B. TECH IN ELECTRICAL ENGINEERING

1. Program Educational Objectives (PEOs)

PEO-1: will be productive in the professional practice of engineering and related fields, will be able to identify, formulate, create, analyze, design, develop, optimize, and implement electrical systems.

PEO-2: will contribute to industry and/or government organizations by applying the skills and knowledge acquired during the program period.

PEO-3: shall be prepared for the successful pursuit of graduate studies and shall have the ability to engage in lifelong learning in electrical engineering and related fields and will understand the challenges of a dynamically and globalized changing world adapting their skills through continuous learning and self-improvement.

PEO-4: will be provided with solid foundation in mathematical and engineering fundamentals required to solve engineering problems and also to pursue research within the appropriate technological, global, societal, ethical and organizational context.

PEO-5: will be able to inculcate a sense of ethics, professionalism and effective communication skills amongst graduates.

2. PROGRAM OUTCOMES (POs)

1. An ability to apply knowledge of mathematics, science and engineering to the solution of complex electrical engineering problems.

2. An ability to identify, formulate, design and conduct experiments as well as to analyze and interpret data related to complex engineering problems.

3. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

4. An ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to draw valid inferences.

5. An ability to use the techniques, skills, and appropriate modern engineering tools necessary for engineering practice.

6. The broad education necessary to understand and assess social, health, safety, legal and cultural issues and the consequent responsibilities relevant to the engineering practice.

7. An ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.

8. An understanding of professional and ethical responsibility.

9. Ability to function as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. An ability to communicate effectively.

11. An ability to demonstrate knowledge and understanding of the engineering and management principles and apply them to manage projects and in multidisciplinary environments.

12. A recognition of the need for, and an ability to engage in life-long learning.

3. PROGRAM SPECIFIC OUTCOMES (PSOs)

At the end of the programme, the students are -

PSO1.Able to apply fundamental knowledge of mathematics, science and engineering to identify, formulate, analyze, investigate, and design complex problems in the field of electrical engineering.

PSO 2.Able to apply the appropriate techniques and modern engineering tools to manage and solve complex electrical engineering projects, adapt in multi-disciplinary environments and engage in life-long learning.

PSO3.Aware of the impact of engineering solutions in the context of environment, society, economy, able to maintain professional ethics and have good communication skills.

COURSE STRUCTURE FOR B. TECH IN ELECTRICAL ENGINEERING

Semester I

Sl. No.	Code	Subject	Hours per week			Credit
			L	T	P	
1	CH 101	Chemistry	3	1	0	4
2	MA 101	Mathematics I	3	1	0	4
3	CS 101	Introduction to Programming	3	1	0	4
4	EC 101	Basic Electronics	3	1	0	4
5	CE 102	Environmental Science & Engineering	3	0	0	3
6	CH 111	Chemistry Laboratory	0	0	3	2
7	CS 111	Programming Laboratory	0	0	3	2
8	EC 111	Basic Electronics Laboratory	0	0	3	2
9	ME 111	Workshop Practice	0	0	3	2
10		Extra-Academic Activities (EAA)[1]	0	0	2	0
Total Credit						27

TOTAL CREDIT (Semester I) 27

Semester II

Sl. No.	Code	Subject	Hours per week			Credit
			L	T	P	
1	PH 101	Physics	3	1	0	4
2	MA 102	Mathematics II	3	1	0	4
3	ME 101	Engineering Mechanics	3	1	0	4
4	EE 101	Basic Electrical Engineering	3	1	0	4
5	HS 101	Communicative English	3	0	0	3
6	CE 101	Engineering Graphics & Design	1	0	3	3
7	PH 111	Physics Laboratory	0	0	3	2
8	EE 111	Basic Electrical Engineering Laboratory	0	0	3	2
9	HS 111	Language Laboratory	0	0	3	2
10		Extra-Academic Activities (EAA)[1]	0	0	2	0
Total Credit						28

TOTAL CREDIT (Semester II) 28

1 EAA consists of YOGA/Physical Training/NCC/NSS/NSO, where YOGA is compulsory as a one semester course (first or second semesters), while any one from the rest is compulsory as a one semester course. Thus, if YOGA is registered in first semester then any one from the rest four is to be opted in second semester and vice-versa.

Semester III

Sl. No.	Code	Subject	Hours per week			Credit
			L	T	P	
1	EE 201	Signals and Systems	3	1	0	4
2	MA 201	Mathematics III	3	1	0	4
3	EE 202	Analog Electronics	3	1	0	4
4	EE 203	Energy Science and Technology	3	0	0	3
5	EE 204	Measuring Instruments and Measurements	3	1	0	4
6	EE 205	Electromagnetic Field Theory	3	1	0	4
7	EE 211	Programming and Simulation Laboratory	0	0	3	2
8	EE 212	Measurement Laboratory	0	0	3	2
9	EC 226	Analog Electronics Laboratory	0	0	3	2
Total Credit						29

TOTAL CREDIT (Semester III) 29

Semester IV

Sl. No.	Code	Subject	Hours per week			Credit
			L	T	P	
1	EE 206	Electrical Machines -I	3	1	0	4
2	EE 207	Power Systems I	3	1	0	4
3	EE 208	Digital Electronics	3	1	0	4
4	EE 209	Circuit Theory	3	1	0	4
5	EE 210	Microprocessors & Microcontrollers	3	0	0	3
6	CS 221	Programming & Data Structure	3	0	0	3
7	EE 213	Circuit Theory Laboratory	0	0	3	2
8	EE 214	Microprocessor & Microcontroller Laboratory	0	0	3	2
9	EE 215	Digital Electronics Laboratory	0	0	3	2
Total Credit						28

TOTAL CREDIT (Semester IV): 28

Semester V

Sl. No.	Code	Subject	Hours per week			Credit
			L	T	P	
1	EE 301	Control Systems	3	1	0	4
2	EE 302	Power Systems II	3	1	0	4
3	EE 303	Electrical Machines II	3	1	0	4

4	EE 304	Power Electronics	3	1	0	4
5	EE 305	Digital Signal Processing	3	0	0	3
6	EE 311	Electrical Machine Laboratory-I	0	0	3	2
7	EE 312	Power System Laboratory-I	0	0	3	2
8	EE 313	Control System Laboratory	0	0	3	2
9	EE 314	Signal Processing Laboratory	0	0	3	2
Total Credit						27

TOTAL CREDIT (Semester V): 27

Semester VI

Sl. No.	Code	Subject	Hours per week			Credit
			L	T	P	
1	EE 306	Switchgear and Protection	3	1	0	4
2	EE 307	Industrial Drives	3	1	0	4
3	EC 327	Analog and Digital Communication	3	0	0	3
4	EE 308	Modern Control Systems	3	1	0	4
5	EE 3XX	Professional Core Elective I	3	0	0	3
6	EE 3XX	Open Elective I	3	0	0	3
7	EE 315	Electrical Machine Laboratory II	0	0	3	2
8	EE 316	Power System Laboratory II	0	0	3	2
9	EE 317	Power Electronics and Drives Laboratory	0	0	3	2
Total Credit						27

TOTAL CREDIT (Semester VI): 27

Semester VII

Sl. No.	Code	Subject	Hours per week			Credit
			L	T	P	
1	EE 401	Instrumentation	3	1	0	4
2	MS 401	Business Management	3	0	0	3
3	EE 4XX	Professional Core Elective II	3	0	0	3
4	EE 4XX	Open Elective II	3	0	0	3
5	EE 497	Industrial Training (Minimum 6 weeks)				2
6	EE 498	Project I	0	0	6	4
Total Credit						19

TOTAL CREDIT (Semester VII): 19

Semester VIII

Sl. No.	Code	Subject	Hours per week			Credit
			L	T	P	
1	EE 4XX	Professional Core Elective III	3	0	0	3
2	HS 401	Managerial Economics	3	0	0	3

3	EE 4XX	Open Elective III	3	0	0	3
4	EE 499	Project II	0	0	6	6
Total Credit						15

TOTAL CREDIT (Semester VIII): 15

Professional Core Elective I (6th Semester) (EE 331 - EE 380)

1. EE 331: Digital Control Systems
2. EE 332: Advanced Power Electronics and Devices
3. EE 333: Computer Organization
4. EE 334: LT & HT Distribution Systems
5. EE 335: Introduction to VLSI
6. EE 336: Renewable Energy

Open Elective I (6th Semester) (EE 381 - EE 397)

1. EE 381: Optimization Methods and its Application in Engineering
2. EE 382: Fuzzy Set Theory and Applications
3. EE 383: Adaptive Signal Processing
4. EE 384: Mathematical Methods in Dynamic Systems
5. EE 385: Software-based System Design
6. EE 386: Hardware-based System Design

Professional Core Elective II – (7th Semester) (EE 431 - EE 450)

1. EE 431 Switch Mode Power Supply
2. EE 432: Electric Power Utilization and Traction
3. EE 433: Biomedical Signal Processing and Control
4. EE 434: Electric Power Quality
5. EE 435: Optimal Control
6. EE 436: Modelling and Control of AC Drives
7. EE 437: Computer Applications in Power Systems
8. EE 438: Power System Operation and Control
9. EE 439: Data Acquisition and Signal Conditioning
10. EE 440: AC-DC Micro grid
11. EE 441: Flexible AC Transmission Systems
12. EE 442: High Voltage AC/DC
13. EE 443: Intelligent and Knowledge Based Systems
14. EE 444: Demand Side Management
15. EE 445: Control of Wind Energy Conversion System and its Challenges
16. EE 446: Geometrical Aspect of Control Systems
17. EE 447: Nonlinear Systems
18. EE 448: VLSI System Design

Open Elective II (7th Semester) (EE 481 - EE 490)

1. EE 481: Introduction to Biomedical Engineering
2. EE 482: Optimization Techniques and Numerical Methods
3. EE 483: Industrial Instrumentation
4. EE 484: Artificial Neural Networks
5. EE 485: Design Aspect of Control Systems
6. EE 486: Modelling and Simulation of Dynamical Systems

Professional Core Elective III – (8th Semester) (EE 451 - EE 480)

1. EE 451: Power System Reliability and Deregulation
2. EE 452: Power System Stability and Control
3. EE 453: Electrical Networks and Pricing
4. EE 454: System Identification and Parameter Estimation
5. EE 455: Advanced Control Systems
6. EE 456: Advanced Digital Signal Processing
7. EE 457: Biomedical Instrumentation
8. EE 458: CAD for VLSI Systems
9. EE 459: EHV Transmission
10. EE 460: Power Electronics Application to Wind and Solar Energy System
11. EE 466: Distribution Systems Planning and Automation
12. EE 467: Intelligent Algorithms for Power Systems
13. EE 468: Hydro-electric Engineering
14. EE 469: Non-Conventional and Distributed Generation
15. EE 470: Navigation, Guidance and Control
16. EE 471: Non-linear System Analysis and Control
17. EE 472: Computer Relaying and Phasor Measurement Unit
18. EE 473: Smart Grid Technologies
19. EE 474: Advanced Instrumentation
20. EE 475: Special Electrical Machines and Drives
21. EE 476: Intelligent Control
22. EE 477: Energy Auditing, Conservation and Management

Open Elective III (8th Semester) (EE 491 - EE 497)

1. EE 491: Electric Vehicles
2. EE 492: Soft Computing Techniques and Applications
3. EE 493: Electrical Safety
4. EE 494: Control System Components

EE 101	Basic Electrical Engineering B. Tech (All Branch) First and Second Semester (Core)	L	T	P	C
		3	1	0	4

Unit-1:	**Introduction:** Definition of active, passive, linear, non-linear, unilateral, bilateral, symmetrical, unsymmetrical network with example. Basic concept of circuit elements and their uses. Sources: current sources and voltage sources, dependent source, independent source, circuit laws (KCL & KVL), commonly used symbol and notations in electrical circuits	(3)
Unit-2:	**A.C. Fundamentals and R, L, C Circuit:** Equation of AC Voltage and currents, waveform, time period, frequency, amplitude, different forms of emf equations, phase, phase difference, average value, RMS value, form factor, peak factor. Series and parallel RL, RC, and RLC circuits and their phasor representation; steady state response; Operator j notation of complex quantity in rectangular and polar form. Concept of Impedance and admittance: definition, relation, impedance, and admittance triangle. Complex power: active, reactive and apparent power, power triangle	(10)
Unit-3:	**Network Theorems:** Star delta conversions, Node & loop equations, Thevenin's Theorem (AC & DC), Norton's Theorem (AC & DC), Superposition Theorem (AC & DC), Maximum power transfer theorem (AC & DC), Reciprocity Theorem (AC & DC) (All theorems with independent sources only).	(8)
Unit-4:	**Poly-phase Networks:** Balanced Star-Delta connections, phase and line currents and voltages and their relations;	(3)
Unit-5:	**Electromechanical Energy conversion:** Electromechanical laws: relation between electricity and magnetism, production of emfs (ac & dc), Faraday's law of electromagnetic induction, direction of induced emf, Lenz law, dynamically and statically induced emfs, self-inductances, and mutual inductances.	(4)
Unit-6:	**Electrical Machines:** Types of Electrical Machines and their applications; Working principle of DC machines, single phase transformer, and 3-phase induction motor; EMF equation,	(7)
Unit-7:	**Measurement:** Measurement of voltage, current and Power in single and three phase	(3)
Unit-8:	**Electrical safety:** Definition, precautions, concepts of grounding and earthing.	(2)

Text and Reference:

1. Del Toro V. ***Electrical Engineering Fundamentals***. PHI
2. Theraja B. L. ***Electrical Technology.*** S Chand
3. Hayt W. H., Kemmerly J. E. ***Engineering Circuit Analysis.*** McGraw Hill
4. J. B. Gupta. ***Basic Electrical Engineering.*** Katson

Course Outcomes (Cos):

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

1. Appreciate the consequences of linearity, in particular the principle of superposition, Thevenin-Norton equivalent circuits and Reciprocity theorem.
2. Gain an intuitive understanding of the role of AC power flow in star and delta networks and relationship of line and phase values.
3. Develop the capability to analyse the concept of electromechanical conversion of energy using DC machines and basics of transformer with 3 phase induction machines.
4. Apply various modes and methods of measurement of voltage, current and power in both 1 phase and 3 phase circuits.
5. Demonstrate the common safety practices of using electricity in workplace with knowledge of grounding and earthing.

EE 111	**Basic Electrical Engineering Laboratory**	**L**	**T**	**P**	**C**
	B. Tech (All Branch) First and Second Semester (Core)	**0**	**0**	**3**	**2**

List of Experiments

1. Study and verification of Kirchhoff's Laws applied to direct current circuit.
2. Study the behaviour of AC series circuits.
3. Study the behaviour of AC Parallel circuits.
4. Verification of Superposition theorem.
5. Verification of Thevenin's theorem.
6. Verification of Norton's theorem.
7. Verification of Maximum power transfer theorem.
8. Verification of Reciprocity theorem.
9. Measurement of LC parameters by using 3- Ammeter method.
10. Calibration of milliammeter.
11. Resonance of series RLC circuit.
12. To study the balanced three phase circuit.
13. Speed control DC motor using flux control and armature resistance control methods
14. OC and SC test on Single-phase transformer.
15. Study of balanced three-phase circuit/ measurement of three phase power using two wattmeter method.
16. Reversal of direction of rotation of a three-phase Induction motor/ Load test of three- phase Induction motor

Course Outcomes (Cos):

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

1. Demonstrate the different circuit laws in practical circuits.
2. Apply various network theorems to solve circuit parameters including Series and parallel connections.
3. Gain an intuitive understanding of the role of common measurement methods used for current, voltage and power in 1 phase and 3 phase circuits.
4. Become adept at using various methods calibration of measuring meters.
5. Demonstrate the ability to control of speed of DC motors using flux control and armature resistance control

EE 201	Signals and Systems	L	T	P	C
	B. Tech (Electrical Engg.) Third Semester (Core)	**3**	**1**	**0**	**4**

Unit-1:	**Introduction to signals and systems**: Introduction to standard continuous time (CT) and discrete time (DT) signals: impulse, step and ramp, sinusoid, exponential signals, their properties and importance, power signal, energy signals. Basic properties of systems: linearity, time-invariance, causality, stability, invertibility etc. with special emphasis on LTI system, mathematical model for systems, impulse response of a LTI system (CT and DT systems), Computation of convolution integral and convolution sum, block diagram representations of CT and DT systems.	(12)
Unit-2:	**Fourier series and Fourier transform**: Response of LTI systems (CT and DT) to complex exponentials, concept of Eigen functions, condition for orthogonality, Fourier series representation of CT and DT periodic signals, Basic properties of CT and FT Fourier series coefficient, Parseval's Theorem. CT and DT Fourier transform (FT) of an a periodic signal, convergence of FT, properties of FT. Parseval's relation, Magnitude and phase response, introductory concepts of ideal and practical filters.	(11)
Unit-3:	**Sampling:** Concept of sampling, impulse sampling, Nyquist sampling theorem, zero order hold, reconstruction of signals from its samples.	(5)
Unit-4:	**Laplace transform and Z-transform:** Bilateral and unilateral Laplace transform (LT), Concept of poles and zeros, Region of Convergence (ROC), relation of system causality and stability with ROC, properties, inverse LT, applications. Bilateral and unilateral Z Transform (ZT), Concept of poles and zeros, relation of system causality.	(6)
Unit-5:	**Statistical signal analysis**: Random signals, random process, auto-correlation and cross correlation functions and their properties. Spectral density, relation of spectral density to autocorrelation function and white noise, analysis of linear systems with white noise.	(6)

Text and Reference:

1. Oppenheim, Wilsky and Nawab., ***Signals and Systems,*** Pearson Education
2. T. K. Rawat. ***Signals and Systems.*** Oxford University Press
3. Cooper G.R and C. D. McGillem. ***Probabilistic Methods of Signals and System Analysis.*** Oxford University Press
4. Hwei P. Hsu. ***Signals and Systems.*** Schaum's Outlines McGraw-Hill
5. C.T.Chen. ***Systems and Signal Analysis.*** Oxford University Press
6. R.E. Ziemer, W.H Tranter and D.R.Fannin. ***Signals and Systems.*** Pearson Education

Course Outcomes (Cos):

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

1. Define, represent and analyse various signals and system and their applications.
2. Apply Fourier series and transform to analyse the signals it in frequency domain.

3. Understand the Concept of sampling and reconstruction of signals from its samples.
4. Apply the knowledge of Laplace and Z-Transform to analyse the continuous and discrete time systems in frequency domain.
5. Analyse the statistical phenomenon of random signals and it's spectra

EE 202	Analog Electronics	L	T	P	C
	B. Tech (Electrical Engg.) Third Semester (Core)	**3**	**1**	**0**	**4**

Unit-1:	**Diode:** Review of p-n junction diode, Zener diode**,** half wave and full wave diode rectifiers, filtering, efficiency.	(4)
Unit-2:	**Bipolar Junction Transistors:** Review on principle of operation of BJT, BJT Ebers Moll model, CE, CB and CC configurations. Hybrid-π model of transistor in CE mode, conductance, capacitance, short-circuit current gain, CE current gain with resistive loads, CE stage as an amplifier and frequency response.	(8)
Unit-3:	**MOSFET:** Small signal operation and models for MOSFET. Single stage MOSFET amplifiers.	(4)
Unit-4:	**Multistage Transistor Amplifiers:** Analysis of CE- CE, CE-CC and CE-CB stages, Darlington pair, Millers Theorem..	(4)
Unit-5:	**Operational Amplifiers:** Basic building block, Differential stage, gain stage, CMRR, Op-Amps as inverting, non-inverting amplifiers, buffers. Applications of Op-Amps: as adder, subtractor, integrator, differentiator, and Logarithmic functions. Use of Op-Amp as comparators, zero-crossing detectors, Schmitt Trigger and Relaxation Oscillator. ADC and DAC design using Op-Amps. 555 timers- Its applications	(8)
Unit-6:	**Active filters:** Low pass, high pass, band pass, band reject filter design using Op-Amps and analysis of frequency response using Bode plot.	(6)
Unit-7:	**Feedback Amplifiers:** Classification and basic concepts of feedback amplifiers. Loop gain. Stability problem: Nyquist and Bode plots. Voltage Shunt Feedback using OPAMP. Basic principle of sinusoidal oscillators. RC oscillator. LC and crystal oscillator. Voltage Controlled Oscillator (VCO).	(6)

Text and Reference:

1. Robert L. Boylestad. ***Electronic Devices and Circuit Theory***. Pearson, 8th Edition
2. A.S. Sedra and K. C. Smith. ***Microelectronic Circuits.*** Oxford University Press, 5th Edition
3. Jacob Millman. ***Electronic Devices and Circuits.*** McGraw Hill Education; 4th edition

Course Outcomes (Cos):

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

1. Design suitable diode rectifiers for given specifications and desired performance in terms of efficiency. Design amplifiers using BJT and MOSFETs for desired specifications.
2. Implement Op-Amp based circuits to perform arithmetic and differential operations.
3. Design active filters based on specified requirements.
4. Design oscillator circuits for given specifications.

EE 203	**Energy Science and Technology**	**L**	**T**	**P**	**C**
	B. Tech (Electrical Engg.) Third Semester (Core)	**3**	**0**	**0**	**3**

Unit-1:	**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	(3)
Unit-2:	**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	(15)
Unit-3:	**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	(16)
Unit-4:	**Energy Management System:** Energy Management, Energy Auditing, Energy and Carbon Benchmarking, Zero energy and energy-positive buildings, Demand side management, Demand response	(6)

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.

Course Outcomes (Cos):

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

1. State the Indian energy challenges and opportunities.
2. Model, simulate and optimize different energy systems.
3. State utility of different non-conventional and advanced bio energy systems.
4. Apply energy management for demand and supply criteria.

EE 204	Measuring Instruments and Measurements	L	T	P	C
	B. Tech (Electrical Engg.) Third Semester (Core)	**3**	**1**	**0**	**4**

Unit-1: **Introduction**: Introduction to measurement and instruments, Static and dynamic characteristics of instruments. Different types of instruments. Operating forces required for working of indicating instruments. Different types of damping and control systems. Construction and working principles of PMMC, MI, Induction type, Electrodynamometer type, their applications advantages and disadvantages, Errors in measurements (5)

Unit-2: **Galvanometers and Dynamics:** Dynamic behaviour of Galvanometer - equation of motion for different damping conditions. Response of galvanometer, operational constants, CDRX, relative damping, logarithmic decrement, sensibility. Ballistic Galvanometer and Flux meter construction and theory of operation. (6)

Unit-3: **Magnetic Measurements:** Magnetic measurements, types of tests, Ballistic tests, measurement of flux density, determination of B.H. curve (4)

Unit-4: **Measurement of Resistance, Inductance and Capacitance using DC and AC Bridges:** Measurement of low resistance by Kelvin's Double Bridge Method, Insulation resistance measurement by loss of charge method. A.C. & D.C. bridges: Maxwell's commutated D.C. bridge, Anderson bridge, Schering Bridge, Hays Bridge, Wagner's Earthing device, Campbell's Mutual Inductance Bridge, Circuit diagram, phasor diagram, derivations of equations for unknown, Q-factor, dissipation factor. Advantages and disadvantages. (10)

Unit-5: **Potentiometers**: Standardization, Principle of working and construction of Crompton, potentiometer (D.C.) Polar and Co-ordinate type of potentiometers (5)

Unit-6: **Measurement of Power, Power Factor and Energy**: Measurement of power and energy, use of Current transformer and potential transformer, Electrodynamometer type of Wattmeter, Induction type energy meter, Indicating type Frequency meter, Electrodynamometer type P.F. meter, Maximum demand indicator. (6)

Unit-7: **Electronic Instruments:** Digital Voltmeters, CRO, DSO, Lissajous Patterns, Digital Multimeter (4)

Text and Reference:

1. A.K. Sawhney. ***Electrical & Electronics Measurements and Instrumentation.*** Dhanpat Rai and Sons
2. E.W. Golding and F.C. Widdis. ***Electrical Measurements and Measuring Instruments***. A.H. Wheeler & Company
3. H.S. Kalsi. ***Electronic Instrumentation***. Tata McGraw-Hill Education
4. S. Tumanski. ***Principles of Electrical Measurement.*** CRC Press, Taylor & Francis

Course Outcomes (Cos):

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

1. Define, classify and use various analog & digital measuring instruments in Electrical Engineering field.
2. Describe and analyze the behavior of magnetic measurements using B-H curve.

3. Identify and evaluate the performance of AC-DC bridges and other methods for measurement of resistance, inductance and capacitance.
4. Apply, analyse and evaluate instruments for the measurements of power, power factor and energy

EE 205	Electromagnetic Field Theory	L	T	P	C
	B. Tech (Electrical Engg.) Third Semester (Core)	3	1	0	4

Unit-1:	**Vector Analysis:** Introduction, co-ordinate–system transformation, vector calculus, Divergence of vector and Divergence theorem, curl of a vector and Stokes theorem, Laplacian of a scalar, classification of vector fields.	(6)
Unit-2:	**Electrostatics:** Coulomb's law, Electric field strength, field due to a line charge, sheet charge and volume charge. Electric flux-density, Gauss's law (Maxwell's first equation in electrostatics), applications of Gauss's law. Electric Potential and potential difference, Potential of a point charge and system of charges, Conservative property, potential gradient, dipole. Energy density in electrostatic field.	(8)
Unit-3:	**Magnetostatics:** Biot-Savart's law- magnetic field due to filamentary current, distributed current surface and volume currents. Ampere's circuital law, Scalar and vector magnetic potentials. Maxwell's equations for steady magnetic fields, force on a current element in a magnetic field. Force between two current elements and torque in a current loop.	(7)
Unit-4:	**Electromagnetic field:** Faraday's law, Lorentz-force equation, displacement current and modified Ampere's circuital law in integral form. Continuity equation. Power flow in electromagnetic field - the Poynting theorem, sinusoidally time-varying fields and its Maxwell's equation. The retarded potentials, polarization of vector fields	(7)
Unit-5:	**Materials and fields:** Current and current density. Conductors in fields- drift velocity, mobility, conductivity. Dielectrics in fields- polarization, flux-density, electric susceptibility, relative permittivity. Magnetic materials, magnetization, permeability and magnetic boundary conditions.	(7)
Unit-6:	**Electromagnetic waves:** Helmontz equation, radiation of electromagnetic waves. Wave motion in free space, perfect dielectric, lossy dielectric, propagation in good conductors-skin effect. Reflection of plane waves	(5)

Text and Reference:

1. Mathew N.O. Sadiku. ***Elements of Electromagnetics***. Oxford Univ Press
2. N.N. Rao. ***Basic electromagnetic and applications.*** Prentice Hall
3. William H. Hayt, Jr., John A. Buck. ***Engineering Electromagnetics.*** McGraw Hill Education
4. Bradshaw and Byatt. ***Introductory Engineering Field Theory***. Prentice Hall

Course Outcomes (Cos):

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

1. apply the knowledge of the coordinate system and vector calculus along with Stokes and Divergence theorems for calculation of electromagnetic fields.
2. evaluation of electrostatics-field intensities due to different charge distributions, Gauss law and its advantage and applications and polarization of electric charge in the different medium.
3. analyze of magnetic field intensities due to different current distributions, Amperes circuital law and its applications.

