Scheme & Syllabi
of
B. Tech. (Electrical Engineering)

May 2023

DEPARTMENT OF ELECTRICAL ENGINEERING
MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Curriculum Structure of B. Tech. (Electrical Engineering)

I Semester

S. No.	Course Code	Course Title	Course Type	Credits (L T P)
1.	22EET107	Basic Electrical Engineering	Institute Core	2 (2 0 0)
2.	22EEP102	Electrical Engineering Lab	Institute Core	1 (0 0 2)
3.	22EET108	Power Generation Sources	Program Core	4 (3 1 0)

II Semester

S. No.	Course Code	Course Title	Course Type	Credits (L T P)
1.	22EET151	Measurements and Actuators	Program Core	4 (3 1 0)
2.	22EET152	Network Theory	Program Core	4 (3 1 0)
3.	22EEP153	Measurement and Instrumentation Lab	Program Core	1 (0 0 2)
			Total Credits (I & II Sem)	**37 (Fixed) + 13 = 50**

III Semester

S. No.	Course Code	Course Title	Course Type	Credits (L T P)
1.	22EET201	Advanced Programming for Design	Program Core	3 (3 0 0)
2.	22EET202	Analysis & Design of Digital Logic Circuits	Program Core	4 (3 1 0)
3.	22EET203	Electrical Machines-I	Program Core	4 (3 1 0)
4.	22EET204	Integrated Electronics	Program Core	4 (3 1 0)
5.	22EET205	Network, Systems and Signals	Program Core	4 (3 1 0)
6.	22MAT242	Advanced Engineering Mathematics	Program Linked Course-1 (Department of Mathematics)	4 (3 1 0)
7.	22EEP206	Electrical Machines Lab - I	Program Core	1 (0 0 2)
8.	22EEP207	Electrical Software and Simulation Lab	Program Core	1 (0 0 2)
9.	22EEP209	Integrated Electronics Circuit Lab	Program Core	1 (0 0 2)
			Total Credits	**26**

IV Semester

S. No.	Course Code	Course Title	Course Type	Credits (L T P)
1.	22EET251	Control System Engineering	Program Core	4 (3 1 0)
2.	22EET252	Electrical Machines-II	Program Core	4 (3 1 0)
3.	22EET253	Microprocessor and Microcontroller	Program Core	4 (3 1 0)
4.	22EET254	Power Electronics-I	Program Core	4 (3 1 0)
5.	22EET255	Transmission and Distribution Systems	Program Core	4 (3 1 0)
6.	22EEP256	Control System Lab	Program Core	1(0 0 2)
7.	22EEP257	Digital Electronics and Microprocessor Lab	Program Core	1 (0 0 2)
8.	22EEP258	Electrical Machine Lab-II	Program Core	1 (0 0 2)
9.	22EES259	Seminar	Program Core	1 (0 0 2)
			Total Credits	**24**

V Semester

S. No.	Course Code	Course Title	Course Type	Credits (L T P)
1.	22BMT921	Basics of Management	Management	3 (3 0 0)
2.	22ECT341	Principles of Communication Engineering	Program Linked Course-2 (Department of Electronics and Communication)	4 (3 1 0)
3.	22EET301	Modern Control Engineering	Program Core	4 (3 1 0)
4.	22EET302	Power Electronics-II	Program Core	4 (3 1 0)
5.	22EET303	Power System Switchgear and Protection	Program Core	4 (3 1 0)
6.	22EEP304	Power Electronics Lab	Program Core	1 (0 0 2)
7.	22EEP305	Power System Lab	Program Core	1 (0 0 2)
8.		Honours Course 1 (Optional)		3 (3 0 0)
9.		Honours Course 2 (Optional)		3 (3 0 0)
			Total Credits	**21 (+6)**

VI Semester

S. No.	Course Code	Course Title	Course Type	Credits (L T P)
1.	22EET351	Advanced Power Transmission	Program Core	4 (3 1 0)
2.	22EET352	Digital Signal Processing and Applications	Program Core	4 (3 1 0)
3.	22EET353	Electric Drives & Control	Program Core	4 (3 1 0)
4.	22EET354	Industrial Machine Learning	Program Core	4 (3 1 0)
5.	22EET355	Operation and Control of Power Systems	Program Core	4 (3 1 0)
6.	22EEP356	Electrical Drives Lab	Program Core	1 (0 0 2)
7.	22EEP357	Power System & Electrical Design Lab	Program Core	1 (0 0 2)
8.		Honours Course 3 (Optional)		3 (3 0 0)
9.		Honours Course 4 (Optional)		3 (3 0 0)
			Total Credits	**22 (+6)**

VII Semester

S. No.	Course Code	Course Title	Course Type	Credits (L T P)
1.	22EEW401	Minor Project	Project (Core)	3 (0 0 6)
2.	22EEO401	Training Seminar	Program Core	2 (0 0 4)
3.		Program Elective		4 (3 1 0)
4.		Program Elective		4 (3 1 0)
5.		Open Elective 1		3 (3 0 0)
6.		Honours Course 5 (Optional)		3 (3 0 0)
			Total Credits	**16 (+3)**

VIII Semester

S. No.	Course Code	Course Title	Course Type	Credits (L T P)
1.	22EEW451	Major Project (Option A)	Project (Optional)	8 (0 0 16)
2.		Option B	Program Elective	4 (3 1 0)
			Program Elective	4 (3 1 0)
3.		Program Elective		4 (3 1 0)
4.		Program Elective		4 (3 1 0)
5.		Open Elective 2		3 (3 0 0)
6.		Honours Course 6 (Optional)		3 (3 0 0)
			Total Credits	**19 (+3)**

Total Credits = 178 (+18)

List of Program Electives (for VII Semester)

S. No.	Course Code	Course Title	Credits (L T P)
1.	22EET922	Advanced Electric Drives & Control	4 (3 1 0)
2.	22EET923	Basics of Image Processing	4 (3 1 0)
3.	22EET924	Computer Aided Power System Analysis	4 (3 1 0)
4.	22EET925	Computer Architecture and Organization	4 (3 1 0)
5.	22EET926	Electrical Machine Design	4 (3 1 0)
6.	22EET927	High Voltage Engineering	4 (3 1 0)
7.	22EET928	Optimal Control Systems	4 (3 1 0)
8.	22EET929	Power System Restructuring, Deregulation and Economics	4 (3 1 0)
9.	22EET930	Robotics	4 (3 1 0)
10.	22EET931	Utilization of Electrical Power	4 (3 1 0)

List of Program Electives (for VIII Semester)

S. No.	Course Code	Course Title	Credits (L T P)
1.	22EET932	Applications of Power Electronics in Power Systems	4 (3 1 0)
2.	22EET933	Biomedical Signal Processing	4 (3 1 0)
3.	22EET934	Electric Vehicle Technology	4 (3 1 0)
4.	22EET935	High Power Converters	4 (3 1 0)
5.	22EET937	Intelligent Systems & Control	4 (3 1 0)
6.	22EET938	Modelling and Analysis of Distribution Systems	4 (3 1 0)
7.	22EET939	Power System Reliability	4 (3 1 0)
8.	22EET940	Power System Stability	4 (3 1 0)
9.	22EET941	Smart Grid Systems	4 (3 1 0)
10.		Microcontroller Based System Design	4 (3 1 0)

B. Tech. with Honours (List of Courses)

S. No.	Course Title	Semester	Credits (L T P)
1.	Modelling & Simulation of Power Electronic Systems	V	3 (3 0 0)
2.	Special Electrical Machines and Applications	V	3 (3 0 0)
3.	Advanced Power System Protection	VI	3 (3 0 0)
4.	Nonlinear Control Systems	VI	3 (3 0 0)
5.	Power System Dynamics	VII	3 (3 0 0)
6.	Switched Mode Power Conversion	VIII	3 (3 0 0)
		Total Credits	**18**

Open Elective (For other departments)

S. No.	Course Title	Credits (L T P)
1.	Control System Engineering	3 (3 0 0)
2.	Energy Conservation and Management	3 (3 0 0)
3.	Electric Vehicle Technology	3 (3 0 0)
4.	Smart Grid Systems	3 (3 0 0)

Program Linked Courses offered by the Department:

S. No.	Course Title	Credits (L T P)
1.	Control System Engineering	4 (3 1 0)
2.	Network Theory	4 (3 1 0)
3.	Smart Grid Systems	4 (3 1 0)

SYLLABUS -B.TECH. (ELECTRICAL ENGINEERING)

Semester: I

Course Title: Basic Electrical Engineering

Course Category: Common for all branches **Credit: 3 (2 1 0)**

Unit I- DC Circuits: Introduction to electrical circuits, Source conversion, Node Voltage and Mesh Current methods, Delta-Star and Star-Delta transformations. Superposition principle, Thevenin's and Norton's Theorems, Maximum Power Transfer Theorem.

