). Fundamentals of Information Technology, 2/e. New Delhi. Vikas Publishing House Turban, R. R. (2014).
2. Introduction to Information Technology. John Wiley and Sons (Asia) Pvt. Ltd.
References materials:
1. Sinha, P. K., & Sinha, P. (2007). Computer fundamentals: concepts, systems & applications. New Delhi: BPB Publications.Norton, P. (2006).
2. Peter Norton's computing fundamentals. Boston, Mass: McGraw-Hill Technology Education.Morley, D. &. (2013).

3. Understanding Computers Today and Tomorrow. Cangage Learning.V. Rajaraman, Neeharika Adabala (2014).
4. Fundamentals of Computers 6th Edition. New Delhi: PHICox, J., Lambert, J., & Frye, C. (2011).

EE 2353 Transducers & Signal Conditioning 3-0-0-3

Unit-1: Strain and Pressure: Mechanical strain, Interferometry, Fibre optic methods, pressure gauges, low gas pressures, Ionization gauges, Transducer use. Position, direction, distance, and motion: Position, Direction, Distance measurement, Distance travelled, Accelerometer systems, Rotation.
Unit-2: Light and associated radiation: Nature of light, Color temperature, Light flux, Photo sensors, Photo resistors and photoconductors, Photodiodes, Phototransistors, Photovoltaic devices, Fiber – optic applications, Light transducers, Solid-state transducers, Liquid crystal displays (LCD), Light valves, Image transducers, Radio waves.
Unit-3: Temperature sensors and thermal transducers: Heat and temperature, the bimetallic strip, Liquid and gas expansion, Thermocouples, Metal – resistance sensors, Thermistors, Radiant heat energy sensing, Pyroelectric detectors, Thermal transducers,
Unit-4: Thermal to electrical transducers.
Sound, infrasound and ultrasound: Principles, Audio electrical sensors and transducers, Electrical to audio transducers.
Solids, liquids and gases: Mass and volume, Electronic sensors, Proximity detectors, Liquid levels, Liquid flow sensors, Timing, Gases, Viscosity.
Unit-5: Environmental Sensors: Environmental quantities, Time, Moisture, Acidity/alkalinity, Wind chill, Radioactive count rate, Surveying and security, Animal fat thickness, Water purity, Air purity, Smoke and fire detectors, Building acoustics.

Textbook
1 Sensors and Transducers Ian R. Sinclair Newnes 3 rd Edition, 2001

EE 2354 Energy Efficiency & Conservation 3-0-0-3

Unit-1: Energy scenario, Principles of energy Conservation, Energy consumption pattern, Resource availability.
Unit-2: Evaluation of thermal performance, calculation of heat loss –heat gain, estimation of annual heating & cooling load factors that influence thermal performance, analysis of existing buildings.
Unit-3: Organizing for energy conservation programme, the energy audit and energy information system, technology for energy conservation, co-generation of process, steam & electricity, computer controlled energy management, commercial options in waste heat recovery equipment, and cases of energy studies, energy conservation opportunity, and Energy conservation in I. C. Engine.
Unit-4: Strategies for electricity and management, setting up an energy management programme, electricity saving technique by category of end use, Electrical end use in industries, energy & power management in industry, energy management strategies for industry, demand management.

Books:
1. C.B.Smith, Energy Management Principles, Pergamon Press, New York, 1981.
2. W.C. Turner, Energy Management, Hand Book.
3. Hamies, Energy Auditing and Conservation, Methods, Measurements, Management and Case Study, Hemisphere, Washington, 1980.
4. Kreith, Economics of Solar Energy and Conservation Systems, Vol -3.
5. W.F.Kenny, Energy Conservation in Process Industry.
6. Trivedi, P.R, Jolka K.R., Energy Management, Commonwealth Publication, New Delhi, 1997.
7. Witte, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washinton, 1988.