4. examine of Maxwell’s equations modified for time- varying electric and magnetic field (electro-magnetic field).
5. deduce the EM wave motion in different dielectrics

		L	T	P	C
EE 211	**Programming and Simulation Laboratory**	**L**	**T**	**P**	**C**
	B. Tech (Electrical Engg.) Third Semester (Core)	**0**	**0**	**3**	**2**

List of Experiments

1: **MATLAB/ C/ Python**- Basic computation, use of different functions, plotting a graph. Sorting of data. Use of matrices- multiplication of two matrices, sorting of elements etc. Solution of linear system algebraic equations. Drawing regular curves, curves from equations. Numerical differentiation and integration. Finding roots of non-linear equations using Newton-Raphson or other iterative method. Solution of first order differential equation applying forth order Runge-Kutta method. Curve fitting. (15)

2: **MATLAB Simulink**-Simulation of different mathematical expression. Importing/ exporting data from/ to workspace. Basic design using MATLAB Graphical User Interface (GUI). Use of GUI to plot graphs (9)

3: **MULTISIM, PSPICE** - Verification of Network Theorems (Superposition, Thevenin's and Norton's theorem). Simulation of rectifier circuit using normal p-n junction diode. (9)

Text and Reference:

1. B. S. Grewal. ***Higher Engineering Mathematics***. Khanna Pub.
2. Rudra Pratap. ***Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers***. Oxford Pub.
3. Avijit Chakrabarty. ***Circuit Theory: Analysis and Synthesis***. Dhanpat Rai & Co.
4. Robert L. ***Boylestad and Louis Nashelsky***. Electronic Devices and Circuit Theory., Pearson
5. Yashvant Kanetkar. ***Let Us C***. Bpb Pub

Course Outcomes (Cos):

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

CO1: solve electrical engineering problems using various numerical methods

CO2: simulate and verify electrical and electronic circuits.

CO3: design and analyse electrical systems using specialized tools.

EE 212 Measurement Laboratory

	L	T	P	C
B. Tech (Electrical Engg.) Third Semester (Core)	**0**	**0**	**3**	**2**

List of Experiments

1. To calibrate a three phase Energy Meter by comparing with a Sub–standard meter.
2. Measurement of Power and Power Factor of a three-phase circuit.
3. Measurement of Power in HV circuit using instrument transformers (CT & PT).
4. To calibrate Single–phase Energy meter by comparing with a Sub-standard meter and by calculation.
5. To measure high resistance by loss of charge method.
6. To measure medium resistance with the help of Wheatstone bridge and Substitution method.
7. To measure:
    a. the low resistance by using Kelvin's Double Bridge method.
    b. the value of Earth resistance.
8. To measure self-inductance of a coil using A.C. Anderson's bridge and Hay's bridge.
9. To measure capacitance of a given capacitor by using A.C. bridge.
10. To determine the phase sequence of a three-phase supply using phase sequence indicator.
11. Measurement of electrical quantities by using Cathode Ray Oscilloscope (CRO).

Course Outcomes (Cos):

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

1. Acquire hands-on experience about various electrical measuring devices and their working principles.
2. calibrate the measuring instrument and find the calibration curve.
3. work with analog and digital instruments such as ammeter, voltmeter, wattmeter, AC & DC bridges, CT/PT, single-phase and three-phase energy meters, CRO and DSO.

EC 226	Analog Electronics Laboratory	L	T	P	C
	B. Tech (Electrical Engg.) Third Semester (Core)	0	0	3	2

List of Experiments

1. To design and setup a voltage follower circuit with OPAMP IC 741 and observe the waveforms.
2. To design and setup a non-inverting amplifier circuit with OPAMP IC 741C for a fixed gain, plot the waveform, observe the phase reversal, measure the gain.
3. To design and setup an inverting amplifier circuit with OPAMP 741 for a fixed gain, plot the waveforms, observe the phase reversal, measure the gain.
4. To design and setup a summing amplifier circuit with OPAMP 741 for a fixed gain and verify the output.
5. To design and setup a Schmitt trigger, plot the input and output waveforms and measure V_{UT} and V_{LT}.
6. To design a differentiator and integrator using OPAMP IC 741.
7. To design a low pass and high pass filter with a given fixed cut-off frequency.
8. To design and setup symmetrical and asymmetrical astable multivibrators using IC 555 and (i) Plot the output waveform (ii) Measure the frequency of oscillation.
9. To design and setup a RC phase shift oscillator using OPAMP IC 741 and (i) Plot the output waveform (ii) Measure the frequency of oscillation.

Course Outcomes (Cos):

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

1. set up testing strategies and select proper instruments to evaluate performance characteristics of electronic circuit.
2. choose testing and experimental procedures on different types of electronic circuit to analyze their operation.
3. evaluate possible causes of discrepancy in practical experimental observations in comparison to theory.
4. practice different types of wiring and instruments connections keeping in mind technical, economical, safety issues.

EE 206 Electrical Machines-I

B. Tech (Electrical Engg.) Fourth Semester (Core)

L	T	P	C
3	1	0	4

Unit-1: **Constructional features** - Magnetic circuit: Different types of field and armature structures, their placement and magnetic path with special reference to transformer. Material used, laminations, magnetic saturation, cooling arrangement, medium used for cooling in reference to DC and AC machines. **Electrical circuit**: Different types of field and armature windings, pole formation, and winding parameters (full pitch & short pitch) concentrated winding and distributed winding, single layer and double layer winding. Brush slip ring &commutator arrangement in AC and DC machines. (6)

Unit-2: **Basic Concept of Rotating Electrical Machines** - Nature of MMF developed by concentrated winding carrying DC and AC supply, Nature of mmf due to distributed winding, harmonic reduction, Flux density distribution, concept of main flux and leakage flux, Equation for instantaneous value of flux, Nature of MMF produced in AC and DC machines (10)

Electromotive Force: Expressions of induced emfs, Expression for emf developed across distributed winding, Nature of the emf developed across the coil in AC and DC machines, Equivalent circuit models for DC and AC machines, generalized torque equation, Energy flow, efficiency and rating of AC and DC machines.

Unit-3: **DC Generators** - EMF equation, Classification on methods of excitation, armature reaction, interpoles and compensating winding, commutation, characteristic of DC generators, losses and efficiency, voltage regulation, parallel operation. (8)

DC Motors: Torque equation, characteristic curves of shunt, series and compound motors, starter and grading of starting resistance, speed control - armature voltage control and field control methods. Ward Leonard method, speed regulation, losses and efficiency, testing- Swinburn's test, back to back test, brake test.

Unit-4: **Transformer**- Emf equation, phasor diagram and equivalent circuit, per unit equivalent resistance and reactance, open circuit and short circuit tests, back to back test, voltage regulation, losses and efficiency, All day efficiency, Two winding and three winding transformers, auto transformer, three phase transformer and winding connections, parallel operation. (8)

Unit-5: **Polyphase Induction Motor**- Principle of operation of poly phase induction motors, equivalent circuit and phasor diagram, torque and power, speed - torque curve - effect of rotor resistance, deep bar and double cage rotors, performance calculation from circle diagram, methods of speed control, testing, losses and efficiency, application, induction generators and induction regulator. (8)

Text and Reference:

1. P.S. Bimbhra, ***Electrical Machines.*** Khanna Publishers
2. Nagrath& Kothari. ***Electrical Machines.*** TMH

3. Dr. S.K. Sen. ***Electrical Machines.*** Khanna Publishers

Course Outcomes (Cos):

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

1. illustrate the constructional features of DC and AC machines.
2. analyze the principle of operation of DC and AC machines.
3. develop the equivalent circuit model and analyse the performance of DC machines, Transformers, Induction Motors.
4. select types of DC and AC machines suitable for different applications.

EE 207	Power Systems-I	L	T	P	C
	B. Tech (Electrical Engg.) Fourth Semester (Core)	**3**	**1**	**0**	**4**

Unit-1:	**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.	(6)
Unit-2:	**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.	(6)
Unit-3:	**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.	(6)
Unit-4:	**Overhead Transmission Line Constants:** Introduction, Conductors, Resistance of overhead line, inductance of solid cylindrical conductor, composite conductors, two conductor single phase line, three phase single circuit and double circuit lines with symmetrical and unsymmetrical spacing, transposed and un transposed line. Capacitance of two wire line, three phase symmetrical and unsymmetrical line, charging current, effect of earth on capacitance of transmission line. Skin and Proximity Effects. Corona in transmission line, critical disruptive and visual disruptive voltages, factors effecting corona, corona power loss, advantages and disadvantages of corona. Problems.	(10)
Unit-5:	**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.	(6)
Unit-6:	**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	(6)

Text and Reference:

1. C.L. Wadhwa. ***Electrical Power systems.*** Wiley Eastern
2. Ashfaq Hussain. ***Electrical Power System.*** CBS Publishers

3. Soni, Gupta, Bhatnagar. ***Electric Power.*** Dhanpat Rai & Sons
4. J.B.Gupta. ***A course in Power Systems.*** S. K. Katia & Sons
5. O.I.Elgerd. ***Electric Energy system Theory – An Introduction.*** Tata McgrawHilll
6. B.R.Gupta. ***Generation of Electrical Energy.*** S. Chand.
7. T.K. Nagsarkar and M.S. Sukhija. ***Power System Analysis.*** Oxford University Press
8. I.J. Nagrath and D.P. Kothari. ***Power System Engineering.*** Tata McGraw-Hill

Course Outcomes (Cos):

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

1. **describe the working principle of various power generation plants.**
2. **analyze the various load curves of economic power generation.**
3. **compute the electrical parameters for overhead and underground power lines.**
4. design various components of transmission and distribution systems.
5. **apply knowledge to solve operational problems in power system.**

EE 208	Digital Electronics	L	T	P	C
	B. Tech (Electrical Engg.) Fourth Semester (Core)	3	1	0	4

Unit-1:	**Logic Families and Logic Gates:** TTL, ECL, NMOS, CMOS and PTL logic families and realization of basic logic gates-AND, OR, NOT, NAND, NOR, XOR, XNOR. Transfer characteristics, Inverter ratios, Noise margin, power consumption, propagation delays, fan-in and fan-out.	(6)
Unit-2:	**Number Systems and Codes:** Signed and unsigned numbers and their arithmetic operation, Binary, Hexadecimal, Octal numbers and their conversions. BCD, Excess-3, Gray, 3 out of 5 and Alpha-numeric codes, Boolean Algebra.	(5)
Unit-3:	**Combinational Logic Circuits:** Two-level and Multi-level logics, single and Multi-output functions, logic minimization, K-Map and Queen-Mclauski’s Method, Multiplexers, Demultiplexers, Encoder, Decoder, Priority Encoder, parity checkers, half-adders and Full adders	(10)
Unit-4:	**Sequential Logic Circuits**: Latches and Flip-flops: RS, JK, D-type Flip-flops, Master-slave flip-flops, Edge triggered FF. Shift Registers- serial and parallel and mixed modes, Counters-Binary, Ripple, Synchronous, asynchronous, Mod-K and decade counters and their design.	(12)
Unit-5:	**Introduction to ADCs:** flash ADC, dual slope ADC, successive approximation ADC, DAC, R-2R ladder network, weighted resistance DAC, Weighted capacitance DAC.	(5)
Unit-6:	**Semiconductor Memories:** ROM, PROM, EPROM, Static and Dynamic RAM, MOS memories, Flash Memory, Memory addressing	(2)

Text and Reference:

1. Malvino and Leech. ***Digital Principles and Application.*** McGraw-Hill
2. M .M. Mano. ***Digital logic and Computer Design. 3rd*** Edition, Prentice Hall
3. Alan Markovitz. ***Introduction to Logic Design.*** McGraw-Hill
4. R.P. Jain. ***Modern Digital Electronics 4th Edition.*** Tata-McGraw Hill
5. J.M. Rabaey. ***Digital Integrated Circuits: A Design Perspective***. 2nd Edition, Prentice Hall
6. Zvi Kohavi. ***Switching and Finite Automata Theory.*** Tata-McGraw Hill

Course Outcomes (Cos):

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

1. understand the fundamental concepts and techniques used in digital electronics.
2. understand and examine the structure of various number systems, logic families, logic gates and their application in digital design.
3. analyze and design various combinational and sequential circuits.
4. explain the analog to digital and digital to analog converters
5. classify and design semiconductor memories

EE 209	Circuit Theory	L	T	P	C
	B. Tech (Electrical Engg.) Fourth Semester (Core)	3	1	0	4

Unit-1:	**Revision of Networks Theorems** (for AC circuits): Maximum Power Transfer Theorem, Millman's Theorem, Reciprocity Theorem, Substitution Theorem, Compensation Theorem, Tellegen's Theorem.	(6)
Unit-2:	**Two Port Networks**: One port and two port networks, Sign convention, Admittance Parameters, Impedance Parameters, Hybrid Parameters, Inverse Hybrid Parameters, Serial and Parallel connection of two port networks. Driving point and transfer admittance and impedance. Symmetrical two ports and bisection, Image impedance. Conversion of impedances from star to delta and vice-versa using two port circuit analyses	(6)
Unit-3:	**Magnetically Coupled Circuit (MCC)**: Mutual Inductance, Coupling coefficient, Dot convention for MCC, Energy stored in MCC, Analysis of MCC, T-equivalent network of a transformer	(2)
Unit-4:	**Graph Theory**: Definition of node, branch, loop and mesh, Graph of a network, Tree, Co-tree, Incidence matrix, cut-set matrix, tie-set matrix and loop currents, Number of possible trees of a graph, Analysis of Networks, Network Equilibrium Equation, Duality.	(6)
Unit-5:	**Applications of Laplace Transform**: Familiarization with standard electrical signals, Waveform Synthesis, Theorems and properties of Laplace Transform- Initial and Final Value theorems, Circuit response to arbitrary inputs using Laplace Transform.	(4)
Unit-6:	**Frequency Response**: Concept of complex frequency, complexfrequency plane, pole and zero, plot of poles and zeros of simple RL, RC and RLC circuit connected in series and parallel, Polar plot. Concept of resonance – series and parallel resonance, Q-factor, half power frequencies, concept of transfer function of a network.	(4)
Unit-7:	**Fourier analysis**: Application of Trigonometric Fourier series, Fourier coefficients, Exponential Fourier Series, Waveform symmetry and Fourier transform used for finding response of electric circuits.	(5)
Unit-8:	**Filter Circuits**: Classification of filters, Ideal filter and T and π sectional representation of a filter circuit. Constant (k) type filters – low pass (LP), high pass (HP), band pass, band rejection and all pass filters – discussion and analyses. M-derived filters – Theory of LP and HP filters. Butterworth and Chebyshev filters (Basic theory only).	(5)

Text and Reference:

1. Hayt & Kemmerly. ***Engineering Circuit Analysis.*** Mc Graw Hill
2. Van Valkenburg. ***Network Analysis and Synthesis.*** Pearson 3rd Edition
3. Roy Choudhury. ***Network and Systems.*** New Age
4. Rajeswaran. ***Electric Circuit theory.*** Pearson
5. Wadhwa. ***Network Analysis and Synthesis.*** New Age
6. Soni & Gupta. ***A Course in Electrical Circuit Analysis.*** Dhanpat Rai & Sons.

Course Outcomes (Cos):

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

1. Apply the knowledge of network theorems and graph theory in finding circuit response.
2. Analyze the two port networks along with interconnections.
3. Apply Laplace and Fourier transforms to find electrical responses of circuits..
4. Demonstrate frequency response on AC circuits particularly under resonance..
5. Design different types of passive filter circuits. .

Microprocessors and Microcontrollers

		L	T	P	C
EE 210	**B. Tech (Electrical Engg.) Fourth Semester (Core)**	**3**	**0**	**0**	**3**

Unit-1:	**Introduction**: Evolution of microprocessor, Types of various architectures: Harvard and Von-Neumann, RISC and CISC processors.	(4)
Unit-2:	**Microprocessor architecture**: Arithmetic Logic Unit (ALU), Timing and control Unit, Registers, Data and Address bus, Interface unit, Intel 8085 instructions, Instruction word size: one byte, two byte and three byte instructions, Timing and control signals, Fetch operations, Execution operations, Machine cycle and state, Instruction and data flow, System timing diagram, Types of main memories, Memory map and addresses	(8)
Unit-3:	**Programming microprocessors**: Data representation, Instruction formats, Addressing modes, Instruction set, Assembly language programming, Program looping, Stacks and subroutine	(6)
Unit-4:	**Peripheral devices and their interfacing:** Interrupts, ADC/DAC, programmable peripheral interface (8255), programmable DMA controller (8237), Programmable timer (8254), Programmable keyboard/display interface (8279), Serial communication.	(7)
Unit-5:	**Important features of some advanced microprocessor**: Introduction to 8086/8088 Microprocessor: Pin assignments, architecture. Introduction to Pentium Pro microprocessor.	(7)
Unit-6:	**Microcontrollers**: Architecture, instruction set and assembly language programming of 8051 microcontroller, Registers, Timers and Counters.	(8)

Text and Reference:

1. John P. Hayes. ***Digital Systems and Microprocessors***. McGraw-Hill I.E.
2. R. S. Gaonker. ***Microprocessor Architecture, Programming and Application.*** Wiley Eastern
3. D. V. Hall, ***Microprocessor and Interfacing: Programming and Hardware.*** McGraw-Hill I.E
4. John P. Hayes. ***Digital Systems and Microprocessors.*** McGraw-Hill I.E.
5. Lyla B.Das. ***The x86 Microproccessors.*** Pearson Education, 2010

Course Outcomes (Cos):

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

1. understand the internal architecture of microprocessors and microcontroller.
2. demonstrate the programming skills using assembly language.
3. justify the concepts of stacks and interrupts.
4. understand peripheral devices and its interfacing.
5. apply the programming skills for various real time applications.

CS221	Programming and Data Structure	L	T	P	C
	B. Tech (Electrical Engg.) Fourth Semester	3	0	0	3

Unit-1: Introduction to Programming (10)

variables, assignments; expressions; input/output; conditionals and branching; iteration; functions; introduction to pointers

Linear Data Structures

Sequential representations - Arrays and Lists, Stacks, Queues and Dequeues, strings, Application. Linear Data Structures - Link Representation - Linear linked lists, circularly linked lists. Doubly linked lists, application.

Unit-2: Recursion

Design of recursive algorithms, Tail Recursion, When not to use recursion, Removal of recursion. (10)

Non-linear Data Structure

Trees - Binary Trees, Traversals and Threads, Binary Search Trees, Insertion and Deletion algorithms, Height-balanced and weight-balanced trees, B-trees, B+ -trees, Application of trees; Graphs - Representations, Breadth-first and Depth-first Search.

Hashing

Hashing Functions, collision Resolution Techniques.

Unit-3: Sorting and Searching Algorithms (10)

Bubble sort, Selection Sort, Insertion Sort, Quicksort, Merge Sort, Heapsort and Radix Sort.

File Structures

Sequential and Direct Access. Relative Files, Indexed Files - B+ tree as index. Multi-indexed Files, Inverted Files, Hashed Files.

Text and Reference:

1. Byron Gottfried. ***Schaum's Outline of Programming with C.*** McGraw-Hill
2. O.G.Kadke and U.A.Deshpandey. ***Data Structures and Algorithms.*** ISTE/EXCEL
3. Aho Alfred V., Hopperoft John E., UIlman Jeffrey D., ***Data Structures and Algorithms,*** PearsonEducation
4. Ajoy Agarwal, ***Data Structures***, C.Cybertech.
5. Lipschutz, ***Data Structures,*** TMH
6. Heileman, ***Data structures, Algorithims & OOP***, Tata McGraw Hill
7. M.Radhakrishnan and V.Srinivasan. ***Data Structures Using C.*** ISTE/EXCEL BOOKS
8. Weiss Mark Allen, Algorithms, ***Data Structures and Problem Solving with C++"***, Pearson Education.
9. Horowitz Ellis & Sartaj Sahni, ***Fundamentals of Data Structures***, Galgotria Pub.
10. Tanenbaum A. S., ***Data Structures using 'C'***, Pearson Education

Course Outcomes (Cos):

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

1. understand simple C Programs using pointers and Functions
2. apply C programming for Linear, Non-Linear and recursion data structure operations and its applications

3. analyze programs using various sorting algorithms
4. analyze programs using different searching methods
5. understand and apply File Manipulation and Hashing concepts

EE 214	Microprocessor and Microcontroller Laboratory	L	T	P	C
	B. Tech (Electrical Engg.) Fourth Semester (Core)	0	0	3	2

List of Experiments

Familiarization with 8085 register level architecture and trainer kit components including the memory map. Familiarization with process of storing and viewing the contents of memory as well as registers.

(a) Familiarization with 8085 simulators on PC

(b) Study of prewritten program using basic instruction set (data transfer, load/store, and arithmetic, logical).

(c) Assignment based on that.

Programming using kit/simulator.

1. Introduction to 8085 Microprocessor and Different IC's of Kit.

2.Write an Assembly Language Program for

a. Addition of two 8 bit numbers

b. Subtraction of two 8 bit numbers

3.Write an Assembly Language Program for

a. Multiplication of two 8 bit numbers

b. Division of two 8 bit numbers

4.Write an Assembly Language Program for

a. Sorting given 'n' numbers in Ascending order

b. Sorting given 'n' numbers in Descending order

5.Write an Assembly language for

a. To Convert Binary to BCD code

b. To convert BCD to Binary code

6. Write an Assembly language program to transfer a block of data placed in one memory location to another memory location in forward order.

7. Write an Assembly language program for searching a number in the given array and also find the occurrence of that data.

8. Write an Assembly language program to generate 15 Fibonacci number and sum of them.

9. Write an Assembly language program to find out Factorial of a F given 8-bit number.

10. Write an Assembly language program to obtain a rolling display of a particular data by using 8085 microprocessors.

Course Outcomes (Cos):

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

1. Identify relevant information to supplement to the Microprocessor and Microcontroller course.
2. Set up programming strategies and select proper mnemonics and run their program on the training boards.
3. Practice different types of programming keeping in mind technical issues and evaluate possible causes of discrepancy in practical experimental observations in comparison.

4. Develop testing and experimental procedures on Microprocessor and analyse their operation.
5. Prepare computational results, incorporating accepted data analysis and synthesis methods, simulation software

EE 215	Digital Electronics Laboratory	L	T	P	C
	B. Tech (Electrical Engg.) Fourth Semester (Core)	**0**	**0**	**3**	**2**

List of Experiments

1. Study of PIN diagram of ICs and to test the logic gates and verify their truth tables
2. Implementation of half adders, full adders using NAND gates only
3. Implementation of Boolean functions of three or four variables using 74153 (4:1) Multiplexer
4. Addition of two binary numbers using IC 7483
5. To compare two 4-bit binary numbers using magnitude comparator 7485
6. To Design and Verify the Encoder/Decoder circuit.
7. To study the different modes of operation of shift registers using 7495
8. Designing an asynchronous counter of any modulus using JK FF 7473
9. Design of a synchronous counter of any arbitrary count using IC 7473.
10. Design of a UP/DOWN counter.

Reference Books:

1. Malvino and Leech.***Digital Principles and Application.*** McGraw-Hill
2. M .M. Mano.***Digital logic and Computer Design. 3rd*** Edition, Prentice Hall

Course Outcomes (Cos):

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

1. understand the functionality of Digital ICs
2. Design combinational Logic circuits.
3. design FFs and Registers using Digital ICs
4. design Sequential Logic Circuits

EE 213	**Circuit Theory Laboratory**	**L**	**T**	**P**	**C**
	B. Tech (Electrical Engg.) Fourth Semester (Core)	**0**	**0**	**3**	**2**

List of Experiments

1. To Verify Reciprocity theorem in a given AC circuit.
2. To Verify Millman's theorem in a given AC circuit.
3. To verify Maximum Power Transfer theorem in a given AC circuit.
4. To measure the supply frequency using series resonant circuit.
5. To determine hybrid (h) parameters of an AC two port network.
6. To determine ABCD (T) parameters of an AC two port network.
7. To determine impedance (Z) parameters of an AC two port network.
8. To determine admittance (Y) parameters of an AC two port network.
9. To find the impedance and resonance phenomenon of series RL, RC and RLC circuits.
10. To find and theoretically validate the effect of induced voltage of an energized coil in presence of another energized coil with all possible combinations

Course Outcomes (Cos):

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

1. demonstrate the verification of network theorems on AC circuits.
2. compute frequency, impedance and voltage of various AC circuits and also in resonating RLC series and parallel circuits.
3. determine and identify different types of parameters of an AC two port network.
4. demonstrate the effect of magnetic coupling on an energized coil in proximity to another in order to affect its net induced voltage.

EE 301	Control Systems	L	T	P	C
	B. Tech (Electrical Engg.) Fifth Semester (Core)	**3**	**1**	**0**	**4**

Unit-1:	**Introduction:** Introduction of feedback control systems with motivational examples, Basic terminologies of feedback control systems	(1)
Unit-2:	**Modelling of physical systems:** Transfer function, poles and zeros, Examples: R-L, R-L-C circuits, Spring-mass-damper system, armature-controlled and field-controlled DC motor. Block diagram reduction techniques, Signal flow graphs, Mason's Gain formula.	(8)
Unit-3:	**Time domain analysis:** Time domain response of First and Second order system, Time domain specifications, Static and Dynamic error coefficients, Sensitivity analysis. Concept of stability, Stability using Routh array, relative stability.	(7)
Unit-4:	**Root locus analysis:** Definition, Rules to sketch root loci, Stability and transient performance using root locus.	(6)
Unit-5:	**Frequency domain analysis:** Basic input-output relation, Bode plots, Polar plots, Nyquist plots, Nyquist stability criteria, frequency domain specifications and relative stability, Nichols plot. Co-relation between time and frequency domain specifications.	(10)
Unit-6:	**Compensators and controllers:** Lead, lag and lag–lead compensators, introductory examples for each type of compensator design using root locus and bode plot	(8)

Text and Reference:

1. Katsuhiko Ogata, ***Modern Control Engineering***, Pearson Education
2. J. Nagrath and M. Gopal, ***Control Systems Engineering***, New Age international
3. Dorf and Bishop, ***Modern Control Systems***, Addison Wesley
4. D' Azzo and Houpis, ***Linear Control Systems Analysis and Design,*** McGrow Hill
5. N S Nise, ***Control Systems Engineering***, Wiley
6. M. Gopal, ***Control Systems Principles and Design,*** Tata McGrow Hill

Course Outcomes (Cos):

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

1. apply the physical laws or reduction technique from a complex control block diagram to find the transfer function of a system and analyze the system in terms of basic terminologies.
2. analyze and evaluate the transient and steady-state characteristics of a standard 2nd order LTI systems
3. apply the basic rules to sketch the root locus and analyze the characteristics of closed loop feedback systems.
4. apply the basic rules to sketch the frequency response in terms of Bode, Nyquist, Polar plots; analyze the characteristics of the closed loop feedback system and Correlate it with time domain behavior of the system.
5. design and evaluate the basic compensators using root locus and bode plot reshaping technique

EE 302	Power Systems II B. Tech (Electrical Engg.) Fifth Semester (Core)	L	T	P	C
		3	1	0	4

Unit-1: **Performance of overhead transmission lines:** Introduction; classification of transmission lines; performance calculation of short and medium transmission lines, Nominal T and nominal π methods; Performance Long transmission lines; Power circle diagrams (PCD). (8)

Unit-2: **Power system stability:** Introduction to synchronous machine, rotor angle, Infinite bus; Definition of stability, classification of stability, power limit of transmission lines, steady state stability, transient stability, the swing equations, equal area criterion, calculation of critical clearing angles, Calculation of power angle curves for fault and post fault conditions for various types of faults, dynamic stability, factors effecting stability (8)

Unit-3: **Control of active and reactive power:** Active power and frequency control: fundamental speed governing system, Governor speed regulation parameter, , Fundamentals of automatic generation control, Frequency bias, Primary and secondary control, Basic simulation models of automatic generation control; Reactive power and voltage control: Production of absorber of reactive power, methods of voltage control; shunt reactors, series reactors, synchronous condensers, static VAR system, tap changing transformers. (8)

Unit-4: **Transients in power systems:** Lightning phenomenon, Switching surges, travelling waves, shape and specifications of travelling waves, attenuation and distortions of travelling waves, alteration due to corona, behaviour of travelling waves at open, short and joints of overhead lines and cables, construction of lattice diagrams. (4)

Unit-5: **Load flow studies:** Introduction to load flow study, Y_{BUS} , formulation of load flow problems, methods. (4)

Unit-6: **Economic operation of steam 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. (8)

Text and Reference:

1. C.L. Wadhwa, ***Electrical Power systems***, Wiley Eastern
2. Ashfaq Hussain, ***Electrical Power System***, CBS Publishers
3. B.R.Gupta, ***Generation of Electrical Energy,*** S. Chand
4. Soni, Gupta, Bhatnagar, ***Electric Power***, Dhanpat Rai & Sons
5. J.B.Gupta, ***A course in Power Systems,*** S.K.KATIA & SONS
6. P.Kundur, ***Power system stability and control***, McGraw-Hill
7. O.I.Elgerd, ***Electric Energy System Theory***, Tata Mcgraw Hilll

Course Outcomes (Cos):

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

1. define various performance indices of a power system network and describe the importance of each.
2. impart the knowledge to design transmission lines and analyse the power control methodologies in electrical networks.
3. summarize the transient phenomena, load flow studies and stability issues in power system networks.
4. explain the economic operation of thermal and hydro power plants.