Unit II- Single Phase AC Circuits: Phasor Algebra, Solution of R-L-C series, parallel and series-parallel circuits. Resonance.

Unit III-Three-Phase AC Circuits: Three-phase e.m.f. generation. Phase Sequence. Delta and Star Connections. Line and phase quantities. Solution of three-phase balanced circuits.

Unit IV-Basic Electrical Machines: Construction, basic working principle and major applications of transformers, dc motors, three-phase cage induction motors and synchronous motors. (Qualitative treatment only).

Text / References Books:

1. Electrical Engineering Fundamentals, By V. Del Toro, PHI
2. Problems in Electrical Engineering by S. Parker Smith, CBS Publishers and Distributors Pvt. Ltd.
3. Electric Circuits, Joseph Edminister, Mahmood Nahvi, Schaum’s Outlines, Tata McGraw-Hill
4. Electrical Machinery and Transformers, Irving Kosow, Pearson Publications
5. A Textbook of Electrical Technology-Volume I & II, by A. K. Thareja and B.L. Thareja, S. Chand and Company Ltd.
6. Fundamentals of Electric Circuits: Charles K. Alexander, Matthew N.O. Sadiku; McGraw Hill.

Semester: I

Course Title: Electrical Engineering Lab

Course Category: Common for all branches **Credit: 1 (0 0 2)**

LIST OF EXPERIMENTS:

ROTOR-I

1. To measure the power consumed by a given choke coil at different voltages and determine the choke coil's power factor, resistance, and inductance.
2. To verify Kirchhoff's Current Law (KCL) and Kirchhoff's Voltage Law (KVL) for a given circuit.
3. To observe the operation of a given fluorescent lamp/LED driver/Electronic Choke at different voltages and determine the power consumed and power factor.
4. To verify Thevenin's and Norton's theorem for a given network and to obtain the equivalent circuit thereof.

ROTOR-II

1. To make connections of
   (a) Staircase wiring
   (b) House wiring
2. To determine the power consumed by two incandescent lamps connected in parallel at different supply voltages.
3. To connect, run, and reverse the direction of rotation of the single-phase induction motor.
4. To study the V-I characteristics of an incandescent lamp.
5. Measurement of power using two-wattmeter method.

General Study:

1. To study safety precautions in the lab.
2. To study symbols of various electrical equipment.
3. To study different types of electricity tariffs.
4. To study the working of various electrical apparatus in the lab.

Semester: I

Course Title: Power Generation Sources

Course Category: Program Core **Credit: 4 (3 1 0)**

Conventional Power Plants: Energy Sources & their Availability, Renewable Energy Sources & their prospects.

Bulk energy generation: conventional generation of electrical energy using thermal, hydro, nuclear and diesel/gas-based power plant.

Renewable Energy Sources: Solar photovoltaic. Solar photovoltaic conversion, description and principle, performance characteristics, maximum conversion efficiency, manufacturing and applications.

Wind energy. Nature of wind, history, recent development, classification, wind data, energy in the wind. Brief idea about integration of RES into Power Grids. Energy from the biomass, gasification, bio-gas, bio-ethanol, bio-diesel, wave energy, tidal, ocean thermal energy conversion (OTEC).

Energy Economics: Load and load curves, load forecasting, electricity tariffs and power factor improvement

Emerging Trends in Power Generation: Electrical equipment of power stations and sub-stations and their general arrangement, Standards of supply systems, power generation scenario in India, Emerging trends in power station practices

Text / References Books:

1. P.K. Nag, Power Plant Engineering.
2. Philip Kiameh, Power Generation Handbook: Selection, Applications, Operation, and Maintenance.
3. S P Sukhatme, J K Nayak, Solar Energy: Principles of Thermal Collection and Storage, Third Edition, McGraw Hill Education
4. Gupta B. R., Generation of Electrical Energy, Fourth Edition, S. Chand & Company Ltd.
5. M. V. Deshpande, Elements of Electrical Power station Design, PHI India
6. Alexandra Von Meier, Electric Power Systems: A Conceptual Introduction.
7. Dipak Sarkar, Thermal Power Plant: Design and Operation.
8. William D. Mincks and Christopher E. Larsen, Hydroelectric Handbook
9. John R. Lamarsh and Anthony J. Baratta, Introduction to Nuclear Engineering.
10. Godfrey Boyle, Renewable Energy: Power for a Sustainable Future.

Semester: II

Course Title: Network Theory

Course Category: Program Core **Credit: 4 (3 1 0)**

Steady-State Analysis: Node and Mesh Analysis. Network Theorems. Analysis of Three-phase Circuits.

Transient Analysis: Transient Analysis of Circuits in Time and Frequency Domains. Special Signal Waveforms.

Non-sinusoidal Periodic Waves: Trigonometric and Exponential forms of Fourier series, Waveform Symmetry, Response to Linear Networks.

Magnetically Coupled Circuits: Analysis and Design of Magnetically Coupled Circuits.

Resonance: Resonance in Series, Parallel and Series-parallel Circuits. Frequency Response, Bandwidth, Selectivity and Q-factor.

Fundamentals ofGraph Theory: Network Graph, Network Matrices and Equilibrium Equations, Duality.

Generalized Two-port Networks: Two-port Parameters, Interconnection, Symmetry and Reciprocity, Image Parameters.

Text / References Books:

1. M. E. Van Valkenburg: Network Analysis, III Ed.., Prentice Hall of India.
2. W. H. Hayt, J. E. Kemmerly and S. M. Durbin: Engineering Circuit Analysis, VII Ed., McGraw Hill.
3. Joseph Edminister: Electrical Circuits, III Ed., Schaum's Outline, Tata McGraw Hill.
4. Lawrence P. Huelsma: Basic Circuit Theory, III Ed., Prentice Hall of India.
5. D. Roy Choudhury: Network & Systems, Wiley Eastern Ltd.
6. De Carlo and Lin, Linear Circuit Analysis, Oxford Press
7. Franklin F Kuo, Network Analysis and Synthesis, Wiley, Second Edition, 2006

Semester: II

Course Title: Measurements and Actuators

Course Category: Program Core **Credit: 4 (3 1 0)**

Measuring Instruments: Functional characteristics of measuring instruments and their types, Analog Instruments: Shunts and multipliers for analog instruments, Electronic Instruments, Measurement of Current, Voltage, Power, energy, power factor and frequency; DSO; Theory and types of errors.

Measurement of Resistance, Inductance and Capacitance: Low, medium and high resistance measurement methods, Impedance Measurement: Principle of AC Bridges, measurement of inductance, capacitance and frequency using AC bridges.

Transducers: Classification, Types and characteristics of transducers; measurement of physical quantities: temperature, pressure, flow, strain, displacement; commonly used transducers: resistive potentiometer, strain gauge, RTD, thermistors, thermocouples, capacitive, inductive, piezo-electric, hall-effect and ultrasonic transducers.

Sensors and Actuators: Terminology, Principles, Characteristics and Classifications, Applications: Automotive Sensors, Home Appliance Sensors, Aerospace Sensors, Sensors for manufacturing and environmental monitoring, Pneumatic, hydraulic, mechanical and electrical actuators, Types of control valves, Types of motion, Electrical Actuation Systems.

Internet of Things: Introduction to IoT: Sensors, Actuators, Smart objects, Basics of IoT networking. IoT architecture and design.

Text / Reference Books:

1. Modern Electronic Instrumentation and Measurement Techniques: A.D. Helfrick and W.D. Cooper, Pearson/Prentice Hall of India.
2. Measurement Systems- Applications and Design: E.O. Doebelin, Tata McGraw Hill, New York.
3. Instrumentation Measurement and Analysis: B.C. Nakra and K.K. Chaudhry, Mc-Graw Hill Education.
4. Electronic Instrumentation and Measurements: David A. Bell, Oxford University Press, Third Edition.
5. Electrical Measurements and Measuring Instruments: E.W. Golding, F.C. Widdis, A.H. Wheeler & Company Pvt. Ltd. India.
6. Electronic Measurements and Instrumentation: Oliver and Cage, TMH.
7. Sensors and Actuators: D. Patranabis, 2nd Ed., PHI.
8. Mechatronics: W. Bolton, Pearson Education Limited.
9. Handbook of Modern Sensors: Jacob Fraden, 5th Edition, Springer.
10. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, J. Henry, 1st Edition, Pearson India Pvt. Ltd.
11. Internet of Things -Architecture and Design Principles, Kamal, R, 1st Edition, Mcgraw Hill.