EE 2355 Utilization of Electric Power 3-0-0-3

Module 1 Heating and welding: Electric Heating, Resistance ovens, Radiant Heating, Induction Heating, High frequency Eddy Current Heating, Dielectric Heating, The Arc Furnace, Heating of Buildings, Air -Conditioning, Electric Welding, Modern Welding Techniques. Electrolytic Electro-Metallurgical Process: Ionization, Faraday's Laws of Electrolysis, Definitions, Extraction of Metals, Refining of Metals, Electro Deposition.
Module 2 Illumination: Introduction, Radiant Energy, Definitions, Laws of Illumination, Polar Curves, Photometry, Measurement of Mean Spherical Candle Power by Integrating Sphere, Illumination Photometer, Energy Radiation and luminous Efficiency, electric Lamps, Cold Cathode Lamp, Lighting Fittings, Illumination for Different Purposes, Requirements of Good Lighting.
Module 3 Braking: Introduction, Regenerative Braking with Three Phase Induction Motors, Braking with Single Phase Series Motors, Mechanical braking, Magnetic Track Brake, Electro-Mechanical Drum Brakes. Electric Traction Systems and Power Supply: System of Electric Traction, AC Electrification Transmission Lines to Sub-Stations, Sub-Stations, Feeding and Distribution System of AC Traction Feeding and Distribution System for DC Tramways, Electrolysis by Currents through Earth, Negative Booster, System of Current Collection, Trolley Wires. Trams, Trolley Buses and Diesel-Electric Traction: Tramways, The Trolley-Bus, Diesel Electric Traction.

EE 2356 Electric vehicle and charging technology [3-0-0-3]

Unit-1: Introduction: Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs, Comparison of EV Vs IC Engine. EV System: EV Configuration: Fixed & variable gearing, single

& multiple motor drive, In-wheel drives EV Parameters: Weight, size, force, energy & performance parameters.

Unit-2: Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, In wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors, Comparison of Electirc Motors for EV applications

Unit-3: Comparison of EV power devices, introduction to power electronics converter, four quadrant DC chopper, three-phase full bridge voltage-fed inverter, soft-switching EV converters, comparison of hard-switching and soft-switching converter, three-phase voltage-fed resonance dc link inverter, Basics of Microcontroller & Control Strategies

Unit-4: EV Charging systems: Current status and future trends, Types of charging stations: Level 1, Level 2, and DC fast charging, Public vs. private charging networks, isolated and non-isolated charging, wired and wireless charging, types of connector, static and dynamic wireless charging, G2V charging, V2V charging, Impact of EV charging on the power grid.

1. "Electric Vehicle Technology Explained" by James Larminie and John Lowry
2. "Electric and Plug-In Hybrid Vehicle Networks: Optimization and Control" by Emanuele Crisostomi, B. Ashtari, and M. A. Rotea
3. "Electric Vehicles: Prospects and Challenges" by Tariq Muneer, Irene Illescas García, and Mohamed Khallaf
4. "Electric Vehicles and the Future of Energy Efficient Transportation" by Frank Kreith and D. Yogi Goswami
5. "Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach" by Amir Khajepour, M. Saber Fallah, and Avesta Goodarzi

EE 2357 Modern Electric Traction and Drives [3-0-0-3]

Unit-1: Introduction to Traction: General features of Electric traction, Measurement of train movement.
Tractive Effort: Calculation of tractive effort, Electrical Motors for traction, Modern Power Electric converters in modern traction.
Unit-2: AC Drives in Electric Traction: Diesel electric traction, reference of Indian Standards, AC drives in Electric Traction.
Vector Controller Induction Motor Drive: Dynamic d-q model of 3 phase induction motor d-q equivalent circuit (stator, rotor, synchronously rotating reference frames model), equation of flux linkage, small signal equations of induction motor, dynamic model state space equations, Principles of vector control, direct vector control, implementation with voltage source, Derivation of indirect vector control scheme.
Unit-3: Parameter Compensation: Parameter sensitivity of the indirect vector-controlled induction motor drive, Parameter Sensitivity compensation, Speed- Controller design for an indirect vector controller induction motor drive, Sensor less vector control.

Text Book

1. Fundamentals of Electric Drives by G K Dubey Narosa publishing House , 3rd Edition , 2002
2. Bimal K. Bose, Power Electronics and Motor Drives: Advances and Trends, Academic Press, 2006.

Reference Book

1. S. K. Pillai : A First Course On Electrical Drives, 2nd Edition, New Age International Publishers,2007.
2. N. K. De, P. K. Sen: Electric Drives, 7th Edition, PHI Learning Pvt. Ltd., 2004

EE 2358 Illumination and LED Drives [3-0-0-3]