EE 303 Electrical Machines II

B. Tech (Electrical Engg.) Fifth Semester (Core)

L	T	P	C
3	1	0	4

Unit-1:	**Synchronous Machines** - Types and constructional features, EMF equation, Basic synchronous machine model, Concept of synchronous reactance and its determination, Open circuit and short circuit characteristics, Short circuit ratio, Operating characteristics, Phasor diagrams under various operating conditions, Voltage regulation, Nature of armature reaction, Synchronizing to infinite bus, Effect of excitation variations when connected to bus, Power flow equations, Capability curve and Parallel operation.	(12)
Unit-2:	Introduction to two-reaction theory of salient pole type machine, concept of direct and quadrature axis reactances, Phasor diagram under various operating conditions both for motoring and generating mode, Slip test, Voltage regulation, Damper winding, Synchronizing power, Determination of sequence impedance, Swing equation under dynamic condition, Equal area criteria, Power-angle diagram & stability, Steady state and transient stability limits, V-curve, Hunting, Methods of starting of synchronous motor and Application of synchronous motor as phase modifier	(10)
Unit-3:	AC Motor control by static power converters, Introduction to solid state devices and converters, methods of speed control of synchronous motors, slip power recovery schemes, phase control of AC motor.	(4)
Unit-4:	Single phase motors: Series, repulsion & universal motors - construction, principle of operation starting methods, speed control, power factor, commutation, methods of compensation, Comparison of D.C. & A.C. series motors, Stepper Motor: Constructional features, Torque-stepping rate characteristic, Application area.	(8)
Unit-5:	Single phase induction motor: Double revolving filed theory and development of equivalent circuit and expression for torque, Torque-slip characteristic, Expression for starting torque in presence of auxiliary winding and Estimation of starting capacitance for auxiliary coil using concept of phase splitting	(6)

Text and Reference:

1. P.S. Bimbhra. ***Generalized Theory of Electrical Machines.*** Khanna Publishers
2. Nagrath & Kothari. ***Electrical Machines.*** TMH Publishing Co.
3. A.S. Langsdorf. ***Theory of A.C. Machines.*** TMH Publishing Co.
4. Ashfaq Husain. ***Electric Machines.*** Dhanpat Rai and Co.(Pvt.) Ltd.
5. P.K. Mukherjee and S. Chakravorti. ***Electrical Machines.*** Dhanpat Rai publication
6. Dr.S. K. Sen. ***Electrical Machines.*** Khanna Publishers
7. Taylor. ***Commutator Machines.*** East West Press.

Course Outcomes (Cos):

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

1. illustrate the constructional features and applications of synchronous machines and single-phase machines.

2. analyze the principle of operation of synchronous machines and single-phase machines.
3. develop the equivalent circuit model and analyse the performance of synchronous machines and single-phase machines.
4. devise the speed control of AC motors using solid state converters

EE 304	Power Electronics	L	T	P	C
	B. Tech (Electrical Engg.) Fifth Semester (Core)	**3**	**1**	**0**	**4**

Unit-1:	**Introduction and devices:** Concept of Power Electronics, brief introduction of different types of power electronics devices, converter systems, areas of application, device construction and characteristics of power diode, power BJT, power MOSFET, power IGBT, SCR, two transistor analogy of thyristor, thyristor dv/dt and di/dt protection, series and parallel operation of thyristor, GTO, basics of firing circuit	(10)
Unit-2:	**Phase controlled rectifiers:** Principles of operation of phase-controlled rectifiers (single/three phase) and its applications, performance parameters, evaluation of single-phase half controlled/fully-controlled converter with R, RL, and RLE load, operation of three-phase fully-controlled converter with different types of loads, effect of source impedance, dual converters (single/three phase).	(10)
Unit-3:	**Choppers:** Principle of chopper operation, chopper classifications and quadrant operations and its applications, steady state time domain analysis of class A chopper, voltage commutated chopper.	(8)
Unit-4:	**Inverters:** Introduction of inverter operation, classification of inverters and its applications, performance parameters, analyze the performance of single phase half bridge and full-bridge voltage source inverters with R, RL and RLE load, three-phase voltage source inverters-180 degree and 120 degrees mode of operation, voltage control of single phase inverters-single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation.	(8)
Unit-5:	**AC Voltage Controller:** Types of AC voltage controllers, evaluation of single-phase voltage controllers for R and R-L load, Cycloconverters**:** Principles of cycloconverter operation (step up and step down).	(4)

Text and Reference:

1. P C Sen. ***Power Electronics.*** TMH
2. Dubey. ***Power Electronics.*** TMH
3. Rashid Mohammed. ***Power Electronics.*** PHI
4. V. Subrahmanyam. ***Power Electronics & Drives.*** New Age
5. P.S.Bhimbhra. ***Power Electronics.*** Khanna Publishers
6. M D Singh et. Al. ***Power Electronics***. McGraw Hill

Course Outcomes (Cos):

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

1. select power switching devices for suitable power conversion
2. analyze the performance of different types of phase-controlled rectifiers
3. examine DC-DC converter for a given performance and application
4. analyze the operation of Inverters, ac voltage controllers and cycloconverters

EE 305	Digital Signal Processing	L	T	P	C
	B. Tech (Electrical Engg.) Fifth Semester (Core)	3	0	0	3

Unit-1: **Discrete-Time Signals & Systems:** Advantages of digital over analog signal processing, discrete-time signals and sequences, representation of sequences and elementary operations, classification of discrete-time systems. Resolution of discrete-time signals into impulses, analysis of discrete-time LTI systems. Response to arbitrary inputs, the convolution sum, properties of LTI systems and their interconnections, causality, stability. Linear constant coefficient difference equation and their solutions. Impulse response of LTI system, response to complex exponential and sinusoidal signals, the frequency response function (10)

Unit-2: **Sampling:** Sampling of continuous time signals, periodic sampling, frequency-domain representation of sampling. **Transforms:** Representation of sequences by Fourier transforms-symmetry properties and theorems. The Z-transform, two-sided and one-sided z-transforms, ROC, properties of z-transform, Inverse z-transform, Analysis of LTI system in the Z-domain. **Analysis of LTI System:** System functions-linear constant coefficient difference equations, poles and zeros, rational system function, causality and stability, frequency response of LTI systems, phase distortion and delay, frequency response for rational system functions and for single pole or zero systems. (10)

Unit-3: **Discrete Fourier Transforms:** Frequency domain sampling, the DFT and properties of DFT, circular convolution, linear convolution using DFT, Application of DFT for A.C. transient analysis (8)

Efficient Computation of DFT: Computational complexity, FFT algorithms- the decimation-in-time and decimation-in-frequency; signal flow graph-Butterfly computations, in-place computations, analysis of computational complexities.

Unit-4: **Structures for Discrete-time Systems:** Block diagram representation of linear constant coefficient difference equations and their interconnections. Direct form I, direct form II, cascade form and parallel form structures, Finite precision word-length effect-number representation, analysis of effect of coefficient quantization and rounding off of noise, zero input limit cycles in fixed point realization of IIR digital filters. (4)

Unit-5: **Filter Design Techniques:** Characteristics of practical frequency selective filters, design of FIR filters by windowing technique. Characteristics of Butterworth & Chebyshev filters, design of IIR filters from continuous time filters- impulse invariance and bilinear transformation methods. Multi-rate signal processing and introduction to Wavelets. VLSI implementation of digital filters and signal processing algorithms, implementation of signal processing algorithms in general purpose processor, specialized DSP processors. Applications of Signal Processing: Spectral analysis using DFT, (8) musical sound and audio processing, application of signal processing in power system, fault detection and improving power quality. Implementing filters and other DSP algorithms using MATLAB programming and Simulink.

Text and Reference:

1. Oppenhein and Schaffer. ***Discrete-time Signal Processing.*** PH
2. Proakis&Manolakis. ***Digital Signal Processing.*** PHI
3. T. K. Rawat. ***Digital Signal Processing.*** Oxford
4. Sanjit K. Mitra. ***Digital Signal Processing.*** TMH
5. Chen C.T.***Digital Signal Processing: Spectral Computation& Filter Design***. Oxford Univ. Press
6. V. K. Ingle & John J. Proakis. ***Digital Signal Processing using MATLAB.*** CENGAGE Learning

Course Outcomes (Cos):

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

1. calculate the spectral coefficients and the Fourier series components of discrete-time signals.
2. determine and analyze the frequency response and the z-transform of discrete-time systems.
3. design Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) Filters and evaluate the performance to meet expected system specifications.
4. implement digital filters and DSP algorithms.

EE 311	**Electrical Machine Laboratory-I**	**L**	**T**	**P**	**C**
	B. Tech (Electrical Engg.) Fifth Semester	**0**	**0**	**3**	**2**

List of Experiments

1. Open circuit and short circuit tests on a single-phase transformer.
2. Direct loading test on single-phase transformer.
3. Back to back test or Sumpner's test on a single-phase transformer.
4. Load test and parallel operation of single-phase transformer.
5. Ratio and polarity test of a single-phase transformer
6. Load characteristics of a DC shunt generator.
7. Open circuit characteristics of DC shunt generator.
8. Load characteristics of D.C compound generator.
9. Speed control of DC shunt motor.
10. Swinburne's test of a DC motor.
11. Hopkinson's test on DC motor-generator set.

Course Outcomes (Cos):

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

1. apply and analyze different tests on DC generators.
2. utilize and analyze DC shunt and compound motor.
3. apply and analyze different tests on single-phase Transformer.

EE 312	**Power System Laboratory -I**	**L**	**T**	**P**	**C**
	B. Tech (Electrical Engg.) Fifth Semester	**0**	**0**	**3**	**2**

List of Experiments

1. Determination of ABCD constants of power transmission lines using SCADA based hardware Power TLS Simulator
2. Study of Ferranti Effect, voltage regulation using SCADA based Power TLS Simulator.
3. Solution of various linear/nonlinear equations associated with power system studies using MATLAB.
4. Solution of Economic Load Dispatch of thermal plants using MATLAB software.
5. Study of voltage regulation, efficiency of transmission systems using MI-Power Software.
6. Simulation of transmission line using Simulink.

Course Outcomes (Cos):

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

1. determine various performance indices of power transmission systems using modern hardware and software tools.
2. solve various linear and nonlinear equations using Matlab software.
3. apply Matlab software to conduct experiments on economic operation of thermal plants.

EE 313	Control System Laboratory	L	T	P	C
	B. Tech (Electrical Engg.) Fifth Semester	0	0	3	2

List of Experiments

Module 1: HARDWARE BASED EXPERIMENTS

Experiment 1: Obtain the graph between output errors and angular position difference of a given potentiometer error detector: (i) when the excitation is DC and (ii) when the excitation is AC.
Experiment 2: Experiment to determine the time response of different order of systems
Experiment 3: Obtain the frequency response characteristics of the first and second order active low pass filter.
Experiment 4: To draw the frequency response of a given R-L C network theoretically and to capture the time response for a given square wave input at 50Hz (power supply).

Module 2: SIMULATION BASED EXPERIMENTS (Using MATLAB/SIMULINK)

Experiment 5: Familiarization with MATLAB/SIMULINK software, control systems toolbox (Commands and GUI of SISO toolbox), representation of linear time-invariant systems, plotting commands.
Experiment 6: To determine the time-domain response of first and second -order systems.
Experiment 7: To determine the frequency-domain response of first and second -order systems.
Experiment 8: To study the effect of P, PI, PD and PID controller on step response of a feedback control system.
Experiment 9: Stability analysis of the systems using root locus for the unity feedback system
Experiment 10: Stability analysis of the system using Bode plot and determine GM and PM for the given open loop transfer function and comment on stability.
Experiment 11: Design of lag, lead compensator using root locus technique.
Experiment 12: Design of a lag, lead compensator using frequency domain analysis
Experiment 13: To make a project model using SIMULINK/MATLAB for a physical system
Module 3: Self-Learning Experiments:
Experiment SL1: Design of lag-lead compensator using root locus technique.
Experiment SL2: Design of lag-lead compensator using Bode-plot locus technique.
Experiment SL3: Design of PID controller family using SISO control toolbox of MATLAB

Text and Reference:

1. Katsuhiko Ogata. ***Modern Control Engineering*.** Pearson Education
2. M. Gopal. ***Control Systems Principles and Design*.** Tata Mc Grow Hill
3. I. J. Nagrath and M. Gopal. ***Control Systems Engineering.*** New Age international

Course Outcomes (Cos):

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

1. investigate fundamentals concepts of linear control systems.
2. apply the various appropriate software commands and hardware components to carry out the experiments.
3. implementation of the designed experiments and evaluate appropriate conclusions.
4. create technical report of the conducted experiments

EE 314	Signal Processing Laboratory	L	T	P	C
	B. Tech (Electrical Engg.) Fifth Semester	0	0	3	2

List of Experiments

1. Generation of basic signals (discrete time) using MATLAB
(a) Unit impulse, (b) Unit step, (c) Unit ramp, (d) Exponential and (e) sinusoidal or cosinusoidal
2. Verification of sampling theorem.
3. To study the linear convolution of two sequences (using conv command, DFT, IDFT and circular convolution).
4. To study the computation of N point DFT of a given sequence using DIT/ DIF FFT algorithm and to plot magnitude and phase spectrum.
5. (A) Design and implementation of IIR Butterworth filter to meet the given specifications.
5. (B) Design of IIR filter using Chebyshev filter.
6. Design and implementation of FIR filter in MATLAB/DSP trainer kit using windowing technique.
7. Study of different biomedical signals and associated instruments.
8. Basic digital image processing applications- contrast enhancement, colour to gray conversion, resizing, edge detection in MATLAB/ image processing platform

Text and Reference:

V. K. Ingle & John J. Proakis. ***Digital Signal Processing using MATLAB.*** CENGAGE Learning
Sanjit K. Mitra. ***Digital Signal Processing***. TMH
Oppenhein and Schaffer. ***Discrete-time Signal Processing***. PHI
Proakis&Manolakis. ***Digital Signal Processing.*** PHI
T. K. Rawat. ***Digital Signal Processing.*** Oxford
Chen C.T.. ***Digital Signal Processing: Spectral Computation & Filter Design***. Oxford Univ. Press
Gonzalez and Woods. ***Digital Image Processing***. Prentice Hall
A. K. Jain. ***Fundamentals of Digital Image Processing.*** Prentice Hall India Learning Private Limited

Course Outcomes (Cos):

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

1. compute the spectral coefficients and the Fourier series components of discrete-time signals.
2. compute and analyze the frequency response of discrete-time systems.
3. automate the design of Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) Filters and evaluate the performance to meet expected system specifications.
4. implement digital filters, DSP and DIP algorithms.

EE 306	**Switchgear and Industrial Protection**	**L**	**T**	**P**	**C**
	B. Tech (Electrical Engg.) Sixth Semester (Core)	**3**	**1**	**0**	**4**

Unit-1:	**Symmetrical Fault Analysis:** Causes of faults, types of faults, importance of fault analysis in electrical power systems, fault analysis for generators, transmission lines, concepts of generator reactance's; transient, sub-transients etc., current limiting reactors, types, functions	(6)
Unit-2:	**Symmetrical components and Unsymmetrical Fault Analysis:** Concepts of symmetrical components, Fortescue's theorem, power in terms of symmetrical components, sequence impedances and sequence networks for generators, transformers, transmission lines etc., unsymmetrical fault (L-G, L-L, LL-G) analysis.	(6)
Unit-3:	**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.	(4)
Unit-4:	**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.	(5)
Unit-5:	**Protective 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.	(14)
Unit-6:	**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	(3)
Unit-7:	**Lightning Arrester:** Function, types, working principles and surge absorbers.	(2)

Text and Reference:

1. C. L. Wadhwa. ***Electric Power systems***. New Age International
2. William D. Stevenson Jr**. *Elements of Power System Analysis***. John Wiley & Sons
3. D P Kothari, I J Nagrath. ***Modern Power System Analysis***. TMH Publishing Co.
4. J B Gupta. ***Switchgear and Protection.*** S.K. Kataria & Sons
5. B. Rabindranath and M. Chander**. *Power System Protection and Switchgear***. Wiley Publisher
6. Ashfaq Hussain. ***Power Systems.*** CBS Publishers

Course Outcomes (Cos):

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

1. classify various types of faults, and switchgear components
2. analyze faults in power system.
3. to understand the functions of switchgear protecting devices and instruments.
4. demonstrate various protection schemes used for power apparatuses.
5. compare, and design grounding schemes

EE 307	Industrial Drives	L	T	P	C
	B. Tech (Electrical Engg.) Sixth Semester (Core)	**3**	**1**	**0**	**4**

Unit-1:	**Introduction and drive dynamics**: Concept of Electrical Drive, Advantages over other drives, Different parts, Classification, choice of Electrical Drives. Dynamics of Electrical Drives:Fundamental torque equation, Speed Torque conventions and multi-quadrant operation, Nature and classification of load torques, Dynamics of motor-load combination and equivalent drive system, steady state stability & transient stability of electric drive, Starting, Electric braking of dc motors and induction motors.DC machine and Induction machine transient analysis.	(15)
Unit-2:	**Selection of motor power Rating**: Thermal model of motor for heating and cooling, loading conditions and classes of motor duty, determination of power rating of electric motors for different applications, effect of load inertia, load equalization.	(5)
Unit-3:	**Fundamental concept of drivecontrol**: Modes of operation, speed control and drive classifications, closed-loop control of drives: current-limit control, torque control, speed control, speed control of multi-motor drives, Speed sensing, current sensing, phase-locked-loop (PLL) control, closed-loop position control. Industrial applications: Drives for steel mills, rotary printing machine and electric traction.	(5)
Unit-4:	**Converter fed dc drive:** Speed control (closed/open loop) of dc separately excited motor using: (a) single-phase and three-phase controlled rectifiers (b) dual-converter and (c) chopper.	(8)
Unit-5:	**Converter fed AC drive:** Control(closed/open loop) of Induction Motor (IM) Drives: variable voltage control, control of IM variable frequency operation based on VSI and CSI, Speed control of wound rotor induction Motor: (a) static rotor resistance control (b) static scherbius drive (c) static kramer drive.	(7)

Text and Reference:

1. S.K. Pillai. ***A first course on Electrical Drives.*** Willey Eastern Ltd.
2. G.K. Dubey. ***Fundamentals of Electrical Drives.*** Narosa
3. V. Subrahmanyam. ***Electric Drives.*** New Age
4. B.K. Bose. ***Modern Power Electronics and AC drives.*** Pearson publications
5. R. Krishnan. ***Electric motor drives Modeling, Analysis and Control*** . Pearson Publications

Course Outcomes (Cos):

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

1. demonstrate various parts of electrical motor drives and their dynamics.
2. choose suitable ratings of electrical motor drive and their generalized control.
3. analyze the dynamics of AC and DC electrical motor drives.
4. evaluate suitable power electronic converters and their control aspects with respect to available source and load.

EC 327	Analog and Digital Communication B. Tech (Electrical Engg.) Sixth Semester	L	T	P	C
		3	0	0	3

Unit-1: The history of evolution of Electrical Communication, Concept of information, messages and signals, knowledge of Signals and Information representation, elements of a communication system, Communication channels, Base band and pass band signals, Fundamental limitations, Fourier transform, Properties of the Fourier transform, Parseval's theorem, Rayleig's energy theorem, Dirac-Delta function, Fourier transform of Periodic linear systems. Representation of energy and power signals and their spectral density; External noise, internal noise, Noise calculations, signal to noise ratio. (10)

Unit-2: Amplitude modulation and spectra, DSB Signals and spectra, Tone modulation and phasor analysis, Switching modulator, Envelope detector, Ring modulator and balanced modulator, Single side band modulation, Phase Shift method for generation of SSB, Phase and frequency modulation, Narrowband F.M, Wideband F.M, Transmission B.W. of F.M. signal, Generation of F.M. signal. Indirect F.M. & Direct F.M, Demodulation of F.M. signal using balanced frequency discrimination. AM transmitters and receivers, super heterodyne receiver, IF amplifiers, AGC circuits. (12)

Unit-3: Concept of random variables, Probability density function and probability distribution function of random variable, Mean & Mean square value of a R.V, Concept of Stochastic Process, Ensemble averages and correlation function, Stationary and Ergodic Process, Signal Power, Time average and Power spectral density, Shot noise, Thermal noise and White noise. (6)

Unit-4: Sampling Process, Sampling Theorem (only statement), Analogy Pulse modulation : PAM, PPM and PDM, Time Division Multiplexing, Quantization Process (only uniform quantization), Quantization noise, Pulse code modulation, Delta modulation, Differential Pulse Code modulation, Base band Pulse Transmission concept., Method filter, Pass band transmission model, Gram Schmidt Orthogonalization principle, Geometrical interpretation of signal, Digital modulation techniques, Coherent binary PSK, Coherent binary FSK, Coherent quadriphase shift keying. Introduction to information theory**.** (12)

Text and Reference:

1. Simon Haykin .***Communication Systems***. PHI
2. B. P. Lathi. ***Modern Digital and Analog Communications.*** Oxford Univ. Press
3. John Proakis .***Digital Communications.*** McGraw Hill
4. Taub and Schilling. ***Principles of Communication Systems.*** McGraw Hill I.E.
5. Wayne Tomasi . ***Electronic Communications System: Fundamentals Through Advanced, 5/e*** . Pearson Education

Course Outcomes (Cos):

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

1. demonstrate the different techniques of communication system, its elements, facts to be considered in choosing a communication system, frequency analysis, different communication channels, their merits and limits.
2. evaluate different modulation techniques in analog as well as in digital communication, their operation, merits and demerits.
3. implement sampling theorem, different techniques, merits and demerits to solve engineering problems

EE 308	Modern Control Systems	L	T	P	C
	B. Tech (Electrical Engg.) Sixth Semester (Core)	**3**	**1**	**0**	**4**

Unit-1:	Introduction: System modeling in state-space form, analysis and control.	(2)
Unit-2:	Linear transformations and matrices: Eigenvalues, eigenvectors and generalized eigenvectors; Canonical form, diagonal form, and Jordan form matrix representations.	(4)
Unit-3:	State variable descriptions: Concept of state, state equations for dynamic systems, nonuniqueness of state model, state diagrams.	(5)
Unit-4:	State variable and input-output descriptions: Transfer function matrix, state models from input-output maps, phase variable caonical form, Jordan canonical form.	(5)
Unit-5:	Solution of state equations: The homogeneous solution, evaluation of state transition matrix, the nonhomogeneous solution; Evaluation of matrix exponential using series evaluation, Similarity transformation, Cayley-Hamilton theorem, inverse Laplace transform method.	(6)
Unit-6:	Controllability and observability: General concept, controllability and observability tests, the principle of duality, controllability and observability of state model in Jordan canonical form; Controllable and observable companion forms; Stabilizability and detectability.	(6)
Unit-7:	Stability: Concepts and definition, stability in the sense of Lyapunov, Lyapunov equation.	(4)
Unit-8:	Pole placement by state feedback; full-order observers, reduced-order observers; observer-based state feedback controller design, separation principle	(8)

Text and Reference:

1. M. Gopal. ***Modern Control System Theory***. New Age International (P) Limited, 1993
2. Katsuhiko Ogata. ***Modern Control Engineering***. Prentice-Hall, 2010
3. Thomas Kailath. ***Linear System.*** Pearson, 2016
4. Chi-Tsong Chen. ***Linear System Theory and Design***. Oxford University Press, New York, 1999

Course Outcomes (Cos):

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

1. apply different laws or procedures to derive a state-space representation, respectively, of a physical system or its models; Analyze different characteristics of the system.
2. apply different matrix transformations to find various state-space representations of the same system. Evaluate the representations to judge that they all denote the same system.
3. apply different approaches to find the solution of a state-space model. Analyze the characteristics of the system from its solution. Compare the finding with the stability in the sense of Lyapunov.
4. apply various techniques to test controllability and observability and analyze the outcome.
5. design a state-feedback controller and an observer-based state-feedback controller to meet the given desired specifications, and evaluate the results

EE 315	Electrical Machine Laboratory II	L	T	P	C
	B. Tech (Electrical Engg.) Sixth Semester	0	0	3	2

List of Experiments

1. Speed Control of DC Series Motor.
2. No load and Blocked rotor test on a Single-Phase Induction Motor.
3. Open and Short Circuit Characteristics on a Three Phase Alternator.
4. Determination of Xd and Xq of a Three Phase Alternator.
5. V-curve of a Synchronous Motor.
6. Three phase to Six Phase Conversion.
7. Load Characteristics of DC Series Motor.
8. No load and Blocked rotor test on a Three Phase Induction Motor.
9. Scott Connection.
10. Load test on a Three Phase Squirrel Cage Induction Motor.
11. Synchronization of Three Phase Alternator with Infinite Bus Bar.