Semester: II

Course Title: Measurement and Instrumentation Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

List of Experiments:

1. To determine the active power of unbalanced load by two-wattmeter method and the reactive power of balanced load by one-wattmeter method
2. To measure inductance, resistance and Q-factor of choke coil using AC Bridge
3. To measure capacitance and leakage resistance of unknown capacitances using AC bridge
4. To demonstrate the Hall effect sensor based on AC/DC Current and DC Voltage measurement experimental setup trainer
5. To test the given single phase energy meter at unity power factor by using direct loading and phantom loading arrangements
6. To demonstrate the flow/level process trainer with variable speed pump and pneumatic control valve
7. To measure pressure using Piezo Resistive Transducer (PZT) trainer
8. To demonstrate op-amp as instrumentation amplifier
9. To measure speed using speed sensing transducer trainer
10. To measure liquid level using level measurement transducer by measuring the water column height
11. To investigate the behavior of linear variable differential transformer (LVDT)
12. To measure ground resistance and leakage current using the Earth Tester

Semester: III

Course Title: Electrical Machines-I

Course Category: Program Core **Credit: 4 (3 1 0)**

DC Machines: Basic principles of electromechanical energy conversion, construction, operation, armature reaction, commutation, characteristics, performance of dc generators and motors, testing of dc machines, starting and speed control of dc motors, four quadrant operation of dc motors, braking methods, dc motors used in electric vehicles, applications of dc motors, transient and steady-state modeling of dc motor and performance analysis.

Transformers: Construction, working principle, phasor diagram, open and short circuit tests, equivalent circuit, voltage regulation, efficiency, parallel operation and testing of three-phase transformer, magnetizing current inrush phenomena, auto-transformer, connections and harmonics in three-phase transformer, current and voltage transformers, V-V connection, Scott connection, tertiary winding, neutral shifting phenomena

Text / References Books:

1. Irving L. Kosow: Electric Machinery and Transformers, Prentice Hall India Publication.

2. A.E. Fitzgerald, Charles Kingsley: Electrical Machines, IV Edition, Mc-Graw Hill.

3. A.S. Langsdorf : Theory of Alternating Current Machinery, Tata Mc-Graw Hill.

4. I.J. Nagrath, D.P. Kothari : Electrical Machines, Tata McGraw Hill.

5. M. G. Say: The Performance and Design of Alternating Current Machines, III Edition, CBS Publishers & Distributers

Semester: III

Course Title: Integrated Electronics

Course Category: Program Core **Credit: 4 (3 1 0)**

Operational Amplifiers: Introduction, Differential amplifier, Transition delay, DC & AC analysis of dual input balanced output differential amplifier configuration, Inverting and non-inverting inputs, Common mode rejection ratio (CMRR), Op-Amp symbol & circuit model, the ideal op-amp, equivalent circuit of an Op-Amp, open loop OP-Amp configuration and Op-Amp parameters.

Operational Amplifier Applications: Introduction to single-supply Op-Amp (LM311/339) differential amplifier, adder, subtractor, integrator, differentiator circuit using OP-Amp, voltage to current and current to voltage converter, Instrumentation amplifier, log and anti-log amplifier, the peaking amplifier, sample and hold circuit.

Comparator, Limiters and Converters: Introduction, Basic comparator, Zero Crossing detector, Schmitt trigger, Voltage Limiters, Clippers and Clampers, Voltage to frequency and frequency to voltage converters.

Active Filters and Oscillators: Introduction, First order and second order low pass filters, First order and second order high pass filters, Band pass filter, Principle of oscillator, Phase shift oscillator, Triangular wave generator, Saw-tooth wave generator.

Voltage Regulators: Introduction, Parameters for voltage regulators and voltage references, basic configuration of voltage regulators and references, Shunt regulator& Series pass regulator.

Text / References Books:

1. Sedra / Smith, Micro Electronic Circuits, Oxford University Press, 2019.
2. Schilling and Belove, Electronic Circuits, 3rd Edition, TMH, 2002.
3. Robert L. Boylestad and Louis Nasheresky, Electronic Devices and Circuit Theory, 9th Edition, Pearson Education / PHI, 2013.
4. Thomas L. Floyd, Electronic Devices, Pearson, 2018.
5. David A. Bell, Solid State Pulse Circuits, Prentice Hall of India, 1992.
6. Millman and Halkias. C., Integrated Electronics, TMH, 2017.
7. Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, PHI, 2002.

Semester: III

Course Title: Advanced Engineering Mathematics

Course Category: Program Linked Course **Credit: 4 (3 1 0)**

Optimization Fundamentals: Definition; classification of optimization problems; Unconstrained and constrained optimization; optimality conditions. Lagrange Multipliers, formulation of multivariable optimization, Kuhn-Tucker conditions.

Linear Programming: Simplex Method; Duality; Sensitivity methods. Nonlinear Programming: Powel’s method; steepest descent method; conjugates gradient method; Newton’s Method GRG method; Sequential quadratic programming; Penalty function method; Augmented Lagrange multiplier method.

Dynamic Programming and Integer Programming: Interior point methods; Karmakar’s algorithm; Dual affine; Primal affine; Barrie algorithm.

Meta-Heuristic Optimization: Simulated annealing; Evolutionary Programming; Genetic algorithm and Genetic Engineering; Swarm Optimization and other nature inspired optimization algorithms.

Statistics and Probability: Probability theory, Baye’s theorem, Binomial, Poisson and normal distributions, testing of hypothesis, Chi square test- goodness of fit, independence of two variables, Student’s t-test, analysis of variance, F-test, correlation and regression, coefficient of correlation, rank correlation,lines of regression.

Semester: III

Course Title: Analysis and Design of Digital Logic Circuits

Course Category: Program Core **Credit: 4 (3 1 0)**

Data Representation; Boolean Algebra and Logic Gates; Simplification of Boolean Functions: Karnaugh -Map Quine -Macluskey Minimisation Technique, Determination and Selection of Prime-Implicants.

Digital Integrated Circuits: Bipolar Transistor Characteristics, RTL and DTL Circuits, TTL Logic, Emitter Coupled Logic (ECL), MOS and CMOS Logic Families, Realization of Logic Gates in RTL, DTL, TTL, ECL and CMOS.

Combinational Logic: Design Procedure, Adders and Subtractors, Code Conversion, Multilevel NAND and NOR Circuits, Binary Parallel Adder & Subtractor, BCD Adder & Subtractor, Magnitude Comparator, Encoder, Decoder, Multiplexer, Demultiplexer, Read-only Memory (ROM) and Programmable Logic Array (PLA).

Sequential Logic: Flip-flops. Triggering of Flip-flops. Analysis of Clocked Sequential Circuits, State Reduction and Assignment, Flip-flop Excitation Tables, Design Procedures and Design with State Equations.

Registers, Counters and Memory Unit: Registers -Buffer Register, Shift Registers, Serial and Parallel Loading of Data. Counters -Ripple Counters, Modulus Counter, Ring Counter, Synchronous Counter, UP and DOWN Counters, Timing Sequences. Memory Unit, Memory Cell, Random Access Memory and Memory organisation.

Text/Reference Books:

1. Digital Logic and Computer Design, M. Morris Mano, Prentice- Hall India
2. Digital Computer Electronics, Malvino& Brown, Tata McGraw Hill Edition
3. Digital Electronics and Microprocessors - Problems & Solutions, R. P. Jain, Tata-McGraw Hill
4. Fundamentals of Digital Circuits, A. Anand Kumar, PHI
5. Foundations of Analog & Digital Electronic Circuits, Anant Agarwal & Jeffrey H. Lang, ELSEVIER Morgan Kaufmann
6. Computer Aided Logical Design with Emphasis on VLSI, Frederick J. Hill & Gerald R. Peterson, John Wiley Sons, ING

Note: Book at S.N.1 and S.N.2 are base Text Books.

Semester: III

Course Title: Network, Systems and Signals

Course Category: Program Core **Credit: 4 (3 1 0)**

Network Synthesis: Complex frequency, Network functions; Elements of Passive Network Synthesis; Synthesis of RL, LC, RC and RLC driving point functions.