Unit-1 Fundamentals of illumination engineering:
Radiant energy, Nature of light, Plane angle, Solid angle, Relation between plane angle and solid angle, Luminous flux, Luminous intensity, Lumen, Candle power, Brightness or Luminance, Illumination, Uniform diffuse source, Mean horizontal candle power (M.H.C.P.), Mean spherical candle power (M.S.C.P.), Mean hemi-spherical candle power (M.H.S.C.P.), Reduction factor, Lamp efficacy, Specific consumption, Utilization factor, Space-height ratio, Coefficient of utilization, Maintenance factor, Depreciation factor, Waste light factor, Absorption factor, Beam factor, Reflection factor, Glare.
Unit-2 Measurement and analysis of artificial lighting: Laws of Illumination: inverse square law; cosine law; Lambert's law, Polar curves, Photometry: Photometer bench, Photometer heads, Lummer-bodhun photometer head, Flicker photometer, Integrating sphere, Illumination photometer, Energy radiation and luminous efficiency.
Unit-3 Electric lamps Incandescent lamp: heat radiation; filament materials; filament dimension measurement; coiled-coil filament; lamp characteristics, Arc lamp: carbon arc lamps; flame arc lamps; magnetic arc lamps, electric discharge lamps: excitation; ionization; lamps characteristics, Hot cathode lamp, Cold cathode lamp, Neon lamp, Sodium vapour lamp, Mercury vapour lamp, Halogen lamps, Fluorescent lamp: phosphor; starters; chokes; stroboscopic effect; its operation on DC, LEDs, LEDs in communication.
Unit-4 Lighting fittings and schemes:
Requirements of good lighting, symmetrical fittings: A type fitting; B type fitting; C type fitting; D type fitting; E type fitting, Asymmetrical fittings, Factory lighting, Flood lighting, Street lighting: diffusion principle; specular reflection principle, Recommended illumination levels for different purposes.

Required Text: Text books
1. C.L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", Revised 3rd Edition, 2012, New Age International Publisher
2. R. K. Rajpur, "Utilization of Electrical Power (including electric Drives and electric Traction)", 1st Edition, Reprint 2012, Laxmi Publications (P) LTD
3. Chakrabarti, Soni, Gupta, Bhatnagar, "Power system Engineering", Dhanpatrai & Co., Second revised edition 2010, Reprint: 2014.

Module 4 Electric Vehicles: Configurations of Electric Vehicles, Performance of Electric Vehicles, Tractive Effort in Normal Driving, Energy Consumption. Hybrid Electric Vehicles: Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains

EE2XY	OPEN ELECTIVE-II (8th Sem)	[3-0-0-3]

EE 2451 Power Generation Systems 3-0-0-3

Unit-1: Hydro-electric power plants – selection of site, elements of power plant, classification, water turbines, governor action, hydro-electric generator, plant layout, pumped storage plants.
Unit-2: Thermal steam power plants – selection of site, elements and operational circuits of the power plant, turboalternators, plant layout, steam turbines, controls and auxiliaries.
Unit-3: Nuclear power plants – selection of site, nuclear reaction – fission process and chain reaction, constituents of power plant and layout, nuclear reactor – working, classification, control, shielding and waste disposal.
Unit-4: Renewable power plants – Solar power generation – Photo-voltaic and solar thermal generation – solar concentrators, Wind power generation – types of wind mills, wind generators, tidal, biomass, geothermal and magneto-hydro dynamic power generation, micro-hydel power plants, fuel cells and diesel and gas power plants.
Unit-5: Combined operation of power plants – plant selection, choice of size and number of generator units, interconnected systems, real and reactive power exchange among interconnected systems. Major electrical equipment in power plants, DC systems in power plants, station control - switch yard and control room. Economic considerations – types of costs, tariff and consumers.

Text Books:
1. Chakrabarti A., Soni M.L., Gupta P.V., and Bhatnagar U.S., 'A Text Book on Power Systems Engg', Dhanpat Rai and Sons, New Delhi, 2nd Revised Edition, 2010.
2. J.B.Gupta, 'A Course in Power Systems', S.K.Kataria and Sons, Reprint 2010-2011.
3. B.R.Gupta, 'Generation of Electrical Energy', S. Chand Limited, 2009
Reference Books:
1. Wadhwa, C.L., 'Generation Distribution and Utilisation of Electrical Energy', New Age International Publishers, 3rd Edition, 2010.
2. Deshpande M.V, `Elements of Electrical Power Systems Design', Pitman, New Delhi, PHI Learning Private Limited, 1st Edition, 2009