Text and Reference:

1. Nagrath & Kothari. ***Electrical Machines.*** Tata Mc Graw Hill
2. Dr. S.K. Sen. ***Electrical Machines.*** Khanna Publishers
3. P.S. Bimbhra. ***Electrical Machines.*** Khanna Publishers
4. A.S. Langsdorf**.** ***Theory of A.C. Machines*****.** Mc Graw Hill

Course Outcomes (Cos):

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

1. Illustrate the operation of DC Series, Synchronous and Induction machines.
2. Perform different tests and assess the performance of DC Series, Synchronous and Poly phase induction motors.
3. Illustrate how to obtain two phase and six phase supplies from a balanced three phase supply using transformers.
4. Demonstrate synchronization of alternator to infinite bus-bar.

EE 316	Power System Laboratory II	L	T	P	C
	B. Tech (Electrical Engg.) Sixth Semester	**0**	**0**	**3**	**2**

List of Experiments

1. Study of power system Transient Stability using software tools.
2. Study of Fault analysis using SCADA based Power TLS Simulator and MI-Power Software.
3. Study and demonstration of Transformer Buchholz Relay.
4. Study the characteristics of Over current relay, Reverse power relay, Earth fault relay, differential relay and Distance relay using actual numerical relay setup.
5. Study of Load Flow analysis using MI-Power or ETAP Software.
6. Simulation of Load frequency control model and Automatic voltage control model in Matlab and/or MI power software.
7. Power quality analysis of a 3-phase power circuit using power quality analyser

Text and Reference:

1. C.L. Wadhwa. ***Electrical Power systems***. Wiley Eastern
2. B. S. Grewal. ***Higher Engineering Mathematics***. Khanna Publishers
3. M.A. Pai. ***Computer Techniques in Power System Analysis.*** Tata McGraw-Hill Edition
4. Different Manual Book on Relay setup, Power TLS, ETAP and MI-Power

Course Outcomes (Cos):

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

1. solve and analyze various faults in power systems using modern hardware tools.
2. apply modern tools to solve transient stability and load flow study for a given power system network.
3. determine the operating characteristics of various numerical relays and will be able to adjust the settings of such relays as per requirement.

EE 317	Power Electronics and Drives Laboratory	L	T	P	C
	B. Tech (Electrical Engg.) Sixth Semester	0	0	3	2

List of Experiments

1. To study the operation of single-phase full wave-controlled rectifier using
   a. Mid-point configuration (with R and RL load)
   b. Bridge configuration (with R and RL load)
2. To study the operation of single-phase half-controlled converter (semi- converter) with RL Load
3. To study the operational features of Resistance gate Triggering circuit and Resistance-Capacitance gate Triggering circuit for thyristor
4. Study the operational features of class-A voltage commutated DC chopper with different loads.
5. To study the operation of Single-Phase AC voltage controller (anti-parallel SCR's) with R and RL-Load
6. To study the operation of single-phase to Single-Phase step-down Cyclo-Converter (Mid-point configuration) with R-Load
7. To study the operation of three phase fully controlled bridge rectifier with R load
8. To study the single-phase inverter firing circuits and hence to study the operation of single-phase full bridge inverter circuit
9. To study the three phase inverter firing circuits (180-degree mode of operation) and hence to study operation of three phase IGBT based inverter circuit
10. Speed control of permanent magnet DC motor drive fed from single phase thyristor bridge fully controlled converter using armature voltage control method
    a. Analog mode
    b. Digital PID Mode
11. Closed loop speed control of separately excited DC motor drive fed from single phase thyristor bridge fully controlled converters using armature voltage and field control methods
    a. Analog mode
    b. Digital PID Mode
12. Closed loop speed control of separately excited DC shunt motor drive fed from three phase thyristor bridge fully controlled converter using armature voltage control method
    a. Analog mode
    b. Digital mode
13. Speed control of three phase slip-ring induction motor drive using slip power recovery scheme
14. Speed control of three phase induction motor (V/F Control) using TI DSP kit

Course Outcomes (Cos):

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

1. demonstrate different characteristics of devices and their firing circuits.
2. examine different controlled rectifier, chopper and inverter circuits.
3. perform speed control of converter fed DC motors.
4. Performs peed control of converter fed AC motors.

EE 401 Instrumentation

	L	T	P	C
B. Tech (Electrical Engg.) Seventh Semester (Core)	**3**	**1**	**0**	**4**

Prerequisite: Control Systems (EE 301)

Unit-1: **Introduction:** Generalized performance & functional description of an Instrumentation system, Role of Transducers, Amplifiers, Filters, Display devices etc. Review of idea on DAC/ADC, filters & signal conditioners, OP-AMPS, Instrumentation amplifiers & its circuits (8)

Unit-2: **Analytical Instrumentation:** Measurement of pressure, Measurement of flow (EM flow meter), Measurement of temperature, Measurement of liquid level etc. (6)

Unit-3: **Transducers & Sensors:** Introduction, definition, classification & selection of transducers/ sensors; Resistive, capacitive, inductive (LVDT), piezoelectric transducers & their applications; Thermistors: measurement of temperature; Magnetostrictive, Hall Effect, electromagnetic transducers; photoelectric transducers. (6)

Unit-4: **Nondestructive Testing Equipments:** Introduction, Magnetic particles, Dye penetrants, X rays, Gamma rays; Eddy current testing; Ultrasonic - principle of working. Pulse echo method of flaw detection. (4)

Unit-5: **Data Transmission & Telemetry:** Definition, classification, basic telemetering system. (6)

a) Voltage, current & frequency telemetering systems.
b) Multiplexing & modulation in telemetry
c) PLCC
d) Transmitters-techniques & inter stage coupling. Receivers-techniques.

Unit-6: **Fiber optical instrumentation:** (6)

a) Introduction, principle of working
b) Optical fiber cable, Dispersion & losses
c) Connectors& splices, sources & detectors.
d) Transmitters & receiver circuits.
e) Applications

Unit-7: **Related topics** (6)

(a) Digital data acquisition systems
(b) Smart sensors – Introduction, Principle of working, information coding, data communication &
automation.
(c) Intelligent Instrumentation- definition, practical examples.
(d) Remote control: Introduction, general descriptions, typical scheme of an industrial remote
control system.
(e) Internet based tele-metering.

Text and Reference:

1. D. Patranabis. ***Principles of Industrial Instrumentation***. Tata McGraw Hill
2. D. Patranabis. ***Sensors & Transducers.*** PHI
3. Rangan, Sharma & Mani. ***Instrumentation Devices & system***. Oxford
4. D.V.S Murthy. ***Transducers & Instrumentation.*** PHI

5. Alok Barua. ***Fundamentals of Industrial Instrumentation.*** Wiley India

Course Outcomes (Cos):

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

1. students should be able to analyze the working of different analytical instruments.
2. students should be able to apply different design aspects of signal conditioning systems.
3. students should be able to investigate data transmission systems and their applications

EE 331	Digital Control Systems	L	T	P	C
	B. Tech (Electrical Engg.) Sixth Semester (Professional Core Elective-I)	3	0	0	3

Pre-requisites: Control Systems (EE 301)

Unit-1: **Mathematical Preliminaries:** Review of characteristics of a discrete time (DT) system, Revisiting Z-transform Sampling, ZOH, Folding and Aliasing, Signal reconstruction from its samples, modified z-transform (5) (4)

Unit-2: **Frequency domain Analysis & Design:** Modelling DT Systems by Pulse Transfer Function, Block diagram representation, Reduction of block diagram keeping the sampler at different points of the control loop, discretization of CT system into DT – position and velocity form (5) (18)

Mapping of s-plane to z-plane, analysis of transient and steady state response of DT system, Stability analysis of DT systems, Jury stability test, Stability analysis using bi-linear transformation, effect of sampling on the transient response**. (5)**

Design of P, PI, PID controller and compensator using Root locus method & Bode plot method. (8)

Unit-3: **State-Space Analysis & Design:** State Space representation of DT system, canonical forms, characteristic equation, conversion of continuous time (CT) state space to DT state space representation using ZOH, state transition matrix of DT system, Solution to discrete state equation, controllability, observability, loss of controllability and observability due to sampling, Lyapunov stability theorem for discrete time systems**. (10)** (18)

Design of State feedback controller, Deadbeat controller, Full order observer, deadbeat observer (8)

Text and Reference:

1. K. Ogata. ***Discrete Time Control Systems.*** Pearson Education
2. K.M. Moudgalaya. ***Digital Control***. Wiley India
3. B.C. Kuo. ***Digital Control System.*** Oxford University Press
4. M. Gopal. ***Digital Control and State Space Methods.*** Mc Graw Hill

Course Outcomes (Cos):

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

1. apply techniques to find the pulse transfer function of a system and or reduction technique from a complex control block diagram
2. analyze and evaluate the transient and steady-state characteristics of a DT feedback system from z plane analysis.
3. design and evaluate the basic digital controllers using root locus and bode plot reshaping technique.
4. analyze and evaluate the properties of a DT system in state space form.

EE 332	Advanced Power Electronics and Devices	L	T	P	C
	B. Tech (Electrical Engg.) Sixth Semester (Professional Core Elective-I)	**3**	**0**	**0**	**3**

Pre-requisites: Power Electronics (EE 304)

Unit-1:	**Introduction:** Introduction to different types of advance power electronics switching devices, gate driver circuitry for semiconductor switching devices, snubber circuit and thermal design.	(8)
Unit-2:	**Non-isolated dc-dc converter:** Basic Operation, waveforms and modes of operation: buck and boost converter, interleaved converter, switched capacitor converter.	(7)
Unit-3:	**Isolated dc-dc converter:** Basic Operation, waveforms and modes of operation:flyback converter, forward converter, push-Pull, half and full Bridge Converters	(7)
Unit-4:	**Resonant converter:** Introduction to resonant converters, classification of resonant converters, series load resonant converter, zero voltage and current switching resonant converter.	(7)
Unit-5:	**Switch-mode dc-ac Inverters:** Basic concepts. single phase inverters, sinusoidal pulse width modulation in single phase inverters, choice of carrier frequency in SPWM, spectral content of output in bipolar and unipolar switching in SPWM, space vector PWM, output/input side filter requirements	(7)
Unit-6:	**Industrial applications:** Stabilized power supplies: uninterrupted power supplies, online UPS, offline ups, high frequency online ups, induction heating, active power conditioning	(4)

Text and Reference:

1. Daniel W. Hart. ***Power Electronics.*** TMH
2. Rashid Mohammed. ***Power Electronics.*** PHI
3. Mohan undeland robbins. ***Power*** **Electronics & Drives**. Wiley
4. Keith H Billings and Taylor Morey. ***Switch mode power supply handbook*** . Mc-Graw hill Publishing Company
5. Sanjaya Maniktala. ***Switching power supplies A to Z***. Elsevier
6. SMPSRM/D, Rev,4, Apr-2014, SCILLC. ***Switch mode power supply: Reference Manual On Semiconductor***. www.onsemi.com

Course Outcomes (Cos):

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

1. choose appropriate devices, drivers, snubber circuit and heat sink.
2. evaluate the performance of various types of advanced dc-dc converters.
3. analyze the performance of various types of switched dc-ac inverter.
4. apply the power electronics converter knowledge in various practical scenarios.

EE 333	Computer Organisation B. Tech (Electrical Engg.) Sixth Semester (Professional Core Elective-I)	L	T	P	C
		3	0	0	3

Pre-requisites: Digital Electronics (EE 208)

Unit-1: **Introduction:** Computers and computations, Limitations of computers, First, second and third generation of computer families, The VLSI era: Integrated circuits, Microprocessors and Microcomputers, recent developments (4)

Unit-2: **Processor Design:** Processor organization, information representation, number formats, Instruction sets: instruction formats, instruction types, execution of instructions, Fixed – point arithmetic: addition and subtraction, multiplication, division. (8)

Unit-3: **Controller Design:** Instruction sequencing and instruction interpretation, Hardwired control: design methods, multiplier control unit, CPU control unit, Micro-programmed control: basic concepts, control – memory optimization, multiplier control unit (8)

Unit-4: **Memory Organization:** CPU – memory interaction, Memory array organization and technology, Multiple module memory, Virtual memory: Memory hierarchies, main – memory allocation, segment, pages and files. (5)

Unit-5: **Input – Output Processing:** Data transfer technique, Bus interface, IO accessing and data transfer, IO interrupts, IO Channel/ Processor (5)

Unit-6: **Peripheral Systems:** Principles of DOT Matrix, inkjet and laser printers, Magnetic memory systems, Video display unit and interface logic. (3)

Unit-7: **Introduction to Operating System:** Processor Management, Memory Management, File Systems, Device Management. A brief introduction to assembler and compiler. (5)

Text and Reference:

1. Patterson, D. A. & Hennessy, J. L. ***Computer Organization and Design: The Hardware/ Software Interface***. Elsevier Science
2. Hamachar, C., Vranesic, Z. and Zaky, S. ***Computer Organization***. McGraw-Hill
3. Hayes, J. P. ***Computer Architecture and Organization.*** McGraw-Hill
4. Stallings, W. ***Computer Organization and Architecture: Designing for Performance.*** Pearson Education
5. Heuring, V. P. & Jordan, H. F. ***Computer Systems Design and Architecture.*** Pearson Education
6. Shen, J. P. & Lipasti, M. H**. *Modern Processor Design: Fundamentals of Superscalar Processors.*** Tata McGraw-Hill

Course Outcomes (Cos):

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

1. Understand the basic concepts and structure of computers
2. Design data path unit and control unit of a Processor
3. Understand Memory Organization and Input – Output Processing
4. Analyze the Peripheral Systems
5. Understand the operating system, assembler and compiler

EE 334 LT & HT Distribution Systems

B. Tech (Electrical Engg.) Sixth Semester (Professional Core Elective-I)

L	T	P	C
3	0	0	3

Pre-requisites: Nil

Unit-1:	**Introduction:** Distribution system structure, HT and LT distribution systems, Types of loads, load estimation, distribution substation	(6)
Unit-2:	**Modelling of Distribution System Components:** Overhead lines, feeders and cables, single and three phase distribution transformers, distributed generators, VAr compensating devices	(8)
Unit-3:	**Distribution System Analysis:** Power flow analysis in distribution system, load balancing, short circuit analysis, network reconfiguration	(12)
Unit-4:	**Performance Measurement:** power loss calculation, voltage stability indices and reliability assessment	(8)
Unit-5:	**Operation and Control:** Communication in distribution system, SCADA system, Active and reactive power control, demand side management	(6)

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

Course Outcomes (Cos):

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

1. **Explain** the basic features of HT and LT distribution system.
2. **Design** and model various components of distribution system.
3. **Analyse** and evaluate the performance of distribution system.
4. **Investigate** and apply knowledge to solve operational problems in distribution systems

EE 335	Introduction to VLSI B. Tech (Electrical Engg.) Sixth Semester (Professional Core Elective-I)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1: **Introduction to MOS Design:** PMOS, NMOS and CMOS, Electrical characteristics and process technologies. Operation of MOS transistor as a switch. Design and analysis of nMOS and CMOS inverters, common gates, latches and flip-flops. (8)

Unit-2: **MOS Fabrication for IC:** Basic IC processing steps. Crystal growth and wafer preparation. Epitaxy-basics of vacuum deposition, MBE. CVD- low and high temp/pressure depositions. Diffusion –kinetics, Ficks law, sheet resistivity methods of diffusion. Oxidation –properties of oxides, theory of oxidation, oxidation under different ambient. Ion implantation. Etching techniques. CVD of polysilicon, oxides and nitrides. (15)

Unit-3: **Design structuring:** Regular structure circuits, PLAs and FSMs, system timing and clocking issues, scaling. CMOS subsystem design. Low power circuits and systems. System case studies. Design automation of VLSI Systems: basic concepts. Deep Sub-micron Technologies: Some Design Issues. (12)

Text and Reference:

1. N. H. E. Weste and K. Eshraghian. ***Principles of CMOS VLSI Design: A Systems Perspective***. Pearson Education
2. W. Wolf. ***Modern VLSI Design: Systems on Silicon.*** Pearson Education
3. J. Rabaey, A. Chandrakasan and B. Nikolic. ***Digital Integrated Circuits: A Design Perspective.*** Prentice Hall of India
4. M. Sarafzadeh and C. K. Wong. ***An Introduction to VLSI Physical Design***. MCGraw-Hill
5. D. D. Gajaski, N. D. Dutt, A. C.-H. Wu and S. Y.-L. Lin. ***High-Level Synthesis: Introduction to Chip and System Design.*** Kluwer Academic Publishers

Course Outcomes (Cos):

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

1. understand the operation, design and fabrication of MOS transistors
2. analyze the concepts of diffusion, oxidation and ion implantation
3. analyze structures of PLAs and FSMs and their properties
4. design and analyze VLSI circuits and systems

EE 336	**Renewable Energy** **B. Tech (Electrical Engg.) Sixth Semester (Professional Core Elective-I)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisites: Nil

Unit-1:	**Introduction:** Energy situation and renewable energy sources. Global energy scene, firewood crisis, Indian energy scene. Nonconventional energy sources, potential of renewable energy sources. .	(2)
Unit-2:	**Solar Radiation:** Terrestrial solar radiation, measurement of solar radiation. Low Temperature collectors: Flat plate collectors, optical characteristics of absorber and cover, heat transfer and transmission losser, collector model, collector equations	(7)
Unit-3:	**Application of solar energy:** Solar drying, solar distillation, solar air-conditioning and refrigeration. Photo voltaic energy conversion. Solar cell, equivalent circuit diagram.	(6)
Unit-4:	**Bioconversion:** Biomass, physical and biological thermal methods of bioconversion. Solid fuels, ethanol, methanol, vegetable oils.	(8)
Unit-5:	**Wind energy:** Origin, direction, velocity and measurement of wind. Wind energy converters power coefficient, aerodynamic construction of rotor blade. Wind electric generators in India.	(7)
Unit-6:	**Ocean energy sources:** Wave energy, tidal energy, ocean thermal energy conversion and mini-hydro.	(10)

Text and Reference:

1. G.D Rai. ***Non-conventional Energy Sources.*** Khanna Publication
2. Tiwari and Ghosal. ***Renewable Energy Resources.*** Narosa Publication
3. Dr. N K Giri. Alternatie. ***Energy-Sources, Applications and Technologies.*** Khanna Publishers
4. Twidell& Weir. ***Renewable Energy Sources***. CRC Press.
5. S.P. Sukhatme. ***Solar Energy.*** Tata McGraw-Hill
6. K M. Mittal. ***Non-Conventional Energy Systems.*** A H Wheeler Publishing Co Ltd.
7. Godfrey Boyle. ***Renewable Energy –power for a sustainable future.*** Oxford University Press
8. S. S. Thipse. ***Non-Conventional and Renewable Energy Sources***. Narosa Publication

Course Outcomes (Cos):

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

1. Demonstrate the modern renewable energy conversion technologies.
2. Analyze the capability of renewable energy sources to meet the future energy demand.
3. Identify appropriate renewable resources and techniques for effective utilization.
4. Evaluate the power output from the renewable energy sources.

EE 381 Optimization Methods and its application in Engineering

B. Tech (Electrical Engg.) Sixth Semester
(Open Elective-I)

L	T	P	C
3	0	0	3

Unit-1: Introduction: Basic concept of optimization problems- objective function, constraints, classification of optimization problems, Single variable and Multivariable optimization, with and without constraints, Convex and Non-convex problems. (4)

Unit-2: Traditional Optimization Techniques: Introduction to Linear Programming (LP), Standard form, definition and theorem, Solution of a system of linear simultaneous equation, Simplex method, Introduction to Nonlinear Programming (NLP), Gradient method and Newton's method. Nonlinear Simplex method. Constrained optimization with both interior and exterior Penalty function method. (11)

Unit-3: Non-traditional Optimization Techniques: Introduction, Evolutionary algorithms- Genetic algorithm (basic concept and GA operators), Swarm optimization- particle swarm optimization techniques (basic concept, and position and velocity update. (5)

Unit-4: Application in Engineering Problems: : Application of traditional and Non-traditional optimization techniques in various fields of engineering (e.g. Electrical, Mechanical, Civil, Electronics and Computer science). Traditional methods vis-à-vis non-Traditional method. Hands on practices to solve real-life problems. (12)

Text and Reference:

1. Singireshu S. Rao. ***Engineering Optimization Theory and Application***. John Wiley & Sons
2. Kalyanmoy Deb. ***Optimization for Engineering Design: Algorithms and Examples.*** PHI
3. J. S. Arora. ***Introduction to Optimum design***. Elsevier
4. Osman Guler. ***Foundations of Optimization***. Springer
5. K V Mital. ***Optimization methods in Operation Research and System Analysis.*** New Age International

Course Outcomes (Cos):

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

1. define optimization problems and classify various optimization approaches.
2. apply suitable optimization techniques to solve real-life complex problems.
3. demonstrate the characteristics of linear and non-linear optimization techniques.
4. compare the traditional and non-traditional optimization methods.
5. solve the optimization problems related to varied area of engineering studies.

EE 382 Fuzzy Set Theory and Applications

B. Tech (Electrical Engg.) Sixth Semester
(Open Elective-I)

L	T	P	C
3	0	0	3

Pre-requisites: Introduction to Programming (CS 101)

Unit-1: **Introduction and Fuzzy Sets Theory:** Fuzzy sets, logic and applications, membership functions, Nomenclatures used in fuzzy set theory, set theoretic operations in fuzzy set theory, properties of fuzzy (4)

Unit-2: **Fuzzy Arithmetic:** Arithmetic operations on fuzzy numbers, complement of fuzzy sets, T-norm operators, S-norm operators. (6)

Unit-3: **Fuzzy Relations:** Operations on Crisp and Fuzzy relations, Projection of fuzzy relation set, cylindrical extension of fuzzy sets, properties of fuzzy relations, extension principle, composition of fuzzy relations, properties of composition of fuzzy relations. (9)

Unit-4: **Fuzzy Inference Systems**: Fuzzy rules and fuzzy reasoning, fuzzy inference system, Fuzzifiers and Defuzzifiers, Mamdani fuzzy model, Tsukamoto fuzzy model, TSK fuzzy model. (10)

Unit-5 **Engineering Applications:** Fuzzy Differential equation model using Fuzzy T-S approach, State feedback control for robotic system, PI and PID control design using fuzzy rule base (or FIS) for engineering and biomedical systems (will be selected by the course coordinator). (9)

Unit-6 Exposer to Fuzzy logic control toolbox of MATLAB or Python, Implementation of the design. Students are required to submit a project on design at the end of the semester on complex engineering problems. (2)

Text and Reference:

1. Timothy Ross. ***Fuzzy Logic with Engineering Application.*** John Wiley and Sons
2. George J. Klir , Ute St. Clair, and Bo Yuan. ***Fuzzy Set Theory- Foundations and Applications.*** Prentice Hall PTR
3. Bart Kosko. ***Fuzzy Engineering.*** Prentice Hall.

Course Outcomes (Cos):

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

1. apply basic fuzzy inference and approximate reasoning for solving relevant engineering problems.
2. design Fuzzy logic based models of various dynamical systems.
3. design PI and PID controller using Fuzzy rule base for dynamical systems.
4. implement Fuzzy logic based controllers using MATLAB/Python for complex engineering problems.

EE 383	**Adaptive Signal Processing** **B. Tech (Electrical Engg.) Sixth Semester** **(Open Elective-I)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisites: Signals and systems: EE 201/Equivalent subjects in EIE, ECE

Unit-1:	**Stochastic Process and Models:** Random variables and Process, Expectation, Mean, Covariance, Ergodic Process, stationary process, Correlation matrix of a stationary DT stationary process and its properties, stochastic models, Yule-Walker equations, Power Spectral density and its properties	(10)
Unit-2:	**Wiener Filter:** Problem statement, Orthogonality principle, Minimum mean square error, Wiener-Hopf equation, Error performance surface. (5) **Linear Prediction:** Forward linear prediction, Backward linear prediction, Levinson-Durbin algorithm, Cholesky factorization, predictive modelling of speech. (10)	(15)
Unit-3:	**Linear Adaptive Filtering:** Review of Eigen value and Eigenvectors, Singular value Decomposition, Pseudoinverse. Steepest Descent Algorithm, Least mean square algorithm, Normalized LMS, Recursive Least Square Algorithm, Examples from all the above algorithms**.** **(10 Hours)** **Application of Adaptive Filtering:** Application of adaptive filtering in communication and control. Adaptive filter structures while implementing for specific application**. (5 hours)**	(15)

Text and Reference:

1. Simon Haykin. ***Adaptive Filter Theory.*** Pearson Education, 2008
2. B. Widrow. ***Adaptive Signal Processing.*** Perason Education, 2007.
3. T. Adali, S. Haykin. ***Adaptive Signal Processing: Next Generation Solution***. Wiley-IEEE Press, 2010
4. Pillai, Papoulis. ***Probability, Random Variables and Stochastic Process.*** Tata McGraw Hill.

Course Outcomes (Cos):

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

1. To **evaluate** randomness and statistical attributes of a stochastic process for a given random or stochastic process.
2. To **analyze** the Wiener filter theory.
3. To **derive** various algorithms of linear prediction and adaptive filtering.
4. To **design** filter for appropriate signal processing of bio signals.
5. To **Implement** adaptive filtering algorithms to solve application problems.

EE 384 Mathematical Methods in Dynamic Systems

B. Tech (Electrical Engg.) Sixth Semester
(Open Elective-I)

L	T	P	C
3	0	0	3

Unit-1: **Linear and Numerical Linear Algebra:** Linear Spaces - Vectors and Matrices, Linear transformations, Norms - Vector and Matrix norms, Condition number of a matrix and its interpretation. Eigenvalues and Eigenvectors and Application for the solution of C-T dynamical system and system stability, relationship between Eigen value and singular values**.** (10)

Unit-2: **Matrix factorization and decomposition & Application to Control Theory:** Singular Value Decomposition, LU factorization, Householder transformation, Eigen decomposition and their applications. Projections, Least Square Solutions, computation of state transition matrix, Lyapunov equation and controllability and observability Grammian, Lyapunov equation and H_2 norm. Various examples to apply, analyze and evaluate the methods. (15)

Unit-3: **Random Variable and Stochastic Processes:** Probability, Random Variables, Probability distribution and density functions, Joint density and Conditional distribution, Functions of random variables, Moments, characteristic functions, sequence of random variables, Correlation matrices and their properties, Random processes and their properties (8) (15)

Response of Linear systems to stochastic inputs, PSD theorem. Various examples to apply, analyze and evaluate the methods**. (7)**

Text and Reference:

1. K. Hoffman and R. Kunze. ***Linear Algebra.*** Prentice-Hall, 1986
2. Axler, Sheldon J.. ***Linear Algebra Done Right.*** Springer, 2004
3. G. Strang. ***Introduction to Linear Algebra.*** 4th Edition, Wellesley-Cambridge Press, 2009.
4. Papoulis & Pillai. ***Probability, Random Variable and Stochastic Processes.*** McGraw Hill, 2002.
5. H. Stark & J.W. Woods. ***Probability and Random Processes with Application to Signal Processing.*** Pearson Education Asia, 2002

Course Outcomes (Cos):

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

1. apply, analyze and evaluate the methods of linear and numerical linear algebra to solve problems of dynamical systems.
2. apply, analyze and evaluate the methods of random variable and stochastic process to find the solution of real-life engineering problems.