Filters: Theory of active and reactive filters; Frequency response of filters; Filters design.

Introduction to Signals and Systems: Classification of signals and systems, and their properties; convolution of continuous-time signals, linear time invariant systems and their properties; time-domain representation and analysis of LTI systems based on convolution and differential equations.

Introduction to Transforms: Transform domain Considerations, Laplace Transform and its properties; Fourier Series and Fourier Transform; z-Transform and its properties; applications of transforms to continuous systems-analysis.

Sampling: Sampling Theorem: Sampling of continuous signals; Relation between continuous and discrete time systems, Impulse sampling; Signal reconstruction; Realistic Sampling, Aliasing, Spectrum of sampled signals.

Texts/References Books:

1. A.V. Oppenheim, A.S. Willsky and I.T. Young, Signals and Systems, Prentice Hall, 1983.
2. Simon Haykin: Signals and Systems, II Ed., John Wiley and Sons.
3. H. P. Hsu, “Signals and Systems –Schaum’s Outline Series,” McGraw Hill, 1995.
4. R.F. Ziemer, W.H. Tranter and D.R. Fannin, Signals and Systems - Continuous and Discrete, 4th Edn. Prentice Hall, 1998.
5. M. E. Van Valkenburg: Network Synthesis, Prentice Hall of India.
6. W. H. Hayt, J. E. Kemmerly and S. M. Durbin: Engineering Circuit Analysis, VII Ed., McGraw Hill.
7. D. Roy Choudhury: Network & Systems, Wiley Estern Ltd.
8. L. T bruton: RC Active Networks, PHI
9. F. F. Kuo: Network Analysis and Synthesis, John Wiley, 2ndEdition
10. Behrouz Peikari, Fundamentals of Network Analysis and Synthesis, Jaico Publication, 2006

Semester: III

Course Title: Advanced Programming for Design

Course Category: Program Core **Credit: 0 0)**

MATLAB Fundamentals: Basics: Setup, Variables Functions, Complex Numbers, Arithmetic Operations, Conditional statements, loops Data Imports and Analysis, Lists, Vectors, and Matrices. Root-finding: Newton's Method, Secant Method, Golden Section, Newton-Raphson method. Basics of Plotting: Basins of Attraction, 2D and 3D Plotting. Simulation of non-linear equations.

Python Programming Fundamentals: Data Structure Basics: Tuples, Lists, Array, Tensor. Branching and Iteration, String Manipulation, Guess and Check, Approximations, Bisection, Decomposition, Abstractions, Functions, Recursion, Dictionaries, Testing, Debugging, Exceptions, Assertions, Object Oriented Programming: Python Classes, and Inheritance. Plotting: 2D and 3D Plotting, Scatter plots. Libraries: Matplotlib, NumPy, Pandas.

Arduino Programming: Introduction to the Arduino platform and its capabilities. Set up the IDE for the operating system to the Arduino board. Basic programming concepts, Working with the digital and analog inputs and outputs on the Arduino board, including reading sensors, controlling actuators, and communication interfaces.

Hardware and Software Interfacing: Overview of computer architecture and how hardware components interact with software. Communication protocols and standards, such as I2C, SPI, and UART. Programming techniques for interacting with hardware devices, including direct memory access and device drivers. Advanced topics such as MATLAB & Python programming. Application to power, control, Robotics and Bio-medical.

Texts/References Books:

1. Attaway, S. (2013). Matlab: a practical introduction to programming and problem solving. Butterworth-Heinemann.
2. Moore, H., &Sanadhya, S. (2009). MATLAB for Engineers (p. 672). New York: Pearson Education International.
3. Luciano, R. (2015). Fluent Python: Clear, concise, and effective programming" O'Reilly Media.
4. McKinney, W. (2012). Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. " O'Reilly Media, Inc.".
5. Monk, S. (2016). Programming Arduino: getting started with sketches. McGraw-Hill Education.
6. Hillar, G. C. (2016). Internet of Things with Python. Packt Publishing Ltd.

Semester: III

Course Title: Electrical Software and Simulation Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

List of Experiments/Assignments based on MATLAB and Python Programming:

Experiments/ Assignments	**Total Problems Designed**	**Objectives**
Assignments based on MATLAB Programming:		
Assignment-I	10	To write and execute script files for problems based on: 1) Matrices and Arrays 2) Scalars and Vectors 3) Complex Numbers 4) Mathematical functions 5) Basics of Plotting
Assignment-II	10	To write and execute script files for problems based on: 1) Different Arithmetic operations 2) Different Logical and Relational Functions 3)Basic Electrical Engineering.
Assignment-III	10	To write and execute in-built Function files for problems based on: 1) Different Mathematical Functions 2) Different Control Loops 3) Conditional Statements
Assignment-IV	10	To write and execute user-defined Function files for different mathematical functions
Assignment-V	10	To write programs for problems based on: 1) Differential Equations 2) Symbolic Differentiation and Integration
Assignment-VI	10	To create and simulate model files in SIMULINK for solving problems based on: 1)Basic Electrical Engineering 2)Differential Equations
Assignments based on Python Programming:		
Assignment -VII	10	To write and execute script files for problems based on: 1) Arrays and Strings 2) Arithmetic and Complex operations 3) Plotting Functions

Assignment -VIII	10	To write and execute script files for problems based on: 1)Conditional Statements and Loops 2)In-built and user-defined Functions 3)Basic Electrical Engineering.

Text/ Reference Books:

1. MATLAB: A practical introduction to programming and problem solving by Attaway S., Butterworth- Heinemann, 2013
2. MATLAB for Engineers by Murray H. and Sanadhya S., New York Pearson Education International, 2009
3. Fluent Python: Clear, Concise and Effective Programming by Luciano R., O'Reilly Media, 2015

Semester: III

Course Title: Electronic Devices and Circuit Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

List of Experiments:

Rotor 1:

1. To Study the Zener diode as voltage regulator and plot the Volt –Ampere characteristics of a Zener diode. Find the Zener Breakdown Voltage, Dynamic Forward Resistance and Dynamic Reverse Resistance of Zener Diode.

2. To obtain input and output characteristics of transistor Connected in Common – base configuration & determine the h-parameters for CB configuration.

3. To obtain Input and Output characteristics of transistor connected in Common Emitter Configuration & determine the h -parameters for CE configuration.

4. To obtain Drain and Transfer characteristics of FET connected in Common Source configuration & obtain r d , g m and µ of FET.

5. Design and measure the frequency response of a RC coupled amplifier using discrete components.

6. To observe the characteristics of UJT and to calculate the Intrinsic Stand-Off Ratio (η).

Rotor 2:

7. To design the Monostable Multivibrator and Astable Multivibrator using IC555. Find the duty cycle of output wave.

8. To Design and Realization of Inverting and Non-Inverting Amplifier using Op-Amp. Find the Amplification factor.

9. To Design and Realization of Instrumentation Amplifier and Wein’s Bridge Oscillator using Op-Amp. Find output frequency.

10. To Design and Realization of Adder and Subtracter circuits using Op-Amp.

11. To Design and Realization of Differentiator and Integrator circuits using Op-Amp.

12. To Design and Realization of Voltage to Current and Current to Voltage Converter circuits using Op-Amp.

13. To Study the Comparator and Schmitt Trigger circuits using Op-Amps.

Semester: III

Course Title: Electrical Machine – I Lab

Course Category: Program Core **Credit: 2 (0 0 3)**

List of Experiments:

CYCLE-I

1. To control the speed of DC Shunt motor by armature control and field control method and to plot
    a) Back emf v/s speed characteristics (Armature control)
    b) Field current v/s speed characteristics (Field control)
2. To perform indirect load test on a given DC Shunt motor and plot the following performance characteristics
    a) output power v/s torque
    b) output power v/s armature current
    c) output power v/s speed o
    d) output power v/s efficiency
3. To perform open circuit test and short circuit test on a given 230/115 V,50 Hz, 1-phase transformer and to
    a) find its equivalent circuit
    b) plot load v/s efficiency characteristics at a power factor of 0.8(lag), 0.6(lag)
    c) plot the voltage regulation v/s power factor characteristics at the half and full load
4. To perform Swinburne's test on a given DC machine and to plot load v/s Efficiency characteristics for
    a) DC Motor
    b) DC Generator
5. To observe the operation of the given bank of three 1-phase transformers in the following configurations
    i. Star-Star
    ii. Star-delta
    iii. Delta-Star
    iv. Delta-Delta
    v. V-V

CYCLE-2

1. To draw the open circuit characteristic (OCC) of a DC generator in the following modes
    a) self-excited
    b) separately excited

   at the rated and half the rated speed.