EE 2452 Electrical Safety 3-0-0-3

Unit-1: Primary and secondary hazards- arc, blast, shocks-causes and effects-safety equipment- flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers and signs, safety tags, locking devices- voltage measuring instruments- proximity and contact testers-safety electrical one line diagram- electrician's safety kit.
Unit-2: General requirements for grounding and bonding- definitions- grounding of electrical equipment- bonding of electrically conducting materials and other equipment-connection of grounding and bonding equipment system grounding- purpose of system grounding- grounding electrode system- grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment- grounding of low voltage and high voltage systems.
Unit-3: The six step safety methods- pre job briefings - hot-work decision tree-safe switching of power system lockout-tag out- flash hazard calculation and approach distances- calculating the required level of arc protection-safety equipment , procedure for low, medium and high voltage systems- the one minute safety audit.
Unit-4: Electrical safety programme structure, development- company safety team- safety policy- programme implementation-employee electrical safety teams- safety meetings- safety audit- accident prevention- first aid- rescue techniques-accident investigation. Safety related case for electrical maintenance- reliability centered maintenance (RCM) - eight step maintenance programme- frequency of maintenance- maintenance requirement for specific equipment and location- regulatory bodies- national electrical safety code-standard for electrical safety in work place occupational safety and health administration standards, Indian Electricity Acts related to Electrical Safety.

Text Books:
1. John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield ,'Electrical Safety Handbook', McGraw-Hill Education, 4thEdition, 2012.

Reference Books:

1. Maxwell Adams.J, 'Electrical Safety- a guide to the causes and prevention of electric hazards', The Institution of Electric Engineers, IET 1994.
2. Ray A. Jones, Jane G. Jones, 'Electrical Safety in the Workplace', Jones & Bartlett Learning, 2000.

EE 2453 Power Systems Engineering 3-0-0-3

Unit-I: Overview of generation systems: Sources of Energy, Steam, Diesel, Nuclear and Hydro power plants – site selection - Layout – essential components and operation.
Unit-II: Modes of Transmission and Distribution: HVAC and HVDC Transmission system – over-head lines – towers, conductors and insulators, underground cables – types – laying methods and fault location, comparison of overhead and underground systems, distribution system – classification – components, power factor correction.
Unit-III: Basic protection and switchgears: System faults and abnormal conditions, system grounding, need for protection system, overview of apparatus protection, switch gear mechanisms – fuse, switch, isolator and circuit breakers.
Unit-IV: Economics on power systems: Factors affecting cost of generation – load curve – load factor – diversity, base load and peak load stations – reduction of generation cost by interconnection of stations, price of electricity – types of tariff for HT and LT consumers. Regulation / Electricity Act: Evolution of Indian electricity act – regulator commissions, grid code, Introduction to restructuring of power system – GenCo, TransCo and DisCo, Independent power producers, Introduction to smart grid.

Reference Books:

1. R K Rajput, 'Power System Engineering', Laxmi Publications Ltd., 2006.
2. A Chakrabarti, M L Soni, P V Gupta and U S Bhatnagar, ' Power System Engineering', Dhanpat Rai & Co., Ltd., 2010.
3. S N Singh. 'Electric Power Generation, Transmission and Distribution', PHI Publications, 2008.
4. B.R. Gupta, 'Power System Analysis and Design', S. Chand Limited, 5th Edition, 2008.

EE 2454 Solid State Devices & Circuits 3-0-0-3

Unit-1: Introduction: Evolution and uniqueness of Semiconductor Technology, Equilibrium carrier concentration, Thermal Equilibrium and wave particle duality, Intrinsic semiconductor-ø Bond and band models, Extrinsic semiconductor-ø Bond and band models, Carrier transport, Random motion, Drift and diffusion, Excess carriers, Injection level, Lifetime, Direct and indirect semiconductors
Unit-2: Procedure for analyzing semiconductor devices-Basic equations and approximations
P-N Junction Device structure and fabrication, Equilibrium picture, DC forward and reverse characteristics, Small-signal equivalent circuit, Switching characteristics, Solar cell
Unit-3: Bipolar Junction Transistor- History, Device structures and fabrication, Transistor action and amplification, Common emitter DC characteristics Small-signal Equivalent circuit vEbers-Moll model SPICE model 6 MOS Junction C-V characteristics, threshold voltage, body effect,
Unit-4: Metal Oxide Field Effect Transistor- History, Device structures and fabrication, Common source DC characteristics, Small-signal equivalent circuit, SPICE level-1 model, Differences between a MOSFET and a BJT, Junction FET and MESFET, Recent Developments, Heterojunction FET, Heterojunction bipolar transistor
Books:
1. Millman Halkias, Integrated Electronics, TMH 2011
2 R. L. Boylestad, Louis Nashelsky, Electronic devices & circuits theory, Pearson Education 2009