EE 385	Software-based System Design B. Tech (Electrical Engg.) Sixth Semester (Open Elective-I)	L	T	P	C
		1	0	3	3

Unit-1:	**Introduction:** Importance of Software-based system design, different software tools used for system modeling, simulation and analysis.	(2)
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	(9)
Unit-3:	**LabVIEW:** Introduction to basics of LabVIEW, simulation of LTI systems, PID controller design, Filter design, Speed control of Separately-Excited DC motor, Design and Simulate a Buck and Boost converter. Other design problems considered using MATLAB may also be done here.	(9)
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.	(5)
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	(5)
Unit-6:	**Adam Multibody Simulator, Adam car simulator, Easy 5 and VI Rail:** Design various mechanical and electromechanical control systems, co-simulation between Adams and MATLAB® Simulink. Building a model of railway vehicle & car, and analyze their dynamics.	(6)
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.	(5)

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

Course Outcomes (Cos):

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

1. apply the major features of MATLAB/ LabVIEW to simulate a given process/ problem and analyze the outcome.
2. convert a differential equation or a transfer function to its analog circuit and implement the circuit using PSpice. Compare with the numerical simulation results.

3. implement hydraulics or pneumatics control systems of off-highway vehicles and apply co-simulation with MATLAB or other software.
4. analyze the dynamics of a car body or a rail body and apply the necessary control to achieve the desired outputs.
5. evaluate the performances of an 11/ 33 bus power system using the power simulator and apply the control strategies to achieve the desired objectives.

EE 386	Hardware-based System Design B. Tech (Electrical Engg.) Sixth Semester (Open Elective-I)	L	T	P	C
		1	0	3	3

Unit-1:	**Introduction:** Introduction to hardware-based system design, objectives and outcomes from the course.	(2)
Unit-2:	**PIC Microcontroller:** Introduction to the microcontroller, Generating PWM signals in CCP modules and GPIO pins, multiple servo motor control, Relay interfacing, Serial Peripheral Interface (SPI) communication, dc motor control.	(8)
Unit-3:	**Arduino:** Basics of Arduino board and programming, Interfacing with sensors, Bluetooth, WIFI module, PWM generation and servo motor control	(8)
Unit-4:	**Raspberry Pi:** Motor control with Raspberry Pi and Python,	(6)
Unit-5:	**DSpace:** Checking of signals on analog and digital I/O's using DSO and function generators, Open and closed loop control of a Buck and Boost Converter, Basic DC drive operation, MPPT operation of solar PV system, Battery charging, multilevel converters.	(4)
Unit-6:	**OpalRT:** Design of closed-loop control logic for speed control of DC motor, Generation of firing pulses for a VSI fed Induction Motor Drive. Design of an 11/ 33 bus power system.	(2)
Unit-7:	**CompactRIO/sbRIO:** Design of CompactRIO/sbRIO-based data acquisition system, real-time implementation of Fast Fourier Transform (FFT) and finding the power spectrum using LabVIEW and CompactRIO/sbRIO. Design of a closed-loop control system.	(6)
Unit-8:	**FPGA:** Design of Phase-Locked Loops (PLL), generation of PWM pulses for converter control, closed-loop controller design, control of a VSI fed Induction Motor Drive, power generation and control of WRIG coupled to a wind emulator.	(4)

Text and Reference:

1. Manual of the Hardware
2. Recently published papers

Course Outcomes (Cos):

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

1. create a PIC microcontroller based controlled system and diagnose faults if any.
2. use Arduino and Raspberry Pi to implement a closed-loop system.
3. implement a microgrid using DSpace.
4. design real-time simulation of an 11/33 bus power system using Opal RT.
5. create a closed-loop system using CompactRIO/sbRIO or FPGA.

EE 431	Switch Mode Power Supply	L	T	P	C
	B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	**3**	**0**	**0**	**3**

Pre-requisites: Power Electronics (EE 304)

Unit-1: Introduction and review of basics witched mode power converter topologies: Introduction to switch mode power supplies (SMPS), linear regulator vs. switching regulator; review of non-isolated dc-dc switch mode converters and analysis: buck, boost, buck-boost, cuk, sepic, continuous conduction mode (CCM) and discontinuous conduction mode (DCM) analysis, non-idealities in the SMPS; review of isolated dc-dc switch mode converters and analysis: fly-back, forward, push-pull, half-bridge and full-bridge topologies; dc-ac switched mode driven inverters (10)

Unit-2: Modeling and control of SMPS: dynamic modeling using generalized state-space average method to obtain small-signal linear model of the switch mode power converters under CCM and DCM, input and control transfer functions of converters (input and output impedances, control voltage and current gains, audio susceptibility), closed loop control performance requirements of converters using frequency response analysis, effect of input filter on converter performance, voltage mode and current model control, instability in current control and slope compensation technique,methods of regulating multi-output power supply, unity power factor converter (10)

Unit-3: Resonant SMPS: Review of resonant converter topologies and principle of operations: Resonant load converters, Resonant inverter based SMPS, full power circuit of a resonant load SMPS,resonant switch converters with ZCS and ZVS;resonant transition phase modulated converters,resonant switching converters with active clamp (8)

Unit-4: Design considerations and protections of SMPS: : Selection of filter capacitors and selection of energy storage inductor, design of transformer, transformer design for high frequency isolation, selection of ratings for devices, steps for design of DC-DC converter, EMI Filter components, conducted EMI suppression, radiated EMI suppression, measurement and protection: over current protection, over voltage protection, Inrush current protection (8)

Unit-5: Applications of SMPS : Active front end – power factor correction, High frequency power source for fluorescent lamps, power supplies for portable electronic gadgets (4)

Text and Reference:

1. V. Ramanarayanan. ***Course Material on Switched Mode Power Conversion***. Department of Electrical Engineering, Indian Institute of Science, Bangalore
2. Philip T. Krein. ***Elements of Power Electronics.*** Oxford University Press
3. L. Umanand. ***Power Electronics: Essentials and Applications.*** Wiley India
4. Ned Mohan, Tore M. Undeland and William P. Robbins. ***Power Electronics: Converters, Applications and Design.*** John Wiley & Sons, Inc.

5. Keith H Billings and Taylor Morey. ***Switch mode power supply handbook***. Mc-Graw hill Publishing Company
6. Sanjaya Maniktala. ***Switching power supplies A to Z.*** Elsevier
7. ***Switch mode power supply: Reference Manual on Semiconductor.*** SMPSRM/D. Rev,4, Apr-2014, SCILLC, www.onsemi.com
8. Seddik Bacha, Lulian Munteanu and Antoneta Luliana Bratcu. ***Power Electronic Converters Modeling and Control: with Case Studies.*** Springer

Course Outcomes (Cos):

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

1. analyze the operations of various dc-dc and dc-ac switch mode power converter topologies.
2. develop dynamic modeling and control of different switch mode dc-dc power converters.
3. evaluate steady-state and dynamic performances of different switch mode dc-dc power converters
4. analyze the operations of soft switching (resonant) converters and unity power factor rectifiers for SPMS
5. select different power circuit and protection circuit components of SMPS for various applications.

EE 432	Electric Power Utilisation and Traction	L	T	P	C
	B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	3	0	0	3

Unit-1: **Traction System:** Classification, brief explanation, Electric Traction - Different types, distinguishing features, advantages and disadvantages, Factors affecting final choice of Traction system. (5)

Unit-2: **Power Supply System for Track Electrification:** Different systems of track electrification, block diagram representation, Advantages and disadvantages. (5)

Unit-3: **Power Supply Arrangement:** Constituents of ac power supply system, layout and brief description of each of the constituents, miscellaneous equipment's at control posts and major equipment's at ac substation, Functions of dc traction sub-station. (4)

Unit-4: **Overhead Equipment:** Various current collection system, brief description & areas of application, Constructional details of OHE employing single catenary and supported by swiveling type bracket assembly, Automatic weight tension and temperature compensation scheme, Factors determining the height, span of contact wire, Types of OHE supporting structure. (3)

Unit-5: **Traction Mechanics and its applications:** Types of train services and their distinguishing features, Train resistance, adhesion, Train movements and Energy consumption. Speed-time curve, simplified sp-time curve; Tractive and relevant problems, multiple unit control and metadyne control (3)

Unit-6 **Electric Heating:** Advantages of electric heating, Different methods of electric heating, their working principle; Brief idea about practical oven/furnace (To show the physical positions of main components only), range of operating temp., idea about current and voltage magnitudes used, application area, Different types of heating material electrode and their characteristics, causes of failure of heating element, Methods of controlling the temp. in the oven/furnace, Calculations relating to power input/output and design of main parameters of the furnace. (8)

Unit-7 **Illumination:** Classification of lamps based on the principle of operation; Different accessories required in each case and their circuit connection, Performance comparison with reference to lumen/watt efficiency, installation cost, length of life and quality of service, Method of design of lighting systems with simple problem. (8)

Text and Reference:

1. H. Partab. ***Modern Electric Traction.*** Dhanpat Rai &Co.P.Ltd.
2. H. Partab.. ***Art and Science of Utilization of Electrical Energy***. Dhanpat Rai &Co.P.Ltd.
3. Gupta.J.B. ***Utlilization of Electric Power and Electric Traction***. Kataria, S. K., & Sons
4. Varun Goyal. ***Utilization of Electrical Power***. JBC Press
5. B.L.Theraja. ***A.T.B. Of Electrical Technology Vol III.*** S.Chand Limited,2007

6. C.L.Wadhwa. ***Articulate different types of Electric Heating.*** NewAge International Pvt Ltd Publishers

Course Outcomes (Cos):

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

1. classify the Electric Traction systems and able to discuss about OHE.
2. discuss the mechanics of Train movements and specific energy consumption.
3. illustrates different types of Electric Heating and their characteristics.
4. classify types of Illumination methods and design the lighting scheme.

EE 433	Biomedical Signal Processing and Control B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Control Systems (EE301)

Unit-1: **MODELLING OF PHYSIOLOGICAL SIGNALS AND SYSTEMS:** Review of Transfer function, state-space modeling. Modeling of human movements, parameter estimation, linearizing, Block diagram representation of the muscle stretch reflex, Linear model of respiratory mechanics, model of chemical regulation of ventilation, linear model of muscle mechanics, model of regulation of cardiac output, model of Neuromuscular reflex, motion models with combination of system elements simulation. (12)

Unit-2: **ANALYSIS OF BIOSIGNALS:** Review of fundamental of DSP, filter design (problems only), EEG signal characteristics – EEG analysis, Automatic analysis and classification of ECG, P-wave detection, QRS complex detection, Correlation analysis of ECG signals, Signal averaged ECG, Analysis of Heart Rate variability, Synchronized averaging of PCG envelopes, envelogram, Analysis of PCG signal, Analysis of EMG signal, Filter design for bio signals. (12)

Unit-3: **PHYSIOLOGICAL CONTROL SYSTEM:** Introduction to physiological control systems, Human Thermal system, Neuro muscular system oculomotor system, Respiratory system, difference between engineering and physiological control systems, generalized system properties. Linear model of Type 1 Diabetes patient (12)

Unit-4: **ADVANCE CONTROL SYSTEM DESIGN:** Control Design (frequency domain/state space) for biomedical systems. (8)

Text and Reference:

1. M Rangayyan. ***Biomedical signal processing.*** IEEE press, first edition, 2002
2. Michael C K, Khoo. ***Physiological control systems.*** IEEE press, John Wiley & Sons Inc, First edition, 2000
3. L. Cromwell et al.***Biomedical Instrumentation and Measurements.*** Prentice Hall
4. Jacob Kline. ***Handbook of Biomedical Engineering.*** Academic Press.
5. Reddy D.C. ***Biomedical Signal Processing: Principles and Techniques***. Tata McGraw-Hill, New Delhi,2nd edition ,2005.
6. John G, Proakis and Dimitris Manolakis G. ***Digital Signal Processing, Algorithms and Applications***. PHI of India Ltd., New Delhi, fourth Edition, 2007.
7. Gopal M. ***Control System – Principles and Design.*** Tata McGraw Hill, 2nd Edition, 2002.

Course Outcomes (Cos):

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

1. analyze the physiological system behaviour using frequency and time-domain techniques.
2. interpret the signal characteristics of various bio-signals.
3. design filter for appropriate signal processing of bio signals.
4. design model based controller for the biomedical systems.

EE 434	Electric Power Quality B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

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.	(6)
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.	(10)
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.	(7)
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.	(10)
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.	(7)

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

Course Outcomes (Cos):

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

1. analyse the causes of different PQ problems and their effects on sensitive loads.
2. identify a particular PQ problem and evaluate its optimum solution scheme.
3. mitigate practical problems due to voltage sags and transient voltages in the system.
4. identify causes and eliminate current and voltage harmonics at the load bus.
5. apply and update the knowledge of international PQ standards.

EE 435 Optimal Control

B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)

L	T	P	C
3	0	0	3

Pre-requisites: Control Systems (EE 301) Maths – I, Maths - II

Pre-requisites: Control Systems (EE 301)

Unit-1:	**Introduction:** An overview of optimization problem and some examples of design problem	(2)
Unit-2:	Concepts of optimization problem, necessary and sufficient conditions for a multivariable function, effects of scaling or adding a constant to an objective function and understanding of constrained and unconstrained optimization problems	(4)
Unit-3:	Lagrange multipliers and its application to unconstrained optimization problem and solution of unconstrained minimization problem, constrained optimization problems using Karush-Kuhn-Tucker (KKT) necessary and sufficient conditions	(8)
Unit-4:	Convex sets, convex and concave functions, definiteness of a matrix, test for concavity of function, convex optimization, local and global optima	(3)
Unit-5:	Linear programming: Simplex method, two-phase simplex method, primal and dual problem, matrix form of the simplex method	(6)
Unit-6:	Calculus of variations, variational problems and performance indices, Euler-Lagrange equation, transversality condition	(8)
Unit-7:	Linear quadratic regulator (LQR) problem, finite-time and infinite-time LQR problem, optimal solution of LQR problem	(9)

Text and Reference:

1. Jasbir S. Arora. ***Introduction to optimum design***. Elsevier, (2006)
2. A Ravindran, K.M. Ragsdell, and G.V. Reklaitis. ***Engineering optimization: Methods and Applications.*** Wiley India Edition, (2006)
3. D.S. Naidu. ***Optimal control systems.*** CRC Press, (2003)

Course Outcomes (Cos):

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

1. apply the methods given in the course to solve realistic optimization problems
2. formulate optimal control problems from the given specifications
3. find optimum control input and design an optimal controller

EE 436	Modeling and Control of AC Drives B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Electrical Machines I (EE 206), Electrical Machines II (EE 303), Industrial Drives (EE 307)

Unit-1: **Elements of generalized theory:** Essentials of Rotating Electrical Machines, Conventions, Basic Two-pole Machine, The Per Unit System, Transformer with a Movable Secondary, Transformer and Speed Voltages in the armature, Kron's Primitive Machine, Analysis of Electrical Machines. Invariance of Power, Transformation from a Displaced Brush-Axis, Transformation from Three Phases to Two phases (a, b, c to α, β, 0), Transformation from rotating axes to stationary axes, Physical concept of Park's Transformation. (8)

Unit-2: **Dynamic modeling of induction motor drives:** Dynamic d-q model: power equivalence, generalized model in arbitrary reference frames, electromagnetic torque, commonly used induction motor models - stator reference frame model, rotor reference frame model, synchronously rotating reference frame model; equations in flux linkages, introduction to state space model. (10)

Unit-3: **Field oriented control of induction motor drives:** DC drive analogy-principles of vector control, vector control methods, direct vector control, indirect vector control, flux vector estimation, vector control of line-side PWM rectifier, stator flux oriented vector control, vector control of current-fed inverter drive and cycloconverter drives, speed-sensorless vector control, speed estimation methods, direct vector without speed signal, direct torque and flux control (DTC). (12)

Unit-4: **Modeling and control of synchronous motor drives :**Dynamic modeling of synchronous motor, control strategies, open loop v/f, self control, vector control: constant torque angle control, unity power factor control, constant mutual flux linkage control; flux weakening operation, implementation strategy, sensorless control. (10)

Text and Reference:

1. B. K. Bose. ***Modern Power Electronics and AC drives***. Pearson publications
2. R. Krishnan. ***Electric motor drives Modeling, Analysis.*** Pearson Publications
3. P. S. Bimbhra. ***Generalized Theory of Electrical Machines.*** Khanna
4. G.K. Dubey. ***Fundamentals of Electrical drives.*** Narosa publications
5. B.K. Bose. ***Power Electronics and Variable frequency drives.*** IEEE Press Standard publications, 1st Edn.
6. P. VAS. ***Vector control of AC machines.*** Oxford

Course Outcomes (Cos):

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

1. develop generalized model of AC machines.
2. analyze the field oriented control strategies for induction motor drives.
3. analyze the field oriented control strategies for synchronous motor drives.
4. evaluate the performance of induction and synchronous motor drives.

EE 437	Computer Applications in Power Systems B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1: **Elementary Linear Graph Theory: N**etwork 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. (10)

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. (10)

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. (10)

Unit-4: **Automatic generation control-** economic dispatch, generation schedule, optimum unit commitment interchange negotiation, Hydro-thermal scheduling, volt/ VAR dispatch, weather forecast analysis, load forecast – future, evaluation of proposed operation, system security, load flow calculations, environmental monitoring. (10)

Text and Reference:

1. Stagg and Al Albiad. ***Computer Application in Power System.*** McGraw Hill
2. John. . Grainger & W. D. Stevenson Jr. ***Power System Analysis.*** Tata McGraw-Hill Edition
3. M.A. Pai. ***Computer Techniques in Power System Analysis***. Tata. McGraw-Hill Edition
4. Wood and Wollenberg. ***Power generation and Control.*** John Williey
5. George L. Kusic. ***Computer aided power system analysis.*** PHI

Course Outcomes (Cos):

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

1. Describe the importance of network matrixes in power system studies.
2. Build Z_{bus} and Y_{bus} for a given power system network.
3. Demonstrate and solve the load flow and short circuit analysis for power system network.
4. Illustrate the automatic generation control schemes used for power system networks.
5. Solve the economic operation of thermal and hydro power plants.

EE 438	Power System Operation and Control B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1: **Automatic generation and voltage Control:** Basics of speed governing mechanism and modeling.Speed-load characteristics. Load sharing between two synchronous machines in parallel. Control area concept. Tie line with frequency bias control. Introduction to load Frequency Control (LFC). LFC control of multi-area systems.LFC and Economic dispatch Control. Automatic Voltage Control.LFC with Generation Rate Constraints and Speed Governor Dead-Band. Digital LF Controllers. Decentralized Control (10)

Unit-2: **Reactive Power and Voltage Control:** Operation of a transmission line at no load condition, Operation of a transmission line under heavy loading condition, Voltage regulation of the transmission line and its relation with reactive power, Maximum power transfer in an uncompensated line, Line loadability. Reactive power-voltage (Q-V) coupling concept; Governing effects on reactive power flow; Reactive power requirement for control of voltage in long lines; Basic principle of system voltage control; Reactive power flow constraints and their implications in loss of voltage; Effect of generator excitation adjustment in the post disturbance period; Practical aspects of reactive power flow problems leading to voltage collapse in EHV lines, methods of voltage control tap changing transformer, SVC (TCR + TSC) and STATCOM – secondary voltage control. . (10)

Unit-3: **Introduction to Power System Deregulation and Restructuring:** Introduction; Motivation for Restructuring of power system; Electricity market entities and model; Benefits of Deregulation; Basic terminologies; Deregulation – International scenario; Milestones of deregulation in the world; (4)

Unit-4: **Indian power sector – Past and present status:** Growth of power sector in India – An overview, A time line of the Indian power sector, Players in the Indian power sector, Research and professional bodies (2)

Unit-5: **State Estimation:** Least Squares Estimation: The Basic Solution; Static State Estimation of Power Systems; Tracking State Estimation of Power Systems; (4)

Unit-6: **Power System Security:** Introduction to System State Classification, Security Analysis, Contingency Analysis. (4)

Unit-7: **Load Forecasting:** Forecasting Methodology; Estimation of Average and Trend Terms; Estimation of Periodic Components; Forecasting methods**:** Time Series Approach; Long Term Load Predictions Using Econometric Models; Reactive Load Forecasting (4)

Text and Reference:

1. Olle.I.Elgerd. ***Electric Energy Systems theory – An introduction.*** Tata McGraw Hill Education Pvt. Ltd., New Delhi
2. Allen. J. Wood and Bruce F. Wollenberg. ***Power Generation, Operation and Control.*** John Wiley & Sons
3. AbhijitChakrabarti, SunitaHalder. ***Power System Analysis Operation and Control.*** PHI learning Pvt. Ltd., New Delhi
4. Nagrath I.J. and Kothari D.P. ***Modern Power System Analysis. Tata*** McGraw-Hill
5. Kundur P. ***Power System Stability and Control.*** Tata McGraw Hill Education Pvt. Ltd., New Delhi
6. HadiSaadat. ***Power System Analysis.*** Tata McGraw Hill Education Pvt. Ltd., New Delhi
7. N.V.Ramana. ***Power System Operation and Control***. Pearson
8. C.A.Gross. ***Power System Analysis.*** Wiley India

Course Outcomes (Cos):

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

1. understand the techniques to control power flows, frequency and voltage.
2. explore the significance of power system restructuring.
3. perform system state estimation and explore its importance.
4. learn the power system security and its application as a system operator.
5. carry out load forecasting using available methods.

EE 439 Data Acquisition and Signal Conditioning

B. Tech (Electrical Engg.) Seventh Semester
(Professional Elective-II)

L	T	P	C
3	0	0	3

Pre-requisites: Instrumentation (EE 401)
Pre-requisites: Nil

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.	(8)
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.	(6)
Unit-3:	**Voltage Regulators:** Introduction, Series Op-amp regulator, IC voltage regulators, 723 general purpose regulators, switching regulator.	(4)
Unit-4:	**Active filters:** First and Second order LPF, First and Second orders HPF, Band Pass Filters, Band Reject filters.	(6)
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.	(4)
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.	(8)
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.	(6)

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

Course Outcomes (Cos):

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

1. design and analyze different basic circuits involving op-amp
2. Design and develop op-amp circuits to meet the practical applications
3. Design analog filters to meet the specifications
4. 4. Analyze different data acquisition systems

EE 440	AC-DC Microgrid B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Power Electronics (EE 304), Modern Control Systems (EE 308)

Unit-1:	**Introduction and architecture of microgrids:** Definition of microgrid**,** typical microgrid configurations: AC and DC micro grids, interconnection of microgrids, technical and economic advantages of microgrid, components of microgrid, distributed energy resources (DER): DER interface, storage systems; batteries, fly-wheels, ultracapacitors	(10)
Unit-2:	**Microgrid control techniques:** Control structure and requirements, control hierarchy: distributed and centralized techniques	(6)
Unit-3:	**DC microgrid:** Advantages of dc microgrids and applications, energy resources in dc microgrids, hierarchical power sharing, droop control, centralized control, decentralized control, tertiary control, control of the power electronics converters in autonomous dc microgrids, protection system	(10)
Unit-4:	**AC microgrid:** Master-slave architecture, control strategy for power electronics converter, grid-connected operation: active and reactive power control, power quality issues in microgrids, requirements for grid interconnection, response to grid abnormal conditions, islanded operation and issues, protection system, hybrid ac-dc microgrid, battery energy management systems	(10)
Unit-5:	**Demand side management in microgrid:** Customers category, incentive-based demand response, cooperative power microgrid	(4)

Text and Reference:

1. Magdi S. Mahmoud. ***Microgrid- Advanced Control Methods and Renewable Energy System Integration***. Butterworth-Heinemann (Elsevier)
2. Nikos Hatziargyriou. ***Microgrids Architectures and Control.*** Wiley
3. Remus Teodorescu, Marco Liserre, Pedro Rodriguez. ***Grid Converters for Photovoltaic and Wind Power Systems***. Wiley Publications
4. Suleiman M. Sharkh. ***Power Electronic Converters for Microgrids.*** Wiley

Course Outcomes (Cos):

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

1. examine the architectures of DC/AC microgrid.
2. analyze different control strategies for DC and AC microgrids.
3. evaluate various power quality issues and control strategies for micro grid operation.
4. interpret demand response in a Microgrid.

EE 441	Flexible AC Transmission Systems B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Power Electronics (EE 304), Power System-I (EE 207) and Power System-II (EE302)

Unit-1: **AC transmission line and reactive power compensation:** Transmission interconnection, flow of power in AC system, brief description and definitions of FACTS controllers, analysis of uncompensated line: transmission line equations, performance of a line connected to unity power factor load, performance of a symmetrical line, passive reactive power compensation: distributed and discrete power compensation, compensation by a series capacitor connected at the mid-point of the line, shunt capacitor compensation connected at the midpoint of the line, comparison between series and shunt capacitor compensation (15)

Unit-2: **Static Shunt Compensators:** Objectives of shunt compensation: midpoint voltage regulation for line segmentation, end of line voltage support to prevent voltage instability, improvement of transient stability, power oscillation damping, analysis of SVC, methods of controllable VAR generation: variable impedance type static VAR generators: TSC and TCR, voltage source converter type VAR generators: Static Synchronous Compensator (STATCOM); hybrid VAR Generators: voltage source converter with TSC and TCR (10)

Unit-3: **Static Series Compensators:** Objectives of series compensation: voltage stability, improvement of transient stability, power oscillation damping, sub synchronous oscillation damping, variable impedance type series compensators: Thyristor-Controlled Series Capacitor (TCSC),GTO Thyristor-Controlled Series Capacitor (GCSC),voltage source converter type series compensators: Static Synchronous Series Compensator (SSSC). (10)

Unit-4: **Combined Shunt and Series Compensators:** Basic operating principles and characteristics: Unified Power Flow Controllers (UPFC), Interline Power Flow Controller (IPFC) (5)

Text and Reference:

1. N. Hingorani. ***Understanding FACTS.*** IEEE Press
2. K. R. Padiyar. ***FACTS controllers in power transmission and distribution.*** New Age
3. R. Mohan Mathur, Rajiv K. Varma. ***Thyristor-based FACTS controllers for electrical transmission systems.*** IEEE and Willey-Interscience

Course Outcomes (Cos):

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

1. examine the interconnection system of the transmission line with their limitations
2. analyze the effect of series and shunt passive compensators
3. performance evaluation of different static, shunt and series compensators
4. evaluation of different configurations of combined compensators

EE 442	High Voltage AC/DC B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1:	**Breakdown mechanism of gases, Liquid and solid materials:** Properties of Gas as an insulating medium and their breakdown, Townsend's current growth equation and criterion for breakdown, Electronegative gases-their properties and breakdown, Streamer theory of breakdown in gases, Paschen's law, Conduction and breakdown of liquid dielectric, Pure & commercial liquids - origin, purification and breakdown, Transformer oil - composition, purification, testing and breakdown, Different types of breakdown in solid dielectric, Breakdown in composite dielectric, Measurement of intrinsic strength, partial discharge, Different types of solid dielectric - use, property and breakdown.	(4)
Unit-2:	**Electrical properties of high vacuum:** High vacuum as a dielectric, Pre-breakdown condition, Factors effecting the breakdown voltage and breakdown phenomenon	(3)
Unit-3:	**Over voltage phenomenon & Insulation co-ordination:** Natural cases of over-voltage-lighting over-voltage, Traveling waves on Transmission line, Over voltage due to arching ground, Line design based on lighting, Insulation co-ordination & over voltage protection, Magnetic surge crest ammeter, Klydonograph, Fulcharnograph, Oscillograph, surge absorber, ground and counter-poise wires, lightning arrestors etc.	(4)
Unit-4:	**High voltage generation:** Generation of high voltage DC – voltage multiplier circuit, Generation of A.C. high voltage – cascade transformers & resonant transformers, Generation of Impulse voltage – Multistage Impulse generator method (Marx Circuit),Generation of Impulse current, Van-de-graph generator.	(6)
Unit-5:	**Measurement of High voltage & currents:** Measurement of high D.C. voltage- Generating voltmeter, Measurement of A.C. voltage-Electrostatic voltmeter, sphere gaps, Measurement of A.C. high frequency Impulse voltage- peak voltmeters, sphere gaps, Measurement of DC current – Hall generator, Measurement of AC current- current transformer, Measurement of Impulse currents- CRO.	(6)
Unit-6:	**High voltage Equipments:** Bushing - classification, construction & application breakdown of Design, Guard Ring and shields, High voltage Bus-bar-Introduction, High voltage cables – Introduction.	(6)
Unit-7:	**High voltage Testing and testing techniques:** Testing of over head line insulator, Testing of cable, Testing of Bushing, Testing of power transformer, Testing of circuit breakers and Isolators, Measurement of Resistivity, Dielectric constant and loss factor, High voltage Schering bridge, Testing of surge Arrestors.	(6)

Unit-8:	**Design, planning and layout of high voltage laboratory:** Testing facility, activities of a H.V. Laboratory, Planning, clearance and layouts, Test equipment and layout, Safety measures, Grounding techniques of H.V. Impulse laboratory.	(3)
Unit-9:	**Introduction to EHV. System & EHV lines:** Effect of corona on EHV line, Lightning and lightning protection	(2)

Text and Reference:

1. M.S. Naidu and V. Kamaraju. High voltage Engineering. Tata McGraw Hill, 2nd Edition
2. C.L. Wadhwa. ***High voltage Engineering.*** New Age.
3. M. Khalifa**.** ***H. V. Engineering- Theory and Practice***. Marcel Dekker Inc.
4. Rakesh Das Begamudre**.** ***Extra High Voltage A.C. Transmission Engg.*** New Age
5. E. Kuffel, W. S. Zaengl, J. Kuffel. ***High Voltage Engineering: Fundamentals.*** Butterworth-Heinemann, 2 nd Edition, 2000
6. Prof. D.V. Razevig. ***High Voltage Engineering.*** Khanna Publishers.
7. Sunil S. Rao. ***Switchgear and Protection.*** Khanna Publishers.