2. To draw the external characteristics of a given DC Generator in the following configurations
    a) DC Shunt Generator
    b) cumulative compound DC Shunt Generator
    c) Differential Compound DC Shunt Generator

   at the rated speed.

3. To perform Hopkinson’s test on two dc machines and plot load v/s efficiency characteristics of each of the machine.
4. To perform Sumpner’s back-to-back test on two identical 1- phase transformer and to
    a) find its equivalent circuit
    b) to plot load v/s efficiency characteristics at a power factor of 0.8(lag),0.6(lag)
    c) to plot the voltage regulation v/s power factor characteristics at the half and full load
5. To operate three-phase transformers in parallel and study their load sharing characteristics.

Semester: IV

Course Title: Microprocessor and Microcontroller

Course Category: Program Core **Credit: 4 (3 1 0)**

Architecture of 8085 microprocessor: Introduction, Programming Model, Accumulator, General purpose registers, Flags, Program Counter, Stack Pointer, Bus Organization. Basic Operations of Microprocessor, Pins and Signals, Demultiplexing.

Assembly language Programming: Classification of Instructions. Programming using assembly language (8085).

Stack: Stack and Stack Pointer, Instruction related to Stack, Programming examples.**Subroutine:** Concept, Instructions, Applications, Documentation, Nesting, Programming examples.

Interrupts: Software and Hardware Interrupts, Classification, Call locations, Priority, Trigger level, Interrupt sequence and working, Instruction related to Interrupts, Interrupt Service Routine.

Timing and Time Delay: T-state, Machine Cycle, Instructions Cycle, Types of machine cycles, Time dalay, Software techniques for time dalay, Calculation of time dalay.

Interfacing: Interfacing memory, Interfacing input/output, Interfacing other peripherals e.g., 8255, 8253/54, 8259 and 8257.

Introduction to 8051 Microcontroller: Use and Features of 8051, Pin diagram, Various Special Function Registers (SFRs), Internal RAM and ROM, Requirement of external memory, Connecting external memory, Using internal input/output ports, Internal timers and counters, Serial data communication, Interrupt of 8051. 8051 Instructions Set.

Text / References Books:

1. Ramesh S. Gaonkar, ‘Microprocessor Architecture, Programming and Application with 8085’, Fourth Edition, Penram International Publishing (India)

2. B. Ram, ‘Fundamentals of Microprocessor and Microcomputers’, Fifth Edition, Dhanpat Rai Publications (P) Ltd.

3. Kenneth J. Ayala, ‘The 8051 Microcontroller: Architecture, Programming and Applications’, Second Edition, Thomson Delmar Learning, Penram International Publishing (India).

4. Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay. ‘The 8051 Microcontroller and Embedded Systems – using assembly and C’, PHI, 2006 / Pearson, 2006.

Semester: IV

Course Title: Electrical Machines-II

Course Category: Program Core **Credit: 4 (3 1 0)**

Single-phase induction motors: Double revolving field theory, torque slip characteristics, starting and speed control methods.

Induction Machines: Construction and working principle of slip-ring and wound rotor induction motor, equivalent circuit, torque-slip curves, performance, starting and speed control of three-phase induction motors. Cogging and Crawling. High torque-cage motors. Induction generator.

Synchronous Generator: Construction, working principle. Theory of cylindrical and salient pole synchronous machines. Equivalent circuit, voltage regulation, operational characteristics, parallel operation, synchronizing and hunting.

Synchronous Motor: Working principle, starting, operation and applications of synchronous motors. Permanent magnet synchronous motors (PMSM), brushless DC motor (BLDC), switched reluctance motors (SRM).

Text / References Books

1. Irving L. Kosow: Electric Machinery and Transformers, Prentice Hall India Publication.

2. A.E. Fitzgerald, Charles Kingsley: Electrical Machines, IV Edition, Mc-Graw Hill.

3. A.S. Langsdorf: Theory of Alternating Current Machinery, Tata Mc-Graw Hill.

4. I. J. Nagrath, D.P. Kothari: Electrical Machines, Tata McGraw Hill.

5. M. G. Say: The Performance and Design of Alternating Current Machines, III Edition,

CBS Publishers & Distributers.

Semester: IV

Course Title: Transmission and Distribution Systems

Course Category: Program Core **Credit: 4 (3 1 0)**

Introduction: Fundamentals of Transmission and Distribution Systems, Radial, Ring and Networked Distribution System, Effect of System Voltage on Size of Conductors; Typical Layout of Substation; Substation Equipment

Transmission Lines: Parameters of Transmission Line, Types of Conductors and their Configuration, Modelling of Transmission Lines, Generalised ABCD Line Constants, Performance of Transmission Lines.

Insulators and Mechanical Characteristics of Transmission Lines: Types of Insulators, Grading and Method of Improving String Efficiency; Sag and Tension in Transmission Lines.

Underground Cables: Types of Cables and their Construction, Parameters of Underground Cables, Breakdown.

Grounding: Types and Methods of Grounding.

Introduction to Distribution System Automation: Distribution System Monitoring and Control: SCADA, Concept of Modern Distribution Systems.

Text/ Reference Books:

1. Elements of Power System Analysis, William D. Stevenson Jr., Mc-Graw Hill.
2. Power System Analysis, Hadi Saadat, Mc-Graw Hill.
3. Modern Power System Analysis, D.P. Kothari and I.J. Nagrath, Tata McGraw Hill.
4. C.L. Wadhwa, "Electrical Power Systems", New Age International Publishers, 6th Edition.
5. Power System Analysis and Design, B. R. Gupta, S. Chand Ltd.

Semester: IV

Course Title: Power Electronics-I

Course Category: Program Core **Credit: 4 (3 1 0)**

Introduction: Concept, applications, and advantages of power electronics, power conversion necessity, ideal switch and its characteristics, types of power electronic conversions, key performance indices, power computations.

Solid-State Devices and Operation: Introduction to semiconductor devices, firing circuits, gate driver circuits, commutation methods, switch protection methods & snubber design, power losses and comparison of devices.

Single-Phase AC to DC Converters: Single-phase half-wave converters for various loads (R. RL and RLE), single-phasesemi-converter, and full-converters for various loads, effect of source impedance on the performance of the converter, dual converter, PWM rectifiers, case studies.

Three-Phase AC to DC Converters: Three-phase uncontrolled, semi-converter, and full-converters for various loads, case studies.

Single-Phase DC to AC Converter: Half and full-bridge inverter with R and RL load, square wave operation, sine pulse width modulation, unipolar and bipolar modulation, waveform analysis and performance indices through Fourier analysis, case studies.

Text/ Reference Books:

1. Mohammad H. Rashid, “Power Electronics Circuits, Devices and Applications”, Prentice Hall of India Pvt. Ltd, 2017
2. Robert W. Erickson, Dragan Maksimović, "Fundamentals of Power Electronics", Springer, 2001.
3. Joseph Vithayathil, “Power Electronics: Principles and Applications”, Tata McGraw-Hill Education, 2010.
4. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics, Converters, Applications and Design”, Wiley, 2017.
5. Hart, D.W., “Power Electronics”. New York: McGraw-Hill, 2010.
6. Lander C. W., “Power Electronics”, 3rd Ed., McGraw-Hill International Book Company, 2007
7. Sen, P. C, “Power Electronics”, TMH, 1987.

Semester: IV Sem

Course Title: Control System Engineering

Course Category: Program Core/Open Elective/PLEAS **Credit: 4 (3 1 0)**

Introduction: Classification, open-loop and closed-loop control; servomechanism, physical examples, Control system components, Constructional and working concept of AC servomotor, synchros and stepper motor.

Transfer Function and Its Determination: Transfer function, block diagram reduction, negative feedback, signal flow graph, Mason's gain formula, mathematical modelling of thermal, mechanical, electrical, and electro-mechanical systems.

Time Response Analysis: Standard test signals, time response of first and second order systems, time response specifications, steady state errors and error constants, PID controllers, performance indices.

Stability Analysis: Concept of stability and necessary conditions, Routh-Hurwitz criteria and limitations.

Root Locus Technique: The root locus concepts, construction of root loci, stability analysis.

Frequency Domain Analysis: Frequency response, correlation between time and frequency responses.

Stability Analysis in Frequency Domain: Gain margin, phase margin, gain cross-over frequency, phase cross-over frequency, polar plot, Bode plots, Nyquist stability criterion.