Reference Books
1 David Bell, Electronic Devices & Circuits, Oxford Publications 2009
2 Schultz, Grob's, Basic Electronics, TMH 2007
3 Millman, Electronics Devices and Circuits, ed. 3, TMH 2006
4 Cathey, Electronics Devices and Circuits, ed. 3, TMH 2005
5 J. Millman and A. Grabel, Microelectronics, TMH, International 1999

EE 2455 Power System Operation in Restructured Market 3-0-0-3

UNIT - I - INTRODUCTION TO RESTRUCTURING OF THE POWER INDUSTRY
Deregulation of the power industry, unbundling of electric utilities, Issues involved in deregulation, Deregulation of various power systems –Fundamentals of Economics: Consumer behaviour, Supplier behaviour, Market equilibrium, Short and long-run costs, Various costs of production –Market models: Market models based on Contractual arrangements, Comparison of various market models, Market Mechanism.
UNIT - II - POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT
Role of the independent system operator, Operational planning activities of ISO: ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: GENCOs in Pool and Bilateral markets, market participation issues, competitive bidding.
UNIT - III - TRANSMISSION CONGESTION MANAGEMENT
Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management –Classification of congestion management methods –Calculation of ATC -Non–market methods –Market methods –Nodal pricing –Inter zonal and Intra zonal congestion management –Price area congestion management –Capacity alleviation method.

UNIT - IV - ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK

Introduction of ancillary services –Types of Ancillary services –Classification of Ancillary services –Load generation balancing related services –Voltage control and reactive power support devices –Black start capability service -ancillary service –Co-optimization of energy and reserve services -International comparison - Transmission pricing –Principles –Classification –Role in transmission pricing methods –Marginal transmission pricing paradigm –Composite pricing paradigm –Merits and demerits of different paradigm

UNIT - V - POWER MARKET DEVELOPMENT IN INDIA

Institutional structure in Indian Power sector, generation, transmission and distribution utilities.SO& LDCs.PFC, REC, ERCs, traders, Power Exchanges and their roles. Availability-based tariff, Open access, Industry structure and regulatory framework, market development, RE policies, RPO, Tariff policies. Policy changes, regulatory changes, Critical issues/challenges before the Indian power sector.

TEXTBOOKS

1. Lorrin Philipson, H. Lee Willis, "Understanding Electric Utilities and De-Regulation", CRC Press, 2nd edition, 2005.
2. Kankar Bhattacharya, Jaap E. Daadler and Math H.J. Boolen, "Operation of restructured power systems", Springer, 1st edition, 2001.
3. Loi Lei Lai : Power system Restructuring and Deregulation: Trading, Performance and Information Technology, John Wiley & Sons, Pvt. Ltd., 1st edition, 2001.
4. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 1st edition, 2002.
5. Mohammad Shahidehpour and Muwaffaq Alomoush, "Restructured electrical power systems: operation, trading and volatility", CRC Press; 1 st edition, 2017

EE 2456 Smart Grid and Challenges 3-0-0-3

Unit-1: Basic Power Systems: Load Modeling and generation systems for conventional and restructured power system. Power Flow Analysis.

Unit-2: Renewable Generation: Renewable Resources: Wind and Solar, Micro-grid Architecture, Distributed Storage and Reserves, Dealing with short term variations, stochastic models based on price forecasting. Power System Economics: Power system generation economics, Modeling of Consumers and producers, Electricity market structures, Marginal price, Optimal Power Flows, Distribution systems basics under new environment etc.

Unit-3: Smart Grid: Definition, Various components, Application and standards, Impacts of Smart Grid on reliability, Impacts of Smart Grid on air pollutant emissions reduction. Smart Grid Communications: Two-way Digital Communications Paradigm, Network Architectures, IP-based Systems Power Line Communications, Advanced Metering Infrastructure.

Unit-4: Demand Side Management: Definition, Applications, Load characteristics, load curve and load duration curve, Energy Consumption Scheduling, Controllable Load Models, Dynamics, and Challenges, Plug-in-hybrid Vehicles and smart appliances.

Unit-5: Wide Area Measurement: Sensor Networks, Phasor Measurement Units, Communications Infrastructure, Fault Detection and Self-Healing Systems, Applications and Challenges. Security and Privacy: Cyber Security Challenges in Smart Grid, Load Altering Attacks, False Data Injection Attacks, Defense Mechanisms, Privacy Challenges.