Course Outcomes (Cos):

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

1. describe the causes and types of overvoltage in HV AC/DC lines.
2. explain the nature of Breakdown mechanism in solid, liquid and gaseous dielectrics
3. classify different methods of generating and measuring high voltages and currents.
4. select appropriate testing method (s) for various high voltage apparatus.

EE 443	Intelligence and Knowledge Based Systems	L	T	P	C
	B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	**3**	**0**	**0**	**3**

Pre-requisites: Nil

Unit-1:	Basic concepts of intelligence and knowledge, Definition of AI; Background and past achievements; Aims Overview of application areas, Problem Solving: State space representation, problem reduction, constraint satisfaction networks. Heuristics. Knowledge representation, predicate calculus, resolution-refutation.	(8)
Unit-2:	Reasoning with incomplete information: Non monotonic reasoning. Elements of temporal logic. Diagnostic reasoning. reasoning from incomplete or uncertain information	(6)
Unit-3:	Structural knowledge Representation schemes: Representation models, Predicate logic, rules, Semantic nets, Frames, Conceptual graphs, Inheritance and default reasoning.	(6)
Unit-4:	Expert systems: The nature of Expert Systems. Types of applications of Expert Systems; relationship of Expert Systems to Artificial Intelligence and to Knowledge-Based Systems. Architecture of expert systems. Expert system shells.	(8)
Unit-5:	**Measurement of High voltage & currents:** Measurement of high D.C. voltage- Generating voltmeter, Measurement of A.C. voltage- Electrostatic voltmeter, sphere gaps, Measurement of A.C. high frequency Impulse voltage- peak voltmeters, sphere gaps, Measurement of DC current – Hall generator, Measurement of AC current- current transformer, Measurement of Impulse currents- CRO.	(6)
Unit-6:	**Knowledge bases system:** Theory and practice of knowledge-based system construction with particular emphasis on rule-based expert systems. Fuzziness and uncertainty Security considerations, Fuzzy logic; Statistical techniques for determining probability, Methodologies for developing knowledge-based systems, Knowledge acquisition, knowledge base construction, knowledge integration in databases, inference engines, intelligent decision support, and user tools & interfaces. Forward and backward chaining. Case studies. Distributed artificial Intelligence and agent-based systems.	(6)

Text and Reference:

1. G.J. Klir. ***Fuzzy Sets and Fuzzy logic.*** PHI
2. H.J. Zimmerman. ***Fuzzy Set Theory and Application.*** Kluwer Academic Publisher.

Course Outcomes (Cos):

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

1. explain the intelligent and knowledge-based systems.
2. design the intelligence and knowledge-based systems for problem solving.
3. apply intelligence and knowledge-based systems for real life problems

EE 444	Demand Side Management	L	T	P	C
	B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	**3**	**0**	**0**	**3**

Pre-requisites: Nil

Unit-1:	**Introduction:** The concepts of demand-side management (DSM) for electric utilities; scope of DSM; evolution of DSM concept; DSM alternatives and goals; concept of DSM planning, design, marketing and impact assessment	(6)
Unit-2:	**End-use equipment and control:** utility equipment control; energy storage; dispersed generation	(8)
Unit-3:	**Assessment of impact on system load shape**: energy audit and assessment of customers' load shape for different customer groups, Impact of DSM programs on load shapes in customer groups	(8)
Unit-4:	**Cost/benefit analysisand feasibility of DSM Programme:** Cost/benefit analysis of DSM alternatives; DSM promotions; process for assessment of customer acceptance and programme penetration; issues in forecasting DSM programme impacts; Environmental benefits	(10)
Unit-5:	**DSM Implementation:** Implementation of DSM programme, pricing and incentives.	(8)

Text and Reference:

1. Fawar Elkarmi et al. ***Power System Planning Technologies and application. IGI*** Global
2. Clark W Gellings et al. ***Demand-Side management planning.*** Fairmont Press
3. A de Almedia and Arthur H. Rosenfeld. ***Demand-Side Management and Electricity End-Use Efficiency***. Kluwer Academic Publishers

Course Outcomes (Cos):

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

1. analyse the concept and significance of demand side management.
2. design, apply and analyze various techniques of demand side management.
3. analyse and evaluate the cost-benefit analysis, customer acceptance, impact and issues of demand side management program.
4. design and implement demand side management program.

EE 445 Control of Wind Energy Conversion Systems and its Challenges

B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)

L	T	P	C
3	0	0	3

Pre-requisites: Power Electronics (EE 304), Modern Control Systems (EE 308)

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 (8)

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 (8)

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 (10)

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 (7)

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). (7)

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

Course Outcomes (Cos):

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

1. analyze wind energy conversion system in general
2. evaluate the control strategies and performance of fixed speed WECS.
3. evaluate the control strategies and performance of variable speed WECS.
4. develop suitable closed-loop controllers for specific wind power generation application

EE 446	Geometrical Aspect of Control Systems B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1:	Introduction to the geometrical aspect of linear control systems, Invariant subspaces, Linear algebra	(8)
Unit-2:	Disturbance decoupling, Zeros and zero dynamics, Reachability subspaces, Zero dynamics and high gain control	(8)
Unit-3:	Noninteracting control and tracking, Input-output behavior, Applications of zero dynamics, Sylvester equation	(8)
Unit-4:	Output tracking input, Output regulation	(6)
Unit-5:	Nonlinear systems: examples, basic mathematics, controllability, stability, steady-state response, Center manifold and normal form, zero dynamics and applications, Exact linearization and Consensus problem, Multi-agent systems	(10)

Text and Reference:

1. W. Murray Wonham. ***Linear Multivariable Control – A Geometric Approach***. Springer-Verlag New York, 1985
2. Yuri Sachkov. ***Lecture note on Introduction to geometric control.*** Program Systems Institute Pereslavl-Zalessky Russia
3. Panos J. Antsaklis, Anthony, N. Michel. ***A Linear Systems Primer***. Birkhauser Boston, 2007
4. Harry L. Trentelman, Anton A. Stoorvogel and Malo Hautus. ***Control Theory for Linear Systems***. Springer-Verlag London 2001

Course Outcomes (Cos):

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

1. analyze the geometrical interpretations of various concepts of linear systems.
2. analyze the geometrical interpretations of nonlinear systems.
3. apply the geometrical concepts while designing a controller and evaluate the outcomes.

EE 447	Nonlinear Systems B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1: **Introduction to nonlinear systems**: Models and nonlinear phenomena, common nonlinearity. (4)

Unit-2: **Concepts and characterization of 2nd order nonlinear systems**: Qualitative behavior of linear systems, multiple equilibria, qualitative behavior near equilibrium points, limit cycles, the existence of periodic orbits, bifurcation (6)

Unit-3: **Fundamental properties of nonlinear systems**: Existence and uniqueness of the solution, sensitivity equation, comparison principle (3)

Unit-4: **Lyapunov stability**: Autonomous systems, invariance principle, linear systems and linearization, nonautonomous systems, converse theorems, boundedness (8)

Unit-5: **Input-output stability**: $\mathcal{L}$ stability, $\mathcal{L}$ stability of state models, $\mathcal{L}_2$ gain, small-gain theorem (5 hours). (5)

Passivity and its connection with Lyapunov and $\mathcal{L}_2$ stability: Memoryless functions, state models, $\mathcal{L}_2$ and Lyapunov stability, passivity theorems

Unit-6: **Frequency domain analysis of feedback systems**: Absolute stability, circle criterion, Popov criterion, describing function method (4)

Unit-7: **Advanced stability analysis**: Center manifold theorem, the region of attraction, invariance-like theorem, the stability of periodic solutions (5)

Text and Reference:

1. Hassan K Khalil. ***Nonlinear Systems.*** Prentice Hal

Course Outcomes (Cos):

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

1. apply the concepts to find various nonlinear phenomena of a given system using its model and evaluate its significance in the actual working system and differences from a linear system.
2. analyze the qualitative behavior of a 2nd order nonlinear system; evaluate the existence of periodic orbits and bifurcation; validate the evaluation using simulation.
3. apply various concepts of Lyapunov and Input-output stability on a system; analyze and evaluate the outcomes to find the differences of these concepts in its practical sense.
4. analyze a given system using different concepts of frequency-domain and compare the outcome with that of CO3.
5. analyze a system using passivity and advanced-stability concepts; compare and evaluate the outcomes with that of other approaches.

EE 448	VLSI System Design B. Tech (Electrical Engg.) Seventh Semester (Professional Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Introduction to VLSI (EE 335)

Unit-1: (15)

Introduction to VLSI Design: Different types of VLSI design styles: Full custom, standard cell based, gate array based, programmable logic, field programmable gate arrays etc. VLSI Design flow

VLSI design automation tools: Algorithms and system design. Structural and logic design. Transistor level design. Layout design. Verification methods. Design management tools.

Layout compaction, placement and routing. Design rules, symbolic layout. Applications of compaction. Formulation methods. Algorithms for constrained graph compaction. Circuit representation. Wire length estimation. Placement algorithms. Partitioning algorithms.

Unit-2: (10)

ASIC Library Design

Transistors as Resistors and parasitic Capacitance, Logical effort, gate array, standard cell and datapath cell design. Introduction to hardware description language (HDL) Verilog/VHDL. A logic synthesis examples.

Floor planning and routing

Floor planning concepts. Shape functions and floor planning sizing. Local routing. Area routing. Channel routing, global routing and its algorithms.

Unit-3: (15)

Simulation and logic synthesis: Gate level and switch level modeling and simulation. Introduction to combinational logic synthesis. ROBDD principles, implementation, construction and manipulation. Two level logic synthesis.

High-level synthesis

Hardware model for high level synthesis. Internal representation of input algorithms. Allocation, assignment and scheduling. Scheduling algorithms. Aspects of assignment. High level transformations

Text and Reference:

1. S.H. Gerez. ***Algorithms for VLSI Design Automation.*** John Wiley
2. N.A.Sherwani . ***Algorithms for VLSI Physical Design Automation.*** Kluwer
3. S.M. Sait , H. Youssef. ***VLSI Physical Design Automation.*** World scientific
4. M.Sarrafzadeh. ***Introduction to VLSI Physical Design.*** McGraw Hill

Course Outcomes (Cos):

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

1. understand different types of VLSI design styles
2. analyze the properties associated with ASIC library design

3. design and Simulate VLSI circuits using HDL
4. evaluate logic synthesis examples using Verilog/VHDL
5. understand I/O , power planning and logic synthesis

EE 481	Introduction to Biomedical Engineering B. Tech (Electrical Engg.) Seventh Semester (Open Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Basic Electrical Engineering EE 101

Unit-1: **Introduction to Biomedical Signals and Systems:** Important Physiological systems of the body, Biomedical Transducer, Sources of bio-electric signals, propagation of action potential, Electrode theory, different sensors for biologicsal systems, Measurement of various bio-signals. (12)

Unit-2: **Biomedical recorders:** Electrocardiograph (ECG), Phonocardiograph, Electroencephalograph (EEG), Electromyograph (EMG) (10)

Unit-3: **Medical Imaging:** Instrumentation for diagnostic X-rays, X-ray computed tomography, Basic NMR components, Ultrasonic, imaging systems – Medical ultrasound, A-SCAN, Echocardiograph (M-mode), B-SCANNER, Biological effect of ultra sound. (10)

Unit-4: Fundamentals of biomechanics, Rehabilitation Engineering, Ethics in biomedical engineering research. (8)

Text and Reference:

1. J.D Bronzino. ***Biomedical Engineering Fundamentals.*** CRC Press
2. R.S. Khandpur. ***Handbook of Biomedical Instrumentation.*** Tata McGraw Hill
3. Jacob Kline. ***Handbook of Biomedical Engineering.*** Academic Press.

Course Outcomes (Cos):

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

1. distinguish between various physiological systems, sources of bio-signals
2. apply the measurement techniques for EEG, ECG, EMG and other bio-signals.
3. investigate the Biomedical recorded signals.
4. relate and compare the ideas of biomechanics, rehabilitation engineering and ethics of biomedical research, medical imaging devices and techniques.
5. analyze various medical imaging techniques and bio-signal recordings.

EE 482	Optimization Techniques and Numerical Methods B. Tech (Electrical Engg.) Seventh Semester (Open Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Maths-I, Maths - II

Unit-1:	Introduction to optimization, optimality conditions for function of several variables, unconstrained optimization problem (numerical technique)	(5)
Unit-2:	Solution of constrained problems, KKT conditions, post optimality analysis, convex function and its properties	(7)
Unit-3:	Linear programming: Simplex method, matrix form of the simplex method, two-phase simplex method, Big-M method, primal and dual problems	(9)
Unit-4:	Error in numerical computations; Solution of nonlinear equations; Solution of linear system of equations; Eigen values and eigen vectors	(7)
Unit-5:	Initial value problem (IVP), single-step and multi-step methods; System of first order ODE, higher order IVPs; Numerical solutions of BVP - Linear BVP, finite difference methods, shooting methods, stability, error and convergence analysis	(12)

Text and Reference:

1. Jasbir S. Arora. ***Introduction to optimum design***. Elsevier, 2006
2. A Ravindran, K.M. Ragsdell, and G.V. Reklaitis. ***Engineering optimization: Methods and Applications.*** Wiley India Edition, 2006
3. M.K. Jain, S.R.K. Iyengar, and R.K. Jain. ***Numerical methods for scientific and engineering computation.*** New Age International, 2003
4. Kendall E.Atkinson, Weimin Han, and David E. Stewart. ***Numerical solution of ordinary differential equations.*** Wiley, 2009

Course Outcomes (Cos):

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

1. apply knowledge of mathematics and computing to solve static optimization problems
2. analyze a problem and identify the computing requirements appropriate for its solution
3. apply numerical methods to obtain the solution of mathematical problems discussed in this course
4. analyze and evaluate the error of numerical methods

EE 483	Industrial Instrumentation B. Tech (Electrical Engg.) Seventh Semester (Open Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Instrumentation (EE 401)

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.	(8)
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.	(6)
Unit-3:	**Voltage Regulators:** Introduction, Series Op-amp regulator, IC voltage regulators, 723 general purpose regulators, switching regulator	(4)
Unit-4:	**Active filters:** First and Second order LPF, First and Second orders HPF, Band Pass Filters, Band Reject filters.	(6)
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.	(4)
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.	(8)
Unit-7:	**Module 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	(6)

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

Course Outcomes (Cos):

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

1. design and analyze different basic circuits involving op-amp
2. design and develop op-amp circuits to meet the practical applications
3. design analog filters to meet the specifications
4. analyze different data acquisition systems

EE 484	**Artificial Neural Networks** **B. Tech (Electrical Engg.) Seventh Semester** **(Open Elective-II)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisites: Nil

Unit-1: **Introduction:** Biological neurons and memory: Structure and function of a single neuron; Artificial Neural Networks (ANN). (2) (9)
Typical applications of ANNs: Classification, Clustering, Vector Quantization, Pattern Recognition, Function Approximation, Forecasting, Control, Optimization; Basic Approach of the working of ANN - Training, Learning and Generalization. (7)

Unit-2: **Supervised Learning:** Single-layer networks; Perceptron-Linear separability, Training algorithm, Limitations; Multi-layer networks-Architecture, Back Propagation Algorithm (BTA) and other training algorithms, Applications. Adaptive Multi-layer networks-Architecture, training algorithms; Recurrent Networks; Feed-forward networks; Radial-Basis-Function (RBF) networks. (10) (20)
Unsupervised Learning: Winner-takes-all networks; Hamming networks; Maxnet; Simple competitive learning; Vector-Quantization; Counter propagation networks; Adaptive Resonance Theory; Kohonen's Self-organizing Maps; Principal Component Analysis. (10)

Unit-3: **Associated Models:** Hopfield Networks, Brain-in-a-Box network; Boltzmann machine. (6) (11)
Optimization Methods: Hopfield Networks for-TSP, Solution of simultaneous linear equations; Iterated Gradient Descent. (5)

Text and Reference:

1. Simon Haykin ***Neural Networks-A Comprehensive Foundation.*** Macmillan Publishing Co., New York.
2. K. Mehrotra, C.K. Mohan and Sanjay Ranka. ***Elements of Artificial Neural Networ***k. MIT Press, - [Indian Reprint Penram International Publishing (India)].
3. A Cichocki and R. Unbehauen. ***Neural Networks for Optimization and Signal Processing***. John Wiley and Sons.
4. J. M. Zurada. ***Introduction to Artificial Neural Networks***. Jaico Publishers, Mumbai

Course Outcomes (Cos):

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

1. apply backpropagation algorithm to train ANNs.
2. design classifiers using artificial neural networks.
3. select the appropriate learning algorithms based on the type of the application.
4. solve optimization problems using neural networks

EE 485	Design Aspect of Control Systems B. Tech (Electrical Engg.) Seventh Semester (Open Elective-II)	L	T	P	C
		3	0	0	3

Pre-requisites: Control System EE301/Equivalent course in other branches

Unit-1:	**Introduction:** Review of systems modeling, stability, objectives of feedback control	(2)
Unit-2:	**PID Controller**: PID control, the principle of operation, design of PID Controller: From the process reaction curves (ZN, CC), ZN sustained oscillation method, Based on First Order Plus Dead-Time model (FOPDT), Second-Order Plus Dead-Time model (SOPDT), Online PID tuning based on relay feedback process identification; implementation issues. Industrial relevance of PID control.	(8)
Unit-3:	**Controller design in special control structure**: Feedforward control. Smith predictor, Internal model control, Cascade control, Independent shaping of sensitivity, and complementary sensitivity function in a 2-DOF and 3-DOF control structure.	(5)
Unit-4:	**Reliable State Feedback design**: Pole placement, eigen structure assignment, region-based eigenvalue assignment, Eigen structure-time response relationships. Controller gain selection - noise sensitivity. Controller robustness. Disturbance rejection.	(9)
Unit-5:	**Frequency Domain Loop Shaping**: Output feedback control - compensator design, review of Lead, Lag and Lag-Lead compensators using, bode plot and Nichols chart, Dependency of magnitude and phase characteristics (Bode's Integral).	(6)
Unit-6:	**Design Limitation in non-minimum phase system and OL unstable system**: Limitation of controller performance, Maximum achievable bandwidth.	(4)
Unit-7:	**Zero dynamics**: Significance in servo control design, design for unstable zero dynamics. Observers - concept and design philosophy. Applications in practical controller design scenarios.	(6)

Text and Reference:

1. Goodwin, Graham C., Stefan F. Graebe, and Mario E. Salgado. ***Control system design. Upper*** Saddle River, NJ: Prentice-Hall, 2001
2. Friedland, Bernard. ***Control system design: an introduction to state-space methods***. Courier Corporation, 2012
3. Gopal, Madan. ***Control systems: principles and design.*** Tata McGraw-Hill Education, 2002
4. I. M. Horowitz. ***Synthesis of Feedback Systems***. Academic Press

Course Outcomes (Cos):

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

1. analyze the given desired specifications into design parameters. Design and evaluate the comparative performances of PID controllers using various approaches, considering implementation issues.
2. evaluate the requirement of a special control structure based on a given situation; design and analyze the performance of the special controller.

3. evaluate the requirement of various concepts for a reliable state-feedback design based on the given circumstances; design a reliable state-feedback controller using an observer, if needed.
4. analyze the desired frequency-domain specifications and draw the desired bode plot and/or Nichol plot; design the required compensator and evaluate the performance.
5. analyze the design limitation of a non-minimum phase system, open-loop unstable system; design analyze the performance of the designed controller for such a system. Analyze the zero dynamics of a linear system.

EE 486 Modelling and Simulation of Dynamical Systems

B. Tech (Electrical Engg.) Seventh Semester
(Open Elective-II)

L	T	P	C
3	0	0	3

Pre-requisites: Modern Control Systems (EE308)

Unit-1:	**Introduction to modeling and simulation:** Transfer functions, poles and zeroes, State Space, Linearisation, Linear System Simulation. **(5)** **Numerical methods for differential equations:** Differential equations and difference equations, Runge-Kutta, Least squares. **(7)**	(12)
Unit-2:	**Modeling of Dynamical Systems:** Description of statistical dynamical properties. Physical law based equations for model building: energy balance, mass flow balance, Newtons laws of movement, etc. General principles for model building.	(10)
Unit-3:	**Identification of dynamic systems:** Methods to build models based on measurement data from processes. Blackbox models. Parametric estimation in linear dynamic models. System identification as model building tool. Model validation. (10) **Simulation:** Numeric accuracy and stability. (3)	(13)

Text and Reference:

1. Klee, H. ***Simulation of Dynamic Systems with MATLAB and Simulink***. CRC Press, Boca Raton, FL.(2007).
2. Woods, R. L., and Lawrence, K. L. ***Modeling and simulation of dynamic systems.*** Prentice-Hall, Upper Saddle River, NJ (1997),
3. Steven I. Gordon Brian Guilfoos. ***Introduction to Modeling and Simulation with MATLAB® and Python***. CRC Press (2017)

Course Outcomes (Cos):

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

1. solve differential and difference equations using numerical methods.
2. develop dynamic models of systems based on their physical properties.
3. construct dynamic models of black box and grey box systems using the input output measurements.
4. design simulation programs for dynamic systems using simulation software and programming.

EE 451	Power System Reliability and Deregulation	L	T	P	C
	B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	3	0	0	3

Pre-requisites: Nil

Unit-1:	Basic Concepts of power system reliability, Generating system reliability Analysis, Generation system model, loss of load indices, Capacity expansion analysis, Scheduled outages, load forecast uncertainty, loss of energy indices, Frequency and Duration methods, interconnected system-basic concepts, evaluation techniques. Operating reserve calculations, spinning capacity evaluation, unit commitment risk.	(6)
Unit-2:	Reliability of composite generation and transmission Systems, Radial configuration, Conditional probability approach, Network configurations, State selection, System and load point Indices.	(4)
Unit-3:	Distribution systems reliability evaluation techniques, customer-oriented indices, load and energy-oriented indices, application to radial systems, Effect of lateral distribution protection, Effect of disconnects, Effect of protection failures, Effect of transferring loads, parallel and meshed networks' reliability evaluation techniques.	(10)
Unit-4:	Deregulated Systems: Need and conditions for deregulation-Introduction of Market Structure-Market Architecture-Spot market-forward markets and settlements. -deregulation in Indian power sector - Operations in power markets -Review of Concepts- marginal cost of generation least-cost operation-incremental cost of generation.	(10)
Unit-5:	Reconfiguring Power systems- Unbundling of Electric Utilities-Competition and Direct access. Transmission network and market power - Power wheeling transactions and marginal costing - transmission costing. Framework and methods for the analysis of Bilateral and pool markets.	(6)

Text and Reference:

1. R. Billinton , R. N. Allan. ***Reliability evaluation of Power Systems***. Springer
2. J. Endrenyi. ***Reliability Modelling in Electric Power Systems***. John Wiley and Sons
3. R. Billinton , R. N. Allan. ***Reliability evaluation of Engineering Systems.*** Springer
4. M. Shahidehpour, H. Yamin and Zuyi Li. ***Market operations in electric power systems-Forecasting, scheduling and risk managemen***t. John Wiley & sons Inc.
5. Loe lei lai. ***Power system restructuring and deregulation- trading, performance and information technology.*** John Wiley and sons
6. Kankar Bhattacharya, Math H.J. Bollen, and Jaap E. Daalder. ***Operation of restructured power systems.*** Kluwer international series
7. Dong, Z., Zhang, P. Ma, J., Zhao, J., Ali, Meng, K., Yin . ***Emerging Techniques in Power System Analysis.*** Springer
8. Steven Stoft. ***Power System Economics-Designing markets for electricity***. IEEE Pres

Course Outcomes (Cos):

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

1. understand and *apply* the concept of power system reliability.
2. analyze and evaluate the reliability of different parts of power system.
3. understand and define the structure, characteristics and need of deregulated power system.
4. identify, analyze and explore the roles, responsibilities, issues and scope of different entities in power market

EE 452	Power System Stability and Control B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1: **Introduction to power system stability problems:** Definition of stability, classification of stability, Rotor angle stability, frequency stability, voltage stability, mid-term and long-term stability, classical representation of synchronous machine in a single machine infinite bus system (SMIB), equal area criterion to asses stability of a SMIB system, limitations of classical model of synchronous machines. ()

Unit-2: **Modelling of power system components for stability analysis:** Synchronous machine modelling: sub-transient model, two axis model, one axis (flux decay) model, classical model. Excitation systems modelling: DC excitation, AC excitation and static excitation. Prime mover and energy supply systems modelling. Transmission line modelling, load modelling. Methods of representing synchronous machines in stability analysis. ()

.