Compensation: Types of compensation and their requirement, lead, lag, and lead-lag networks, and design of closed-loop systems using compensation techniques.

State Space Analysis: Introduction, state, state variable, state transition matrix.

Text/ Reference Books:

A. **TEXT BOOKS:**

1. Nagrath& Gopal, "Control System Engineering", 4th Edition, New Age International.
2. K. Ogata, "Modern Control Engineering", Prentice Hall of India.
3. B. C. Kuo & Farid Golnaraghi, "Automatic Control System" Wiley India Ltd, 2008.
4. D. Roy Choudhary, "Modern Control Engineering", Prentice Hall of India.

B. **REFERENCES:**

1. Norman S. Mise, Control System Engineering 4th edition, Wiley Publishing Co.
2. Ajit K Mandal, "Introduction to Control Engineering" New Age International, 2006.
3. R. T. Stefani, B. Shahian, C. J. Savant and G. H. Hostetter, "Design of Feedback Control Systems" Oxford University Press.

Semester: IV

Course Title: Digital Electronics and Microprocessor Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

List of Experiments/Assignments:

1. Perform various experiments on Digital Electronics Trainer Kit
    a. Study of logic gates
    b. Study of universal logic gates
    c. Study of TTL, Clock generation using NAND gates
    d. Study of D bounce circuit using NAND gates
    e. Study of De morgan's theorem
    f. Study of Boolean expression simplification
    g. Study of adder and subtractor
    h. Study of flip flops
    i. Study of decimal and binary counters
    j. Study of Decade counters
    k. Study of shift registers
    l. Study of parity generator/checker
    m. Study of multiplexer/demultiplexer
    n. Study of seven segment decoder.
    o. Study of comparator
    p. Study of code converters
    q. Study of 4-bit binary adder
2. Assembly language programming for 8085 microprocessor
    a. Check various arithmetical/logical instructions and status of flag register.
    b. Programming assignments for looping, decision making, counting, indexing, searching.
    c. Assembly language programming assignments for stack, subroutine and Interrupts.
3. Assembly language programming for 8086 microprocessor
    a. Programming assignments for looping, decision making, counting, indexing, searching, string operation.
4. Study of interfacing cards:
    a. Experiments of Programmable Peripheral Interface (8255) study card
    b. Experiments of Programmable Interval Timer (8253) study card
    c. Experiments of Programmable Interrupt Controller (8259) study card

Semester: IV

Course Title: Electrical Machine Lab - II

Course Category: Program Core **Credit: 2 (0 0 3)**

List of Experiments:

CYCLE- I

1. To perform no-load and blocked rotor test on a given 3-phase, 50 Hz, 400 V, squirrel-cage induction motor and hence
   (a) Find its equivalent circuit.
   (b) To plot the following performance characteristics using circle diagram
      (i) Output power v/s efficiency
      (ii) Output power v/s torque
      (iii) Output power v/s power factor
      (iv) Output power v/s slip
2. To perform no-load and blocked rotor test on 1-phase induction motor and find its equivalent circuit.
3. To draw OCC and SCC of a given 400 V, 3-phase, 50 Hz synchronous generator and hence to plot power factor v/s voltage regulation characteristics at half load and full load using:
   (a) Synchronous impedance method
   (b) Mmf method
4. To synchronize a given 3-phase, 50 Hz, 400 V, synchronous generator with infinite busbar.
5. To separate the iron losses of a given 1-phase, 2 kVA 230/115 V transformer by using variable frequency method.

CYCLE-2

1. To perform indirect load test on a given 3-phase, 400 V, 50 Hz squirrel cage induction motor and to plot the following performance characteristics
   i. Torque v/s output power
   ii. Torque v/s speed
   iii. Torque v/s efficiency
   iv. Output power v/s slip

2. To plot V and inverted V curves of a given 3-phase, 400 V, 50 Hz synchronous motor under no-load and loaded condition.
3. To plot the voltage regulation characteristics of a given 3-phase, 400 V, 50 Hz salient pole synchronous generator at half and full load using X_d-$X_q$method.
4. To connect a three-phase induction motor for 4 pole and 8 pole star configuration and measure the line and phase voltages and current.
5. To control the speed of
   (a) Squirrel cage induction motor using stator voltage control.
   (b) Slip-ring induction motor using rotor-resistance control.

Semester: IV

Course Title: Control System Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

List of Experiments:

1. Plot the characteristics of a synchro-transmitter and synchro-error detector.
2. Speed control of an AC servo-motor and effect of capacitance connected in series with the reference winding.
3. Open-loop and closed-loop time responses of first-order system for standard test signals.
4. Open-loop and closed-loop time responses of second-order system for standard test signals.
5. Design of proportional (P) controller and its effect on transient response of second-order (a) Type-0 (b) Type-1 systems.
6. Design of proportional and integral (PI) controller, proportional and derivative (PD) controller and proportional, integral and derivative (PID) controller and its effect on transient response of second-order Type-0 system.
7. Design of proportional and integral (PI) controller, proportional and derivative (PD) controller and proportional, integral and derivative (PID) controller and its effect on transient response of second-order Type-1 system.
8. Design of a lead compensator based on frequency design method and closed-loop performance.
9. Design of a lag compensator based on frequency design method and closed-loop performance.
10. Identification of the process and perform closed loop response of digital system for (a) Fixed forward gain-variable sampling rate (b) Fixed sampling rate-variable forward gain.

Text/ Reference Books:

Text Books:
1. Nagrath& Gopal, “Control System Engineering”, 4th Edition, New Age International.
2. K. Ogata, “Modern Control Engineering”, Prentice Hall of India.

References:
1. Norman S. Mise, Control System Engineering 4th edition, Wiley Publishing Co.
2. Ajit K Mandal, “Introduction to Control Engineering” New Age International, 2006.

Semester: V

Course Title: Power System Switchgear and Protection

Course Category: Program Core **Credit: 4 (3 1 0)**

Fault Analysis: Symmetrical Components, Sequence Networks, Symmetrical and Unsymmetrical Fault Analysis.

Current and Voltage Transformers: Types and Characteristics of Protective Current and Voltage Transformers.

Introduction to Protective Relaying: Basic Philosophy; Classification of Relays; Operation and Characteristics of Over Current Relays, Differential Relays, Distance Relays.

Protection of Transmission and Distribution Lines: Overcurrent Protection, Directional Protection, Time and Current Grading, Distance Protection, Carrier Current Protection, Relay Coordination.

Protection of Equipment: Protection of Transformers, Alternators and Bus-Bar Protection

Switchgear: Circuit Breaker, Theories of Current Interruption, Classification of Circuit Breakers, Rating of Circuit Breakers, Transients in Circuit Breakers.

Text/ Reference Books:

1. Ravindranath and M. Chander: Power System Protection and Switchgear, Wiley Eastern Ltd.
2. Power System Protection by Patra Basu& Choudhary, Oxford &IBH.
3. Protective Relay, Their Theory & Practices Vol. 1 by A.R.C. Warrington, Chapman & Hall UK.
4. Power system Protection and Switchgear, by Badri Ram and DN Vishwakarma:, Tata Mc Graw Hill Publishing Company Limited.
5. Power System Relaying, by A.G. Phadke, John Wiley & Sons, 2008.
6. Electric Power Transmission System Engineering by Turan Gonen, John Wiley & Sons.

Semester: V

Course Title: Principles of Communication Engineering

Course Category: Program Linked Course **Credit: 4 (3 1 0)**

Introduction of Communication System and Amplitude Modulation: Overview of communication systems, Orthogonal representation of the signal, Double sideband suppressed carrier (DSB-SC) modulation, Double sideband carrier (DSB-C), Single sideband (SSB) modulation, Other AM techniques and frequency division multiplexing, Radio transmitter, and receiver.

Frequency Modulation: Spectrum of tone-modulated signal, arbitrary modulated FM signal FM modulated and demodulated signal, stereophonic FM broadcasting.

Pulse Modulation and Phase-Locked Loops (PLL): Pulse amplitude modulation, Pulse width and Position modulation, Differential pulse code modulation, Delta modulation, voice coders, Analog PLL, digital PLL, and Application of PLL.