Reference:

1. D.S. Kirshen, Fundamentals of Power System Economics, John Wiley & Sons
2. A.J. Wood, B. F. Wollenberg, Power Generation Operation and Control, John Wiley & Sons
3. G. M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons
4. S. Stoft, Power System Economics: Designing Markets for Electricity, Wiley-Interscience

EE 2457 Electric and Hybrid Vehicles 3-0-0-3

Introduction to Hybrid Electric Vehicles, Conventional Vehicles, Hybrid Electric Drive-trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor, Energy Storage Requirements in Hybrid and Electric Vehicles, Sizing the drive system, Design of a Hybrid Electric Vehicle, Energy Management Strategies.

Text books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

EE2331	NETWORK ANALYSIS AND SYNTHESIS	[L-T-P:3-0-2], Credit: 4

Unit I: Network Graphs Matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Solution methods: nodal and mesh analysis.

Unit II: Network theorems: superposition, Thevenin and Norton's maximum power transfer, Wye-Delta transformation. Steady State sinusoidal analysis using phasors. Linear constant coefficient differential equations: time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits.

Unit-III: 2-port network: 2-port network parameters: driving point and transfer functions. State equations for network, Transient analysis using transform methods.

Unit-IV: Filters Low pass, high pass, band pass, band stop, all pass filters and frequency dependent negative resistors, Applications of active networks (op-amp, BJT, FET, tunnel diode etc.) and systems, Non-linear network analysis and systems.

Unit-V: Network Synthesis, Elementary Synthesis Operations, LC Network Synthesis, RC and RL networks.

Texts:
1. Network Analysis, Van Valkenburg, PHI Pbs, 2010
2. Circuit Theory, Kuriakose-PHI Pbs, 2005

References:
1. Network Analysis, Bakshi & Bakshi, Technical Publications, 2009
2. Network Analysis and Synthesis, Wadhwa, New Age Publications, 2008

EE2431	CONTROL SYSTEM	[L-T-P:3-0-2], Credit: 4

Unit I: Models and physical systems Feedback and its effects-linearization Mathematical Modelling of Physical Systems-Block diagram Concept and use of Transfer function. Signal Flow Graphs Mason's gain formula.

Unit II: Time Domain Analysis of Control Systems BIBO and absolute stability, Routh-Hurwitz Criterion. P, PI and PID controllers, State Variable Analysis of Linear Dynamic Systems- controllability and observability Root Locus Techniques-zero and pole.

Unit-III: Frequency Domain Analysis of Control Systems Polar plots, Nyquist stability criterion, Bode plots, application M&N circles, Nichols charts Design of Compensators.

Book:
1. J. Nagrath, M. Gopal, 'Modern Control Engineering', New Age International Publishers, 4th Edition, 2008.
Reference book:
B. C. Kuo, 'Automatic Control Systems' 8/e, 4th Edition, Wiley, 2002.

EE	INDUSTRIAL ELECTRONICS	[L-T-P:3-0-2], Credit: 4

Unit-1: General Introduction of Power Electronics, Scope and Application, Power Semiconductor Devices Power diodes - power transistors - SCRs - Triac - GTO - Power MOSFETs - IGBTs- Principles of operation and characteristics, device specifications and ratings, methods of turning on SCR- gate triggering circuit, methods of turning off SCR- commutation circuits. Protection and gate drive circuits.
Unit-2: Control rectifiers (AC to DC converter): Single phase converters: Principle of phase control, half wave controlled rectifier load, fully controlled bridge converter, half controlled (semi) converter, Effect of single phase full converter with source inductance, Dual converter, 3-phase half wave controlled rectifier, 3-phase fully controlled bridge converter, 3-phase semi converter.
Unit-3: Inverter: Series inverter, parallel inverter, single phase bridge inverter, concept of VSI and CSI, 3-phase bridge inverter (120° and 180° conduction mode), concept of PWM inverter.
Unit-4: D.C. Choppers: Principle of operation, control techniques, transient analysis of step down chopper, buck, boost & buck-boost regulator, voltage commutated chopper, current commutated chopper, load commutated chopper, jones chopper.
Unit-5: Cyclo converters: Single- phase mid-point type and bridge type cyclo converter, Applications: HVDC transmission, UPS, Zero voltage switch, Zero current switch.
Text Books:
1. P.S. Bimbhra, '*Power Electronics*', Khanna Publication, 2012.
References:
1. M.H. Rashid, '*Power Electronics*', Pearson Publication, 2003.
2. P.C. Sen, '*Power Electronics'*, Tata McGraw-Hill, 1987
3. V.R. Moorthi, '*Power Electronics'*, Oxford University Press, 2005