Unit-3: **Small signal stability:** Fundamental concepts, state space representation, Modal analysis: eigen properties, participation factors, stability assessment. Effects of excitation system on stability, power system stabilizer and its design, Angle and voltage stability of multi-machine power systems and phenomenon of sub synchronous resonance ()

Unit-4: **Transient stability:** Fundamentals of transient stability, numerical solutions: simultaneous implicit and partitioned explicit methods, simulation of dynamic response, analysis of unbalanced faults, direct method of transient stability, transient energy function method, Methods of improving transient stability. ()

Unit-5: **Voltage stability:** Classification of voltage stability, modelling requirements, voltage stability analysis: static and dynamic, sensitivity analysis, modal analysis, voltage collapse, prevention of voltage collapse ()

Text and Reference:

1. K. R. Padiyar. ***Power System Dynamics, Stability & Control.*** 2nd Edition, B.S. Publications, Hyderabad, 2002.
2. P. Kundur. ***Power System Stability and Control.*** McGraw Hill Inc, New York, 1995.
3. M. A. Pai and Peter W. Sauer. ***Power system stability.*** Pearson Education.
4. P. Sauer & M. A. Pai. ***Power System Dynamics & Stability.*** Prentice Hall, 1997.

Course Outcomes (Cos):

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

1) analyze key issues in Power System Stability problem and Stability Problems faced by modern Power Systems
2) analyze and Model of Dynamical Systems using Numerical Integration Techniques.
3) describe Modeling of Excitation and Prime Mover Systems, Transmission Lines and Loads, steam turbine, hydro turbine and governor, Prime Mover Control Systems and Other Subsystems - HVDC, protection systems.

4) understand and use Power System Stability Analysis Tools, Direct method of transient stability analysis, Transient Stability Program, Small Signal Analysis Program, EMTP Programs and Real-Time Simulators.

EE 453	Electrical Networks and Pricing B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1:	**Restructuring**: Introduction to restructuring of power industry.	(2)
Unit-2:	**Fundamentals of economics**: Competitive market, supply and demand curve, elasticity & Inelasticity, market equilibrium, Pareto efficiency, Short run and long run cost.	(8)
Unit-3:	**Philosophy of market models**: Introduction, various energy markets, Trading arrangements	(6)
Unit-4:	**Transmission congestion management**, Introduction to Congestion Management, Effects of congestions, Locational Marginal Prices (LMP) and Financial Transmission Rights (FTR).	(6)
Unit-5:	**Pricing of transmission network usage** and loss allocation: Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing, Rolled-in transmission pricing methods, Marginal transmission pricing paradigm, Composite pricing paradigm, Merits and demerits of different paradigms, Debated issues in transmission pricing, Classification of loss allocation methods, comparison between various methods.	(10)
Unit-6:	Introduction to optimal bidding by generator companies, optimal bidding methods.	(6)

Text and Reference:

1) D. Kirschen and G. Strbac. ***Fundamentals of Power System Economics.*** John Wiley & Sons Ltd.
2) S. Hunt & K. Bhattacharya. ***Making Competition work in Electricity.*** John Wiley & Sons Ltd
3) J.E. Daadler, M.H.J. Bollen. ***Operation of Restructured Power Systems.*** Kluwer. Academic Publishers
4) Clark W. Gellings. ***Effective power marketing***. Pennwell Publishers
5) Shahidehpour M and Marwali. ***Maintenance Scheduling in a Restructured Power System.*** Kluwer Academy

Course Outcomes (Cos):

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

1) state the fundamentals of competitive market.
2) describe the necessity of restructuring the electricity market.
3) identify the roles of various entities in energy market.
4) analyze the various market mechanisms and bidding strategies.
5) evaluate ATC, TTC and Congestion Management related problems.

EE 454	System Identification and Parameter Estimation B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Maths – I, Maths - II

Unit-1: **Introduction:** Definition, different types of estimation problems, examples, Brief review of differential equations, Laplace transforms, frequency responses, difference equations, stationarity, autocorrelation, cross-correlation, power spectra. (3) (6)

Input Signal Design and simulation: The signals discussed are pulse, step, Random Binary Sequence (RBS), Pseudo-Random Binary (PRBS), and m-level Pseudo-Random (m-PRS) inputs, MATLAB simulation, and analysis, Real-time implementation aspects. (3)

Unit-2: **Nonparametric methods**: Transient analysis, frequency analysis, Correlation analysis, Spectral analysis, identification of non-parametric input-output models (4) (19)

Measures of goodness of estimators – variance, mean bias, efficiency, sufficiency, mean square error, consistency (3)

Offline and online parameter estimation of a discrete-time system: Least Square, Generalized and Recursive Least Square, Instrumental variables using ARX, ARMAX, FIR, Output Error model structure. Box-Jenkins method, Introduction of AI-based identification of nonlinear system (Self-study in a group). (12)

Unit-3: **Parameter estimation of a state-space model and a closed-loop system**: An overview of parameter estimation of a state-space model, algorithm to find the state-space model (Self-study in a group), different approaches of closed-loop system estimation. (6 hours) (15)

Parameter estimation of a continuous-time LTI system: Comparative analysis between CT and DT parameter estimation. The issue of derivative of a signal under noisy condition, Introduction to State variable filter, and Poisson Moment Functional approaches. (9 hours)

Text and Reference:

1. Arun K Tangirala. ***Principles of System Identification: Theory and Practice.*** CRC Press, 2014
2. Micheal Verhaegen and V. Verdult. ***Filtering and system identification.*** Cambridge University Press, 2007.
3. T Soderstrom and P Stoica. ***System Identification.*** Prentice Hall, New York
4. G. P. Rao and H. Unbehauen. ***Identification of continuous systems***.

Course Outcomes (Cos):

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

1. analyze the need for persistent excitation input signal; design and simulate such an input signal.
2. apply various approaches of nonparametric system identification; analyze and evaluate the performance of these approaches.

3. design various types of estimators in discrete-domain by interpreting the given scenario of uncertainty, noise, and other given conditions; analyze and evaluate the performances.
4. design state variable filter and /or Poisson moment functional-based continuous-time estimator; analyze and evaluate the performances.
5. apply the toolbox commands to simulate the concepts and approaches.

EE 455	Advanced Control Systems B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: **Control Systems (EE 301), Modern Control Systems (EE 308)**

Unit-1:	Introduction, effects of process variations, adaptive schemes, adaptive control problem; Model reference adaptive control; Gain scheduling	(15)
Unit-2:	Norms for vectors, matrices, signals, and linear systems; Small-gain theorem;Physical interpretation of H_∞ norm, H_∞ norm computation, H_∞ control problem	(15)
Unit-3:	Variational approach,LQRcontrol, solution of Riccati equation, LQR with a specified degree of stability, stability, and robustness properties of LQR design, constrained optimal control	(10)

Text and Reference:

1. Karl J. Astrom and Bjorn Wittenmark. ***Adaptive Control***. Prentice-Hall, 1994
2. Kang-Zhi Liu and Yu Yao. ***Robust Control: Theory and Applications***. John Wiley & Sons, 2016
3. John C. Doyle, Bruce A. Francis and Allen R. Tannenbaum. ***Feedback Control Theory.*** Dover Publications Inc., 2009
4. D.S. Naidu. ***Optimal control systems.*** CRC Press, 2003

Course Outcomes (Cos):

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

1. design an adaptive controller and simulate; analyze its performances; compare its outcomes with a robust and an optimal controller.
2. design a robust controller and simulate; analyze its performances; compare its outcomes with an adaptive and an optimal controller.
3. design an optimal controller and simulate; analyze its performances; compare its outcomes with adaptive and robust controllers.
4. apply more than one concept and design a hybrid controller; analyze and compare its performances through simulation.

EE 456	Advanced Digital Signal Processing B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Digital Signal Processing (EE 305)

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.	(3)
Unit-2:	Piecewise constant approximation - the Haar wavelet. Building up the concept of dyadic Multiresolution Analysis (MRA).	(4)
Unit-3:	Relating dyadic MRA to filter banks. Elements of multi-rate systems and two-band filter bank design for dyadic wavelets	(5)
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	(5)
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.	(5)
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.	(5)
Unit-7:	Piecewise linear to piecewise polynomial. The class of spline wavelets - a case for infinite impulse response (IIR) filter banks.	(5)
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.	(5)

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

Course Outcomes (Cos):

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

1. design the multi-rate filter banks.
2. apply concepts of wavelet transformation and related issues
3. apply and implement the wavelet transform in different applications

EE 457	Biomedical Instrumentation B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: EE 204

Unit-1:	**Components of Medical Instrumentation System:** Bioamplifier. Static and dynamic characteristics of medical instruments. Biosignals and characteristics. Problems encountered with measurements from human beings.	(6)
Unit-2:	**Organisation of cell:** Nernst equation for membrane Resting Potential Generation and Propagation of Action Potential, Conduction through nerve to neuromuscular junction. **Bio Electrodes:** Biopotential Electrodes-External electrodes, Internal Electrodes, Biochemical Electrodes. **Mechanical function:** Electrical Conduction system of the heart. Cardiac cycle. Relation between electrical and mechanical activities of the heart	(12)
Unit-3:	**Cardiac Instrumentation:** Blood pressure and Blood flow measurement. Specification of ECG machine. Einthoven triangle, Standard 12-lead configurations, Interpretation of ECG waveform with respect to electromechanical activity of the heart	(6)
Unit-4:	**Neuro-Muscular Instrumentation:** Specification of EEG and EMG machines. Electrode placement for EEG and EMG recording. Interpretation of EEG and EMG	(6)
Unit-5:	**Therapeutic equipment:** Pacemaker, Defibrillator, Shortwave diathermy, Haemodialysis machine. **Respiratory Instrumentation:** Mechanism of respiration, Spirometry, Pneumotachograph Ventilators.	(10)

Text and Reference:

R.S. Khandpur. ***Biomedical Instrumentation: Technology and Applications***. McGraw-Hill
John G. Webster. ***Medical Instrumentation, Application and Design.*** John Wiley
Geoddes and Baker. ***Principles of Applied Biomedical Instrumentation***. John Wiley and Sons
R.S. Khandpur. ***Hand-book of Biomedical Instrumentation.*** McGraw-Hill

Course Outcomes (Cos):

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

1. interpret the working and design of instruments as well as instrumentation system used in Health care.
2. analyze the source and nature of different bio signals.
3. evaluate various sources of bio-signals and its related instrumentation system.

EE 458	CAD for VLSI Systems	L	T	P	C
	B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	**3**	**0**	**0**	**3**

Pre-requisites: VLSI System Design (EE 448)

Unit-1:	**Introduction to VLSI:** VLSI design flow, challenges. Verilog/VHDL: introduction and use in synthesis, modeling combinational and sequential logic, writing test benches. Essential features of Instruction set architectures of CISC, RISC and DSP processors and their implications for implementation as VLSI chips; CISC Instruction-set implementation and RT-Level optimization through hardware flow-charting (without/with pipelining concepts); Microprogramming approaches for implementation of control part of the processor; Handling of Instruction boundary interrupts, Immediate interrupts and traps in processors	(10)
Unit-2:	**Logic synthesis:** Two-level and multilevel gate-level optimization. Binary decision diagrams. Basic concepts of high-level synthesis: partitioning, scheduling, allocation and binding. Technology mapping. Basic of pipeline processing, Pipelined implementation of RISC Instruction Sets; Benefits and problems of pipelined execution; Hazards of various types and pipeline stalling; Scheduling (static and dynamic) and forwarding to reduce/minimize pipeline stalls.	(15)
Unit-3:	**Introduction, CAD and SPICE overview:** Understanding simulation, numerical integration, convergence, time step control. AC, DC and transient analysis, CMOS model, MOSFET model, unified charge control model (UCCM), SPICE level 1, 2, and 3, and barkeley short-channel IGFET model (BSIM), Differential amplifier, current mirrors, active loads, Output stages, Op-Amps, compensation, Macro-modeling, and behavioral modeling.	(10)
Unit-4:	**Physical design automation:** Physical design automation algorithms: floor-planning, placement, routing, compaction, design rule check, power and delay estimation, clock and power routing, etc. Special considerations for analog and mixed-signal designs and FPGA.	(5)

Text and Reference:

1. R.H. Katz. ***Contemporary logic design.*** Addison-Wesley Pub. Co.,
2. M.J.S. Smith. ***Application-specific integrated circuits.*** Addison-Wesley Pub. Co
3. S. Ramachandran. ***Digital VLSI systems design***. Springer, 2007
4. M.L. Bushnell and V.D. Agrawal. ***Essentials of Electronic Testing.*** Kluwer Academic Publishers
5. J. Bhasker. ***Verilog VHDL synthesis: a practical primer***. B S Publications
6. D.D. Gajski, N.D. Dutt, A.C. Wu and A.Y. Yin. ***High-level synthesis: introduction to chip and system design.*** Kluwer Academic Publishers
7. M. Sarrafzadeh and C.K. Wong. ***An introduction to physical design***. McGraw Hill
8. N.A. Sherwani. ***Algorithms for VLSI physical design automation***. Kluwer Academic Publishers
9. S.M. Sait and H. Youssef. ***VLSI physical design automation: theory and practice.*** World Scientific Pub. Co.

Course Outcomes (Cos):

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

1. understand VLSI and Verilog/VHDL
2. analyze optimization of tools and finite state machines
3. apply concepts of CAD and SPICE model
4. create physical automation algorithms

EE 459	EHV TRANSMISSION B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1:	**Introduction to Transmission**: Transmission system, Basic transmission topologies, Power transmission scenario in India	(2)
Unit-2:	**Calculation of line & Ground parameters:** Resistance of conductors, Temperature rise of conductor & current carrying capacity, Properties of bundled conductors, Inductance of EHV line configuration, Line Capacitance calculation, Sequence inductances & capacitances, Line parameter for modes of propagation, Resistance & Inductance of ground return	(5)
Unit-3:	**Voltage gradient of conductors**: Electrostatics, Field of sphere gap, Field of line charges & properties, Change Potential relations for multiconductor lines, Surface voltage gradient on conductors, Gradient factors & its use, Distribution of voltage gradient of subconductors of bundle	(5)
Unit-4:	**Corona Effect:** I^2R loss & corona loss, Corona loss formulas, Charge voltage diagram & corona loss, Audible noise generation & characteristics, Limits for audible noise, Formulae for audible noise & use in design	(6)
Unit-5:	**Electrostatic field of EHV lines:** Electric shocks and threshold currents, Electrostatic Fields (ES) of AC lines, effect of high ES on human, animal and plants, electromagnetic interference	(2)
Unit-6:	**Propagation in EHV Transmission System:** Travelling waves, voltage rise issues in open circuit lines, analysis of travelling waves for different termination scenarios of transmission lines	(4)
Unit-7:	**Compensation in Transmission System:** Series and Shunt compensation in Power system, FACTS devices, Choice of voltage control method in transmission system	(5)
Unit-8:	**HVDC Power Transmission:** Comparison between AC & DC Transmission, Application of DC Transmission, Thyristor - Thyristor device, Thyristor valves, valve test, Converter-Pulse number, Choice of converter configuration, Simplified analysis of Graetz ckts, Converter bridge characteristics, Characteristics of twelve pulse converter, detailed analysis of converters.	(8)

Text and Reference:

1. R. D. Begamudre. ***EHVAC Transmission Engineering.*** New Age International (p) Ltd. 3rd Edition
2. Adamson & Hingrani. ***D.C. Transmission.*** Garraway Ltd
3. K.R. Padiyar. ***HVDC Power Transmission Systems.*** New Age International (p) Ltd. 2nd revised Edition, 2012

Course Outcomes (Cos):

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

1. understand and explain the characteristics of transmission systems
2. analyze the operational issues in AC transmission system
3. apply knowledge to solve operational problems in transmission system
4. understand the opportunities for HVDC transmission system

EE 460	Power Electronics Application to Wind and Solar Energy Systems B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Power Electronics (EE 304), Modern Control Systems (EE 308)

Unit-1:	**Introduction to energy sources:** Recentt 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.	(6)
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&I-V characteristics, effect of change in insolation and temperature on PV cell, partial shading, blocking and bypass diode, modules, MPPT algorithms	(8)
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.	(10)
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.	(10)
Unit-5:	**Applications:** PV Power plant, water pumping, hybrid PV-wind system	(6)

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

Course Outcomes (Cos):

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

1. analyze the various Non-Conventional sources of energy and storage
2. examine the characteristics of solar PV systems.
3. analyze converters for Solar PV system in off grid and grid connected modes.
4. select different converters for wind energy conversion systems.

EE 466 Distribution System Planning and Automation

B. Tech (Electrical Engg.) Eighth Semester
(Professional Elective-III)

L	T	P	C
3	0	0	3

Pre-requisites: Nil

Unit-1: **Distribution system planning and forecasting:** Configuration of distribution system- Distribution system planning-issues and aspects, Introduction to Distribution system forecasting techniques, Stochastic and time series techniques for forecasting, intelligent techniques based load forecasting techniques. (4)

Unit-2: **Distribution Sub-Stations and feeder:** substation layout, Sub-stations site selection procedure, Sub-station capacity expansion, Location of new sub-stations and their rating, Sub-station bus schemes, Characteristics of primary and secondary systems, distribution sub-station and feeder design. Distribution system grounding. (6)

Unit-3: **Load characteristics and Distribution transformers (DTRs):** Definitions and importance of various terms that characterize loads, types of tariffs. Basic design considerations, 3-ph and 1-ph DTRs-types of connections and its relevance in operation, need for special types of distribution transformers, Cast resin, CSP, Amorphous core DTRs, Regulation and efficiency of transformers-use of predetermined curves. (6)

Unit-4: **Voltage drop and power loss calculation:** VD and PL calculations for a service area with four and six feeders, VD and PL calculations for a service area with n-feeders, Importance of power factor in distribution systems, Capacitors and their role in improving power factor. (6)

Unit-5: **Distribution system protection:** Objective of distribution system protection. Basic definitions – types of over current protection devices. Coordination of Protective Devices, Lightning Protection (4)

Unit-6: **Distribution system automation (DSA)**: Need for Distribution automation, characteristics of distribution system, distribution automation, feeder automation, Communication requirements for DSA, Automatic Meter Reading, SCADA. (8)

Text and Reference:

1. Turan Gonen. ***Electric Power Distribution Engineering***. CRC Press, 2014
2. A.S. Pabla. ***Electric Power Distribution.*** TMH,2004
3. Glover Sarma and overbye. ***Power System Analysis and Design.*** Cengage Learning. 2018
4. M.K. Khedkar and G.M. Dhole. ***A Textbook of Electric Power Distribution Automation***. University Science Press, 2010

Course Outcomes (Cos):

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

1. understand the characteristics and components of electric power distribution systems
2. analyze the appropriate substation location, feeder configuration and DTRs
3. design a distribution system
4. apply the components of protection and distribution automation systems.

EE 467 Intelligent Algorithms for Power Systems

B. Tech (Electrical Engg.) Eighth Semester
(Professional Elective-III)

L	T	P	C
3	0	0	3

Pre-requisites: Nil

Unit-1:	**Introduction:** Concept of artificial intelligence, classification and optimization techniques	(2)
Unit-2:	**Artificial Neural Networks:** Fundamental concepts, basic models, Learning rules, multilayer feed-forward networks, back-propagation training algorithm, radial basis function and recurrent networks, supervised and unsupervised learning	(8)
Unit-3:	**Fuzzy Systems:** Fuzzy sets, operation on fuzzy sets, Fuzzy relations, Fuzzy measures, Fuzzy logic.	(6)
Unit-4:	**Optimization algorithms:** Search techniques, conventional and non-conventional optimization, genetic algorithm, swarm optimization.	(12)
Unit-5:	**Applications in Power System:** Short term and long term load forecasting, economic load dispatch scheduling, hydro thermal scheduling, optimal power flow, identification and classification of faults.	(12)

Text and Reference:

1. Stamatios V. Kartalopoulos. ***Understanding Neural Networks and Fuzzy Logic.*** IEEE Press
2. Simon Haykin. ***Neural Networks.*** Pearson Education Asia
3. L. Davis. ***Handbook of Genetic Algorithms.*** Van Nostrand Reinhold
4. M. M. Gupta. ***Intelligent Control System.*** IEEE Press

Course Outcomes (Cos):

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

1. analyze and mathematically model Artificial Neural Networks.
2. analyze the concept of Fuzzy Systems.
3. analyze and mathematically model various optimization algorithms.
4. apply intelligent algorithms to solve practical power system problems.

EE 468	Hydro-Electric Engineering	L	T	P	C
	B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	3	0	0	3

Pre-requisites: **Nil**

Unit-1:	**Hydrology**: Introduction, Hydraulic Cycle, Hydrograph, Flow duration curve. Mass curve. Size of plant and choice of units.	(2)
Unit-2:	**Introduction to Hydro-Electric Power plant (HEPP).** Application. Advantages and disadvantages. Selection of sites. Essential features/ elements of HEPP. Dam- Types and their description. Selection of site for a Dam. Construction. Spillways- types, Conduits, Surge tank and its types. Electrical and mechanical components in HEPP. Average life of hydro-plant components	(6)
Unit-3:	**Classification of hydroelectric power plants**. High, medium, low head power plants. Base load plants. Peak load plants. Run of river plants.Storage type of plants. Pumped storage plants: Pumping schedule, operation and efficiency of pumped storage schemes. Mini and micro hydro plants.Types of Underground Power Plants. Largest Underground.	(6)
Unit-4:	**Hydraulic turbine**: Types and their characteristics. Design of main dimensions of turbines. Draft tubes - types, setting and preliminary dimensions, Selection of turbines and pump capacities.	(8)
Unit-5:	**Cost evaluation of hydroelectric power plant**. Co-ordination of different types of Power Plant in power system. Economic loading of hydro-power plants. Hydro-thermal mix, Load dispatching. Power system security. Load forecasting. Generation allocation control. Generation system reliability.	(8)
Unit-6:	**Automatic and remote control of HEPP:** Safety measures. Preventive maintenance. Calculation of available Hydro power. Cost of Hydro-Power.	(6)

Text and Reference:

1. G.D. Rai. ***An Introduction to Power Plant Technology.*** Khanna Publisher
2. G.R. Nagpal. ***Power Plant Engineering.*** Khanna Publisher
3. M.V. Deshpandey. ***Elements of Electrical Power Station Design***. Weeler
4. Mahesh Verma. ***Power Plant Engineering.*** Metropolitan Book Company
5. Arora and Domkundwar. ***A Course in Power Plant Engineering***. Dhanpat Rai

Course Outcomes (Cos):

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

1. understand and explain the elements, advantages, classification, constructions of hydroelectric power plant.
2. design the main dimensions of hydro turbine
3. evaluate the security, reliability, coordinated operation of Hydroelectric power plants
4. analyze hydrology, available hydropower
5. explain the automatic and remote control, safety and preventive measures.

EE 469	Non-Conventional and Distributed Generation B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1:	**Introduction to Distributed Energy Resources: Distributed generation, active distribution network, concept, technical features, operational and management issues, economic viability and market participation social implications.**	(6)
Unit-2:	**Solar Thermal Power Generation: Introduction, concept and basic characteristics, different concentrating type collectors, state-of-the-art technologies and applications.**	(6)
Unit-3:	**Generators and Power Electronics for Wind Turbines: State-of-the-art technologies, generator concepts, power electronic concepts, applications-economics of wind power.**	(8)
Unit-4:	**Geothermal Electricity Generation: Features of geothermal power plant, dry steam power plant, flash steam power plant, binary cycle power plant and bi-phase power plant, power potentials and flashing characteristics of geothermal fluids**	(5)
Unit-5:	**Combined heat and power systems: Concept, micro-CHP systems, microturbines, common features, construction and applications**	(5)
Unit-6:	**Fuel Cells: Principles of operation of fuel cells-fundamentals electrochemical processes, proton exchange membrane fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell and applications.**	()
Unit-7:	**Storage Devices: Super capacitor, superconducting magnetic storage energy system, battery storage, flywheel storage, compressed air storage system, industrial and domestic applications of storage devices.**	(5)
Unit-8:	**Interconnection of Distributed Energy Resources with the Grid: Interconnection technologies, standards and code for interconnection, interconnection considerations and examples.**	(5)

Text and Reference:

1. S. Chowdhury, S.P. Chowdhury and P. Crossley. ***Microgrids and Active Distribution Networks.*** IET
2. Trevor M. Letcher. ***Future Energy: Improved, Sustaianable and Clean Options for Our Planate.*** Elsevier Science
3. Felix A. Farret, M. Godoy Simões . ***Integration of Alternative Sources of Energy***. Wiley-Blackwell
4. Thomas Ackermann. ***Wind Power in Power Systems.*** 2nd Edition. Wiley
5. Gregory W. Massey, PE. ***Essentials of Distributed Generation Systems.*** Jones & Bartlett Learning
6. Dr. N K Giri. ***Alternatie Energy-Sources, Applications and Technologies***. Khanna Publishers
7. M. H. Nehrir, C. Wang. ***Modeling and Control of Fuel Cells Distributed Generation Application.*** Wiley-Blackwell
8. Sammes, Nige. ***Fuel Cell Technologies-State and Perspectives.*** Springer Publication

Course Outcomes (Cos):

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

1. model and simulate different distributed generation systems.
2. apply knowledge to solve operational problems in distributed generation.
3. analyze the performance of generators and choose the efficient generator for wind application.
4. identify the appropriate standards and code for grid interconnection.

EE 470	Navigation, Guidance and Control B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Control Systems (EE 301)

Unit-1:	**Introduction:** Introduction, Motivation and Overview, Overview of Steady State Approach and Matrix Theory, Review of Numerical Methods. (3) **Optimal Control:** An Overview of Static Optimization, Review of Calculus of Variations, Optimal Control Formulation Using Calculus of Variations, Classical Numerical Methods to Solve Optimal Control Problems, Linear Quadratic Regulator, Discrete-time Optimal Control (6)	(9)
Unit-2:	**Guidance System Design:** Flight Dynamics**,** Linear Optimal Missile Guidance using LQR, State Dependent Riccati Equation and θ – D Designs, Dynamic Programming, Approximate Dynamic Programming (ADP), Adaptive Critic (AC) and Single Network Adaptive Critic (SNAC) Design. (8) **Advanced Numerical Techniques for Optimal Control:** Transcription Method to Solve Optimal Control Problems, Model Predictive Static Programming (MPSP) and Optimal Guidance of Aerospace Vehicles, MPSP for Optimal Missile Guidance, Model Predictive Spread Control (MPSC) and Generalized MPSP (G-MPSP) Designs.(11)	(19)
Unit-3:	**Integrated Estimation, Guidance and Control:** Linear Quadratic Observer & An Overview of State Estimation, Review of Probability Theory and Random Variables, Kalman Filter Design, Integrated Estimation, Guidance & Control, Linear Quadratic Guassian Design, Neighboring Optimal Control & Sufficiency Condition**,** Constrained Optimal Control, Optimal Control of Distributed Parameter Systems.	(12)

Text and Reference:

1. D. S. Naidu. ***Optimal Control Systems.*** CRC Press
2. A.P. Sage and C. C. White. ***Optimum Systems Control***. Prentice Hall
3. A.Sinha. ***Linear Systems: Optimal and Robust Control.*** CRC Press
4. A.E. Bryson and Y-C Ho. ***Applied Optimal Control.*** Taylor and Francis
5. D. E. Kirk. ***Optimal Control Theory***. Prentice Hall

Course Outcomes (Cos):

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

1. formulate optimal control using calculus of variation
2. apply advanced numerical techniques to solve optimal control problems.
3. design obsevers and Kalman filters.
4. formulate an estimation and guidance control system using optimal control and calculus of variation.