AM and FM Reception Performance under Noise: Single Sideband Suppressed Carrier (DSB-SC) Modulation, Comparisons of AM System: A figure of Merit, Threshold Effect in AM and FM Reception. Signal-to-Noise Ratio, Pre-emphasis and De-emphasis and SNR Improvement, The Threshold in an FM Discriminator, FM Demodulation using Feedback (FMFB)

Text/ Reference Books:

1. Lathi B.P, Modern Digital and Analog Communication Systems, 3rd Ed, Oxford University Press, 2005.
2. H. Taub, D. L. Schilling and Gautam Saha, Principles of Communication Systems, 3rd ed, TMH, 2008.
3. Haykin, Communication Systems, 4th Ed, John Wiley & Sons, 2004.

Semester: V

Course Title: Modern Control Engineering

Course Category: Program Core **Credit: 4 (3 1 0)**

Introduction to systems and description: Importance of dynamical systems representation; Comparison of linear versus nonlinear systems; Modelling of an inverted pendulum; Autonomous and nonautonomous systems; Concept of equilibrium points; Linearization technique and its limitations; Common nonlinearities.

Linear system state-space analysis: Comparison tools for classical and modern control theory; Concepts of causality, time-invariant, linearity; State-space representations of linear systems (Mechanical and Electrical). Discretization of continuous-time state model.

State-space solutions and realizations: Solutions methods for continuous and discrete state equations; Determination and properties of state transition matrix; Cayley-Hamilton approach; Canonical forms of state models; Realization of single-input-single-output and multi-input-multi-output systems.

Qualitative analysis of linear systems: Notion of stability in linear-time invariant systems, bounded-input-bounded-output stability, and internal stability; Concept of controllability and observability; Tests for controllability and observability and applications; Kalman decomposition.

State-feedback design: Requirement of automation and control design; Physical importance of PID controller and its time-domain design; State-feedback control using pole placement; Ackerman's approach; Regulation and tracking; linear quadratic regulator; Design of full-order and reduced-orders observers and conditions for existence; Feedback using observed state vector and separation principle.

Textbooks:

1. Chi-Tsong Chen: Linear System Theory and Design, Oxford University Press, Fourth Edition 2013.
2. M. Gopal: Digital Control and State Variable Methods, McGraw Hill Education (India) Private Limited, Fourth Edition 2012.
3. Hassan K. Khali: Nonlinear Systems, Prentice Hall, Third Edition 2002.
4. Bernard Friedland: Control System Design-An Introduction to State-space Methods, Dover Publications, 2005.

Reference(s):

1. Norman S. Nise: Nise's Control Systems Engineering, Wiley India Edition, Seventh Edition 2015.
2. William L. Brogan: Modern Control Theory, Pearson Education Third Edition 2011.

Semester: V

Course Title: Power Electronics-II

Course Category: Program Core **Credit: 4 (3 1 0)**

DC to DC Converters: Operation and analysis of various dc-dc converter configurations: buck, boost, buck-boost, and isolated converters, concept of zero voltage and zero current switching.

Three-phase DC to AC Inverters: Types and operation of inverters, Output voltage control using 120^0 and 180^0 modes of operation, voltage and current waveform analysis using Fourier series for various loading conditions, Single and multiple pulse modulation, Sinusoidal pulse-width modulation, Space-vector pulse-width modulation, Multilevel Inverter: Three-level neutral point clamped, Flying Capacitor, Cascaded H-bridge.

AC to AC Converters: Types of ac voltage controllers, single phase half and full wave ac voltage controller with R and RL load respectively. Principle of cycloconverter operation, single-phase to single-phase step up and step down cycloconverter, three-phase to single-phase cycloconverter.

Text/ Reference Books:

1. Joseph Vithayathil, "Power Electronics: Principles and Applications", Tata McGraw-Hill Education, 2010.
2. Robert W. Erickson, Dragan Maksimović, "Fundamentals of Power Electronics", Springer, 2001.
3. Mohammad H. Rashid, "Power Electronics Circuits, Devices and Applications", Prentice Hall of India Pvt. Ltd, 2017.
4. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics, Converters, Applications and Design", Wiley, 2017.
5. Hart, D.W., "Power Electronics". New York: McGraw-Hill, 2010.
6. Lander C. W., "Power Electronics", 3rd Ed., McGraw-Hill International Book Company, 2007
7. Sen, P. C, "Power Electronics", TMH, 1987.

Semester: V Sem

Course Title: Power System Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

List of Experiments:

1. To study directional overcurrent relay, identify its operational zone for different base angles and study the protection of parallel feeder by directional overcurrent relay.
2. To study and observe the operation of inverse overcurrent relay and IDMT overcurrent relay. Plot the PSM/time of operation characteristics for three different TMS settings of both the relays.
3. To observe the differential protection of a 3-phase generator using static differential relay.
4. To perform the following experiments for a Medium and Long Transmission line (π and T network) simulated on Transmission Line Simulator/Analyser. These set of experiments are to be performed under two conditions: (R Load at the receiving end) and (L load at the receiving end)
   a. To observe Ferranti Effect
   b. To calculate ABCD parameters, sending end and receiving end power factors, line parameters (Z and Y) and plot Complex Power Circle Diagram
   c. Calculate Surge Impedance Loading and Steady State Stability Limit of the lines
   d. Calculate performance parameters of the line viz. Voltage Regulation, Losses and Efficiency of the lines.
   e. Study the current in the neutral conductor for different unbalanced conditions and Draw the Phasor Diagram
   f. Study of effect of Shut Reactor Compensation of the performance parameters of the lines.
   g. Study of effect of Shut Capacitor Compensation of the performance parameters of the lines.
   h. Study of effect of Series Reactor Compensation of the performance parameters of the lines.
   i. Study and observe the operation of protection schemes of the lines comprising of overcurrent earth fault protection and Over/Under voltage protection.
5. To study the operation of the Synchronizing Relay by using Electrical Power Transmission Line Analyser
6. To observe the operation of overcurrent and earth faulty relay for protection of 3-phase feeder under (i) LG, (ii) LL, (iii) LLG, (iv) LLLG fault
7. To observe and verify the current grading and time grading protection of radial feeder.

Semester: V

Course Title: Power Electronics Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

List of Experiments

1. To study and draw the following Silicon Controlled Rectifier (SCR) characteristics:

   a) Anode current characteristics;

   b) Gate control characteristics or (Firing characteristic).

2. To study and investigate the performance of following SCR commutation:

   a) Load Commutation

   b) Resonant Pulse Commutation

   c) Complementary Commutation

   d) Impulse Commutation

   e) External Pulse Commutation

3. To study and observe the following VI characteristics of TRIAC

   a) Forward VI characteristics of TRIAC

   b) Reverse VI characteristics of TRIAC

4. To study and observe the performance of following SCR firing circuits:

   a) Resistance R' firing circuit

   b) Resistance –Capacitance (RC) firing circuit

   c) UJT firing circuit

5. To study and investigate the performance of DC-DC buck and boost converter in open-loop and closed-loop

6. To study and investigate performance of following chopper circuits:

   a) Single-quadrant chopper circuits (Type-A and TypeB)

   b) Two-quadrant chopper circuits (Type-C and Type-D)

   c) Four-quadrant chopper circuits (Type-E)

7. To study and investigate the performance of single-phase rectifier with R and RL load in

   a) Half-wave

   b) Full-wave fully controlled mode

   c) Also observe the effect of source impedance

8. To study and evaluate the performance of single-phase dual converter in circulating and non-circulating mode of operation.

9. To study and experimentally validate the performance of single-phase AC voltage regulator using the following methods:

   a) TRIAC

   b) Anti-parallel thyristor

   c) Combination of TRIAC and DIAC.

10. To study and evaluate the performance of single-phase inverter using

    a) R-Load

    b) RL Load

11. To study and evaluate the performance of single-phase cyclo-converter using

    a) R-Load

    b) RL Load

12. To study and investigate the performance of three-phase rectifier with R and RL load in

    a) Half-wave

    b) Full-wave mode

13. To study and investigate the performance of three-phase inverter under 120^0 and180^0 mode of operation using

    a) R-Load

    b) RL Load

14. To study and perform experiment on the charging and discharging of a battery using a bidirectional dc-dc converter.

15. To study and perform experiments on Maximum power point tracking of Solar PV systems.

Semester: VI

Course Title: Operation and Control of Power Systems

Course Category: Program Core **Credit: 4 (3 1 0)**

Load Flow Analysis: Static Load Flow Equation, Bus Admittance Matrix. Bus Classification, Gauss Siedel, Newton Raphson and Fast Decoupled Load Flow Methods.

Power System Stability: Modelling of Synchronous Machine, Rotor Angle Stability, Voltage Stability, Steady State Stability, Swing Equation, Equal Area Criterion, Solution of Swing Equation.