EE 471	Non-linear Systems Analysis and Control B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1:	**Introduction to nonlinear systems**: Properties of nonlinear systems, Characteristics of common nonlinearity, Concept of equilibrium/singular points, Comparison between linear and nonlinear systems.	(4)
Unit-2:	**G One-dimensional system**: Fixed points and stability (geometric approach), Linear stability analysis, Existence and uniqueness of the solution, Bifurcations, Flow on a circle (oscillator)	(7)
Unit-3:	**Two-dimensional system**: Linear systems and their classifications, Phase portraits, Vector field, Existence, uniqueness, and topological issues, Fixed point and linearization, Limit cycles, Bifurcations, Introduction of isoclines and delta method, Stability analysis by phase plane analysis	(6)
Unit-4:	**Describing function of common nonlinearities**, Stability analysis using Describing function	(3)
Unit-5:	**Lyapunov stability**: Stability in the sense of Lyapunov, Lyapunov theorems, LaSalle's Principles, Lyapunov equation	(8)
Unit-6:	**Introduction to Nonlinear Controllers**: Active nonlinear controller, Backstepping Controller. Feedback linearization, Variable structure control, and Sliding mode control	(12)

Text and Reference:

1. Slotine and Li. ***Applied Non-Linear Control.*** Prentice-Hall
2. Hassan K Khalil. ***Nonlinear Systems.*** Prentice Hall
3. Steven H. Strogatz. ***Nonlinear Dynamics and Chaos.*** CRC Press

Course Outcomes (Cos):

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

1. analyze a system to find its special behaviors and compare them to that of a linear system.
2. analyze the stability and bifurcation of a first or 2nd order nonlinear system; validate the findings by simulation.
3. apply describing function and phase-plane analysis to find stability and analyze the outcomes.
4. apply the concepts of Lyapunov to analyze the stability of the equilibrium point of linear and nonlinear systems.
5. design various controller of a system and evaluate their comparative performances both theoretically and simulation

EE 472	Computer Relaying and Phasor Measurement Unit B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Power System-I (EE 1205), Switchgear & Industrial Protection (EE 1307), Signals and Systems (EE 1206)

Unit-1: Digital/ Numerical Relay: (4)

Introduction to Numerical relay, Comparison between electromechanical relays and numerical relay, Computer relay architecture and subsystems, Advantages and disadvantages of Numerical relay and Adaptive relaying.

Unit-2: Relaying Algorithms: (6)

Mathematical background to protection algorithm, Finite difference technique, Numerical differentiation, Least Squares Method, Fourier analysis: Fourier analysis of analog signals, Fourier analysis of discrete signals and Walsh function analysis.

Unit-3: Hardware Considerations (12)

IC Elements and circuits for interfaces: Zero crossing detector, Phase shifter, Current to voltage converter, Surge protection circuits and Precision rectifier (4)

Data Acquisition System: Signal conditioning, Aliasing, Sampling, Analog Interfacing. (2)

Analog Interfacing: Sample and Hold circuit, Analog Multiplexers, Analog to Digital Converters, Digital to Analog Converters. (4)

Memory and Filters: Data and Program memory, Digital Filters, Finite Impulse Response and Infinite Impulse Response (2)

Unit-4: Phasor Measurement Unit (PMU) (18)

Introduction, Phasor representation of sinusoids, Phasor Estimation of Nominal Frequency Signals, Formulas for updating phasors, Non recursive updates-Recursive updates and Frequency Estimation. (6)

A Generic PMU, The Global Positioning System, Hierarchy for Phasor Measurement Systems, Communication Options for PMUs, Synchro phasor Measurement, Synchro phasor Communication, Phasor Data Concentrator (PDC) Files (6)

Phasor Measurement Applications-State Estimation-History-Operator's load flow- Weighted least square - Linear weighted least squares; Nonlinear weighted least squares- Static state estimation-State estimation with Phasor measurements- linear state estimation. (6)

Text and Reference:

1. Badriraam and Vishwakarma. ***Power System Protection and Switchgear.*** 2nd edition, TMH, 2011
2. Arun G. Phadke, James S. Thorp. ***Computer Relaying for Power Systems.*** A John Wiley and Sons Ltd., Research Studies Press Limited, 2009

3. A.G. Phadke, J.S. Thorp. ***Synchronized Phasor Measurements and Their Applications.*** Springer, 2008
4. A.T. Johns and S. K. Salman. ***Digital Protection for Power Systems.*** Peter Peregrinus Ltd, 1997.
5. Paithankar Y G and S R Bhide. ***Fundamentals of Power System Protection.*** Prentice Hall of India, 2011.
6. Bahvesh Bhaljia, R P Maheswari, and Nilesh G Chothani. **Protection and Switchgear. edition**, Oxford University Press, 2011
7. T S Madhava Rao. **Static Relays with Microprocessor Application.** 2nd edition, TMH, 2009

Course Outcomes (Cos):

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

1. understand the operation of computer relay
2. measure the basics of phasor measurement unit
3. apply the different applications of PMUs in power systems

EE 473	Smart Grid Technologies B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1:	**Smart Grid:** Definition, Various components, Smart Grid architecture, Application and standards.	(4)
Unit-2:	**Renewable Generation:** Renewable Resources: Wind and Solar, Micro-grid Architecture, Distributed Storage and Reserves, Dealing with short term variations.	(6)
Unit-3:	**Smart Grid Communications:** Data communication, Network Architectures, IP-based Systems Power Line Communications, Advanced Metering Infrastructure, communication protocols.	(6)
Unit-4:	**Wide Area Measurement:** Sensor Networks, Phasor Measurement Units, Communications Infrastructure, Fault Detection and Self-Healing Systems, Applications and Challenges.	(5)
Unit-5:	**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	(10)
Unit-6:	**Security and Privacy**: Possible threats and cyber security challenges in smart grid, Information security.	(4)

Text and Reference:

1. A. J. Wood, B. F. Wollenberg. ***Power Generation Operation and Control.*** John Wiley & Sons, 2013
2. J. Ekanayake, N. Jenkins, K. Liyanage K, J. Wu, A. Yokoyama. ***Smart Grid: Technology and applications.*** John Wiley & Sons, 2012
3. James Momoh. ***Smart Grid: Fundamentals of design and analysis.*** John Wiley & Sons, 2012
4. G. M. Masters. ***Renewable and Efficient Electric Power Systems***. John Wiley & Sons, 2004

Course Outcomes (Cos):

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

1. explain the operation and intermittent nature of renewable energy sources.
2. analyze smart grid structure including, technologies, components, standards used and applications.
3. apply knowledge to develop demand side management strategy
4. inspect the cyber security issues of smart grid and protection aspects of micro grid.

EE 474	Advanced Instrumentation B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1:	Review of instrumentation, OP-AMP, signal conditioning, Data acquisition, ADC/DAC, sensors and transducers	(4)
Unit-2:	Industrial remote control – IR, RF and other technologies, advantages, and vulnerability	(4)
Unit-3:	Non- Destructive Testing tools: Die penitrant testing, Eddy current testing, Ultrasonic testing, Radiographic testing tools and others	(6)
Unit-4:	Smart sensors- smart gas sensor, smart door/window sensor, smart leakage detector, smart motion sensor	(4)
Unit-5:	IoT based instrumentation- Home, Office and Industry, Virtual instrumentation (	(6)
Unit-6:	Instrumentation in road, water and air transportation	(5)
Unit-7:	Instrumentation in earthquake seismology	(2)
Unit-8:	Instrumentation in space exploration	(2)
Unit-9:	Instrumentation in robotics and automation	(4)
Unit-10:	Recent topics in instrumentation	(3)

Text and Reference:

1. Patrick H. Garrett. ***Advanced Instrumentation and Computer I/O Design.*** Wiley
2. Impe, Vanrolleghem, and Iserentant. ***Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes***. Springer
3. Sumathi and Surekha. ***LabVIEW based Advanced Instrumentation Systems.*** Springer
4. A.E. Fribance. ***Industrial Instrumentation Fundamentals.*** McGraw-Hill Inc.
5. D.V.S. Murthy. ***Transducers and Instrumentation.*** PHI
6. W. C. Dunn. ***Fundamentals of Industrial Instrumentation and Process Control.*** McGraw-Hill

Course Outcomes (Cos):

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

1. analyse measurement technique, signal conditioning and instrumentation system in different industries
2. design and selection of different types of sensors and transducers in instrumentation system
3. apply advanced instrumentation in seismology, space exploration, robotics and automation

EE 475	Special Electrical Machines and Drives B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Electrical Machines-I (EE 206), Electrical Machines-II (EE 303), Industrial Drives (EE 307)

Unit-1: **Permanent Magnet Motors:** Classification of permanent magnet motors; Principles of permanent magnet material and its various types and characteristics; Permanent Magnet DC (PMDC) Motor: Construction, Working principle, performance characteristics, various types and applications; Brushless DC (BLDC) Motors and Permanent Magnet Synchronous Motors (PMSM): Classification based on rotor construction: Surface-mounted PM (SPM) rotor (Projecting magnet & Inset magnet types) and Interior PM (IPM) rotor

Unit-2: **Brushless DC (BLDC) Motors:** Basic BLDC motor working principle (without current control): Three-phase unipolar and bipolar driven BLDC motor, Rotor position encoder arrangement, Switching sequences for CW and CCW directions, Torque expression and analysis of torque production; Detection of rotor position using Hall elements; Trapezoidal excited BLDC (Trapezoidal PMAC) motor drive with current control:Features of stator and rotor construction, Injection of quasi-square phase current waveform using current regulated voltage source inverter, Torque expression and analysis of torque production; Dynamic modeling of BLDC motor; Closed loop speed control; Important features and applications (24)

Unit-3: **Permanent Magnet Synchronous Motors (PMSM) or Sinusoidal PMAC motors:** Steady state analysis, 1-phase equivalent circuit model and phasor-diagram, Mechanical power and torque developed, Analysis with phasor diagram for maximum torque per ampere under both motoring and braking operation, flux weakening mode of operation, Dynamic model of PMSM, Vector control of PMSM drive, Features and applications

Unit-4: **Permanent Magnet Axial Flow (PMAF) Machines:** Comparison of Permanent Magnet Redial Flux (PMRF) and Axial Flux (PMAF) machines, Types and constructions, Armature windings, Torque and EMF equations, Phasor diagram of PMAF motor, Output equation, Control of Trapezoidal and Sinusoidal PMAF motors, Applications

Unit-5: **Module 2 (8 hours): Switched Reluctance Motors (SRM):** Constructional features; Operating principle, Control requirement: Basics of SRM analysis, Constraints on pole arc and tooth arc, Torque equation and characteristics, Power Converter circuits, Control of SRM, Methods of Rotor position sensing, Current injection principle; Current regulators: Hysteresis type and Voltage PWM type (duty-cycle control), Torque-speed characteristic and different modes of operations, Closed-loop speed control of SRM drive, Features and applications. (8)

Unit-6: **Linear Electric Machines (LEM):** Introduction, Linear Induction Motors (LIM): Types and constructions, Thrust equation, Equivalent circuit, characteristics, Design aspects and control; Linear Synchronous Motors (LSM): Types and constructions, Thrust equation, Control scheme, Advantages and applications; DC Linear Motors (DCLM): Types and constructions, Thrust equation, Advantages and applications; Linear Reluctance Motors (LRM): Types and constructions, Working principle, Features and applications; Linear Levitation Machines (LLM): Principle of Levitation, Attraction and Repulsion types LLM, Levitation goodness factor and stiffness (8)

Text and Reference:

1. T. Kenjo and S. Nagamori. ***Permanent Magnet and Brushless DC Motors.*** Clarendon Press, London
2. R. Krishnan. ***Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application.*** CRC Press, New York
3. E. G. Janardanan. ***Special Electrical Machines.*** PHI
4. G. K. Dubey. ***Fundamentals of Electrical Drives.*** Narosa Publishing House
5. B. K. Bose. ***Modern Power Electronics and AC Drives.*** Pearson Education
6. T.J.E. Miller. ***Brushless Permanent Magnet and Reluctance Motor Drives. Clarendon*** Press, Oxford
7. A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans. ***Electric Machinery.*** McGraw-Hill
8. Nasar.S.A, Boldeal. ***Linear Motion Electric machine.*** John Wiley
9. Ion Boldea. ***Linear electric machines, drives, and MAGLEVs handbook.*** CRC Press, Taylor & Francis group
10. K. Venkataratnam. ***Special Electrical Machines.*** Universties Press
11. P.S. Bhimbra. ***Generalized Theory of Electrical Machines.*** Khanna Publishers
12. R. Krishnan. ***Electric Motor Drives - Modeling, Analysis and Control.*** PHI

Course Outcomes (Cos):

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

1. examine the construction and working principles of different types of PM machines.
2. Illustrate the constructional and principle of operation of variable reluctance and linear electric machines.
3. analyze the performance of different types of PM, variable reluctance and linear electric machines.
4. analyze the control aspects of PM and variable reluctance machines using suitable power converters
5. choose different types of special electrical machines for suitable field of applications.

EE 476	Intelligent Control B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Modern Control Systems (EE 308)

Unit-1:	**Introduction:** Introduction to intelligent control, comparison study between conventional and intelligent control, intelligent supervisory control, intelligent adaptive control.	(3)
Unit-2:	**Neural network based control:** Introduction to Neural Network, theory of neural network for classification and function approximation, supervised and unsupervised learning rules, RBF neural network, Support vector machines, intelligent control using Neural Network, Approximation capabilities by feed-forward and recurrent neural network, Neuro-control based on back propagation algorithm, system identification with neural network.	(15)
Unit-3:	**Fuzzy logic control:** Introduction to fuzzy set theory and logic, application of fuzzy logic in control system, fuzzy quantization of knowledge, fuzzy controller design, Fuzzy T-S modelling for dynamic system and stability using Lyapunov theory.	(10)
Unit-4:	**Genetic algorithm and control:** Basic theory and operations of Genetic algorithm, GA based control system, optimization problem using GA related to control and other engineering problems. **(6)**	(6)
Unit-5:	**Bio-inspired evolutionary algorithms:** Bio-inspired evolutionary algorithms – like Particle swamp optimization (PSO), simulated annealing, Fire-fly optimization, bacterial foraging etc – only the concepts and case studies related control problems. **(6)**	(6)

Text and Reference:

1. S. Haykin . ***Intelligent Control System.*** IEEE Press
2. Goldberg. ***Gentic Algorithm***. Pearson Education
3. J. Yen and R. Langari. ***Fuzzy logic (intelligence control and information).*** Pearson Education

Course Outcomes (Cos):

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

1. design feedback controllers for complex dynamic systems using ANN.
2. design fuzzy logic-based controller for dynamic systems.
3. construct TS fuzzy models for complex dynamic systems.
4. formulate hybrid controllers by combining the concepts of Genetic Algorithm and Bio-Inspired algorithms with ANN and Fuzzy logic.

EE 477	Energy Auditing, Conservation and Management	L	T	P	C
	B. Tech (Electrical Engg.) Eighth Semester (Professional Elective-III)	3	0	0	3

Pre-requisites: Nil

Unit-1:	**Basic Principles of Energy Audit:** Energy audit- definitions, concept , types of audit, energy index, cost index, pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries-energy saving potential, energy audit of process industry, thermal power station, building energy audit.	(9)
Unit-2:	**Energy Management:** Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting- Energy manger, Qualities and functions, language, Questionnaire – check list for top management.	(7)
Unit-3:	**Energy Efficient Motors:** Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics – variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit.	(8)
Unit-4:	**Power Factor Improvement, Lighting and Energy Instruments:** Power factor – methods of improvement, location of capacitors, pf with nonlinear loads, effect of harmonics on power factor, power factor motor controllers – Good lighting system design and practice, lighting control, lighting energy audit – Energy Instruments- wattmeter, data loggers, thermocouples, pyrometers, lux meters, tongue testers ,application of PLC's.	(8)
Unit-5:	**Economic Aspects and Analysis:** Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method , replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment .	(8)

Text and Reference:

1. W.R. Murphy & G. Mckay Butter worth. ***Energy management.*** Heinemann
2. Paul o' Callaghan. ***Energy management.*** McGraw Hill
3. John. C. Andreas. ***Energy efficient electric motors.*** Marcel Dekker Inc Ltd
4. W. C. Turner. ***Energy management hand book.*** John wiley and sons

Course Outcomes (Cos):

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

1. perform energy audit of different industrial consumers
2. predict management of different energy systems
3. establish methods of improving efficiency of electric motors
4. analyse the effect of power factor and to design a good illumination system
5. determine pay back periods for energy saving equipment

EE 491	**Electric Vehicle** **B. Tech (Electrical Engg.) Eighth Semester** **(Open Elective-III)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisites: Nil

Unit-1:	**Fundamentals of Electric Vehicles (EV):** Introduction to Electric Vehicle technology – Types –Fundamental issues related to electric vehicles (EVs) and hybrid electric vehicles (HEVs) – Interdisciplinary Nature of EVs – State of the Art of EVs – Advantages and Disadvantages – Challenges and Key Technologies of EVs – Challenges for EV Industry in India	(8)
Unit-2:	**Electric Vehicle Batteries:** Electric vehicle battery efficiency – type – capacity –charging/discharging –technical characteristics – performance – testing, EV battery for stationary applications (B2U).	(7)
Unit-3:	**Charging Techniques:** Architecture/Components of EV charging station – EVSE (Electric Vehicle Supply Equipment) – Type of EV Chargers – Charging Methods – Automotive networking and communication, EV and EV charging standards.	(8)
Unit-4:	**Energy Management:** Introduction to energy management strategies used in electric vehicle - classification of different energy management strategies - comparison of different energy management strategies - implementation issues of energy strategies.	(5)
Unit-5:	**Grid Applications:** Concept of Vehicle to Grid (V2G/G2V)–Ancillary Services – peak saving – load-generation balance – Demand Response – Energy time shift – Energy Management strategies and its general architecture – integration of EVs in smart grid, social dimensions of EVs.	(8)

Text and Reference:

1. James Larminie, John Lowry. ***Electric Vehicle Technology Explained***. Wiley-Blackwell, 2nd Edition, 2012.
2. Sheldon S. Williamson. ***Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles.*** Springer, 1st Edition, 2016
3. Ali Emadi, Mehrdad Ehsani, John M. Miller. ***Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles.*** CRC Press, 2003.
4. Iqbal Hussain. ***Electric & Hybrid Vehicles Design Fundamentals.*** 2nd Edition, CRC Press, 2011.
5. Sandeep Dhameja. ***Electric Vehicle Battery Systems.*** Elsevier, 1st Edition, 2012.
6. Ali Emadi. ***Advanced Electric Drive Vehicles.*** CRC Press, 1st Edition, 2017.
7. Chris Mi, M. Abul Masrur, D. Wenzhong Gao, A Dearborn. ***Hybrid electric Vehicles Principles and applications with practical perspectives.*** John Wiley & Sons Ltd., 2nd Edition, 2017.
8. T. Muneer and I. Illescas García. ***The automobile, In Electric Vehicles: Prospects and Challenges***. Elsevier, 1st Edition, 2017.

9. S. Rajakaruna, F. Shahnia, and A. Ghosh. ***Plug In Electric Vehicles in Smart Grids.*** Springer Singapore, 1st Edition, 2015.
10. J. Lu, and J. Hossain. ***Vehicle-to-Grid: Linking electric vehicles to the smart grid.*** IET, 1st Edition, 2015
11. N. B. Arias, S. Hashemi, P. B. Andersen, C. Træholt, and R. Romero. ***Distribution System Services Provided by Electric Vehicles: Recent Status, Challenges, and Future Prospects.*** IEEE Transactions on Intelligent Transportation Systems, 2019.

Course Outcomes (Cos):

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

1. understand the Electric Vehicle concepts and its importance in Indian energy scenario.
2. assess the role of EV in modern distribution system and smart grids
3. realize the technology, design methodologies and control strategy of electric vehicles
4. apply energy management techniques for electric vehicles
5. analyze the operation and importance of EVs in Grid Applications.

EE 492	**Soft Computing Techniques and Applications**	**L**	**T**	**P**	**C**
	B. Tech (Electrical Engg.) Eighth Semester (Open Elective-III)	**3**	**0**	**0**	**3**

Pre-requisites: Introduction to Computing

Unit-1:	**Introduction to soft computing**, intelligent decision system, overview of soft computing techniques. Introduction to genetic algorithm, genetic operators and parameters, genetic algorithms in problem solving, theoretical foundations of genetic algorithms, evolutionary programming, particle swarm optimization, differential evolution; implementation issues and applications.	(12)
Unit-2:	**Neural Networks:** Neural model and network architectures, perceptron learning, supervised hebbian learning, backpropagation, associative learning, competitive networks, hopfield network, computing with neural nets and applications of neural network. case-based reasoning (CBR), applications of CBR.	(10)
Unit-3:	**Fuzzy Sets:** Introduction to fuzzy sets, operations on fuzzy sets, fuzzy relations, fuzzy measures, applications of fuzzy set theory to different branches of science and engineering.	(8)
Unit-4:	**MATLAB tutorial** Application of soft computing to control systems Application of soft computing to decision-support systems Application of soft computing to image processing and data compression Application of soft computing to handwriting recognition Application of soft computing to automotive systems and manufacturing Application of soft computing to architecture Application of soft computing to power systems Fuzzy logic control Neuro-fuzzy systems.	(10)

Text and Reference:

1. D. E. Goldberg. ***Genetic Algorithms in Search, Optimization, and Machine Learning.*** Addison-Wesley
2. Z. Michalewicz. ***Genetic Algorithms+ Data Structures + Evolution Programs***. Springer-Verlag
3. N. K. Sinha & M. M. Gupta (Eds) ***Soft Computing & Intelligent Systems: Theory & Applications*** Academic Press
4. M.T. Hagan, H. B. Demuth, and M. Beale. ***Neural Network Design***. Thompson Learning
5. S. Haykin. ***Neural Networks- A Comprehensive Foundation***. PHI
6. C. Lau. ***Neural Networks***. IEEE Press
7. Satish Kumar, ***Neural Networks- A Classroom Approach.*** TMH
8. G. J. Klir, and B. Yuan ***Fuzzy. Sets and Fuzzy Logic: Theory and Applications.***
9. H. J. Zimmerman. ***Fuzzy Set Theory and Its Applications Kluwer.*** Academic Press

Course Outcomes (Cos):

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

1. Apply soft computing techniques in teal life problem.
2. Apply artificial neural network for modeling and simulation.

3. Implement fuzzy sets for decision making process.
4. Program in Matlab codes.

EE 493	Electrical Safety B. Tech (Electrical Engg.) Eighth Semester (Open Elective-III)	L	T	P	C
		3	0	0	3

Pre-requisites: Nil

Unit-1: **Hazards of Electricity and Electrical Safety Equipments:** Hazard Analysis - Shock, Arc, Blast and its 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 and their selection - Proximity and Contact Testers - Safety Grounding Equipments, Safety Electrical One-Line Diagram - Electrician's Safety Kit. (7)

Unit-2: **Grounding and Bonding of Electrical Systems and Equipments:** 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 (7)

Unit-3: **Safety Procedures and Methods:** The Six Step Safety Methods - Job Briefings, Hot-Work Decision Tree, Safe Switching of Power System - Lockout - Tag out - Procedures and Methods - Flash Hazard Calculation and Approach Distances - Calculating the Required Level of Arc Protection - Safety Equipment and Procedures for low, medium and high voltage systems - Electrical Safety around Electronic Circuits, Safety Hazards of Stationary Batteries and Safety Procedures- Electrical Hazards in the Home. (8)

Unit-4: **Maintenance of Electrical Equipment:** Safety Related Case for Electrical Maintenance - Hazards Associated with Electrical Maintenance - Reliability Centered Maintenance (RCM) - Eight Step Maintenance Programme - Frequency of Maintenance - Maintenance Requirement for Specific Equipment and Locations - Regulatory Bodies - National Electrical Safety Code - Standard for Electrical Safety in Workplace - Occupational Safety and Health Administration Standards.Neuro-fuzzy systems. (9)

Unit-5: **Accident Prevention, Safety Management and Organizational Structure:** Accident Prevention - First Aid - Rescue Techniques - Accident Investigation. Electrical Safety Program Structure - Development - Company Safety Team- Safety Policy - Problems and Solutions - Programme Implementation - Company Safety Procedures - Employee Electrical Safety Teams - Safety Meetings - Safety Audit - Procedure - Audit Team - Audit Tools - One Minute Safety Audit (9)

Text and Reference:

1. Dennis Neitzel, Al Winfield. ***Electrical Safety Handbook.*** McGraw Hill
2. John Cadick. ***Electrical Safety Handbook.*** McGraw Hill

3. Maxwell Adams. J. ***Electrical safety- A guide to the causes and prevention of electric hazards.*** Institution of Electric Engineers
4. Ray A. Jones, Jane G. Jones. ***Electrical safety in the workplace.*** Jones & Bartlett Learning

Course Outcomes (Cos):

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

1. analyze the hazards of electricity and select the electrical safety equipments accordingly.
2. analyze and apply various grounding and bonding techniques.
3. determine the safety procedures and select appropriate safety equipment for low, medium and high voltage systems.
4. devise the maintenance of electrical equipments by understanding various standards and procedures to participate in a safety team.

EE 494 Control Systems Components

B. Tech (Electrical Engg.) Eighth Semester
(Open Elective-III)

L	T	P	C
3	0	0	3

Pre-requisites: Nil

Unit-1:	Industrial Control Devices: Switches, Relays and Contactors, Power Controlled Semiconductor, Gears (7) Sensors: Position sensors, angular velocity sensors, proximity sensors, load sensors, pressure sensor temperature sensors, flow sensors, level sensors, Tachometers (8)	(15)
Unit-2:	Synchro, Potentiometers, Op-Amp, DC & AC Servomotors, Stepper Motor (7) 4Pneumatic, Hydraulic, Mechanical& Electrical systems, Hydraulic and pneumatic Valves and their characteristics, Hydraulic and Pneumatic Actuators & their characteristics and Comparison (8)	(15)
Unit-3:	Implementation of PID Controller, Microprocessor based control, PC Based Control, Dedicated customized controllers, PLC, DCS, SCADA.	(10)

Text and Reference:

1. Christopher T. Kilian**.** ***Modern Control Technology: Components and Systems***. Thomson Delmar
2. M. D. Desai. ***Control System Components***. PHI

Course Outcomes (Cos):

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

1. analyse principles of converters, control valves, etc pressure and flow sensors.
2. compare the different types of motors, switches, actuators and configure the transmitters.
3. demonstrate the design of different types of controllers