Voltage and Load Frequency Control: Introduction to Control of Active and Reactive Power Flow, Control of Voltage, Excitation Systems, Introduction to Load Frequency Control and Automatic Generation Control, Single Area Modelling of AGC, Concept of Multi Area AGC.

Economic Operation of Power Systems: Economic Dispatch Problem of Thermal Units, Derivation of Transmission Loss Formula, Unit Commitment Problem.

Text / Reference Books:

1. Nagarth& Kothari: Modern Power System Analysis, TMH Publishing Company.
2. Wood, A.J. and B.F. Wollenberg, Power Generation Operation and Control, John Wiley & Sons, Third Edition, 2013.
3. C.L. Wadhawa: Electrical Power Systems, Wiley Eastern Limited.
4. Elements of Power System Analysis, William D. Stevenson Jr., Mc-Graw Hill
5. O.E. Elgerd: Electric Energy Systems Theory. TMH Publishing Company.
6. Power System Stability and Control, P Kundur, McGraw-Hill

Semester: VI Sem

Course Title: Electric Drives & Control

Course Category: Program Core **Credit: 4 (3 1 0)**

Introduction and Dynamics of Electric Drives: Concept of electric drives, advantages, parts of electric drives, speed torque conventions, multi-quadrant operation, types of loads and load torques, components of load torques, referred load torque/load inertia, determination of the moment of inertia, calculation of starting time, steady-state stability analysis, ratings of converters and motors, speed transitions curves.

Power Rating and Heating of Drive Motors: Load diagram, overload capacity, insulating materials, heating and cooling of motors, service conditions of electric drives (continuous, intermittent, short time), selection of motor power capacity, operation of drives under shock loading condition.

DC Motor Drives: Steady-state speed-torque relations, methods of speed control, starter design, regenerative braking, dynamic braking, plugging, single-phase and three-phase AC to DC converter-fed dc separately excited motor, controlled rectifier fed dc series motor, single/two/four quadrant chopper fed dc separately excited motor and dc series motor, converter rating, and closed-loop control.

AC Motor Drives: Steady-state characteristics, starting methods, conventional speed control methods, braking, variable frequency drives, multi-quadrant operation, current source inverter (CSI) fed IM, ac voltage controller fed IM, closed-loop control of IM.

Text / Reference Books:

1. G. K. Dubey, "Fundamental of Electric Drives", 2nd Ed., Narosa Publishing House. 2. V. Subrahmanyam, "Electric Drives, Concepts and Applications", 2nd Ed, TMH, India, 2011.

3. S. K. Pillai, "A first course in electric drives", 2nd Ed., New Age International Private Ltd. 4. N. K. De and P. C. Sen, "Electric Drives", Printeice Hall, India, 2006. 5. P. C. Sen, "Thyristor DC Drives", John Willey & Sons.

6. J. M. D. Murphy & F. G. Turnbull, "Power Electric Control of AC Motors", Pergamon Press.

7. B. K. Bose, "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors.

8. R. Krishnan, “Electric motor drives: modeling, analysis, and control”, Prentice Hall PTR, 2001.

Semester: VI Sem

Course Title: Digital Signal Processing

Course Category: Program Core **Credit: 4 (3 1 0)**

Discrete Time Signals in the Time Domain: Introduction to discrete-time signals, Time-Domain Representation, Operation on sequences, Operations on finite length sequences, Typical sequences and sequence representation, The sampling process, correlation of signals.

Discrete Time System: Discrete time system examples, classification of discrete time systems, impulse and step responses, Time domain characterization of LTI discrete time system.

Discrete Transforms: Z-Transform, Region of convergence of a rational **z**-transform, Inverse **z-**transform, **z-**transform theorems, Computation of the convolutional sum of finite length sequences, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Discrete Time Fourier Transform (DTFT),

LTI Discrete-Time Systems in the Transform Domain: Transfer Function classification based on Magnitude characteristics, Transfer Function classification based on Phase characteristics, Types of Linear phase FIR transfer functions, simple digital filters.

Digital Filter Structure: Block diagram representation, Equivalent structures, Basic FIR digital filter structures, Basic IIR digital filter structures,

FIR Digital Filter Design: Preliminary considerations, FIR filter design based on windowed Fourier series, Computer aided design of equiripple linear phase FIR filters, Design of minimum phase FIR filters.

IIR Digital Filter Design: Preliminary considerations, bilinear transformation method of IIR filter design, Design of lowpass IIR digital filters, Design of Highpass, Bandpass, Bandstop and AllpassIIR digital filters.

FPGA based system design: Introduction and implementation in VHDL,its applications.

Text / Reference Books:

1. Lathi B.P, Modern Digital and Analog Communication Systems, 3rd Ed, Oxford University Press, 2005.
2. H. Taub, D. L. Schilling and Gautam Saha, Principles of Communication Systems, 3rd ed, TMH, 2008.
3. Haykin, Communication Systems, 4th Ed, John Wiley & Sons, 2004.

4. Prokias John G, Digital Signal Processing, 3rd Ed , Prentice Hall of India,2007.
5. Oppenheim, Schafer, and Buck, Discrete-Time Signal Processing, 3rd Ed, Prentice Hall of India, 2009.
6. Mitra Sanjiv K, Digital Signal Processing, 4th Ed, Mc-Graw Hill, 2013.

Semester: VI Sem

Course Title: Advanced Power Transmission

Course Category: Program Core **Credit: 4 (3 1 0)**

EHV AC Transmission: Need of EHV Transmission, Standard Transmission Voltage, Electrical and Mechanical Considerations of EHV Lines, Surface Voltage Gradients in Conductor, Distribution of Voltage Gradients on Sub-Conductors, Corona Loss, Features of EHV Transmission Lines.

HVDC Transmission: DC Links, Components and Configurations, Converter Station, Operation and Controls of Converters, Characteristics, Power Control, Starting and Stopping of DC Link.

Flexible AC Transmission Systems: Fundamentals of AC Power Transmission, Transmission Problems and Needs, Mechanism of Active and Reactive Power Flow Control, Basic FACTS Controllers with Application and Principles of Operation.

Introduction To Smart Grid: Philosophy of Smart Grid, Attributes of Smart Grid, Key Technology Areas.

Text / Reference Books:

1. Rakesh Das Begmudre, Extra High Voltage AC Transmission Engineering, Wiley Eastern Limited.
2. K.R. Padiyar, HVDC Power Transmission System, Wiley Eastern Limited.
3. E.W. Kimbark. EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers.
4. Math H. J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, Wiley-IEEE Press.
5. Flexible AC Transmission Systems, Yong-Hua Song, Allan T. Johns, IEE publication
6. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Narain G. Hingorani, Laszlo Gyugyi
7. James Momoh, “Smart Grid: Fundamentals of design and analysis”, John Wiley & sons Inc, IEEE press 2012.
8. Power System Stability and Control, P Kundur, McGraw-Hill

Semester: VI Sem

Course Title: Industrial Machine Learning

Course Category: Program Core **Credit: 4 (3 1 0)**

Fundamental Concepts of ML: Basic concepts and terminology of machine learning, such as supervised and unsupervised learning, and the different types of algorithms

Supervised Learning: Linear regression: simple linear regression, multiple linear regression, and regularization techniques. Logistic regression: logistic regression with multiple classes and regularization techniques. Decision trees: Entropy and information gain, and the ID3, C4.5, and CART algorithms. Support Vector Machines: linear and non-linear SVM and kernel trick. Ensemble methods: bagging, boosting, and Random Forest. Evaluation and tuning: Cross-validation, grid search, and performance metrics such as accuracy, precision, recall, and F1 score.

Unsupervised Learning: Clustering: k-means clustering, hierarchical clustering, and density-based clustering. Dimensionality reduction: Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and Singular Value Decomposition (SVD). Anomaly detection: density-based, distance-based and reconstruction-based methods. Association rule mining: Apriori algorithm and the FP-growth algorithm.

Special Topics: Deep learning, Convolutional neural networks, Reinforcement learning, *Case Studies:* Image and signal processing, Object detection, Human activity recognition, and Natural language processing, Weather forecasting, Energy consumption prediction.

Text / Reference Books:

1. Bishop, C. M., &Nasrabadi, N. M. (2006). Pattern recognition and machine learning (Vol. 4, No. 4, p. 738). New York: springer.
2. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT press.
3. Sutton, R. S., &Barto, A. G. (2018). Reinforcement learning: An introduction. MIT press.
4. da Fontoura Costa, L., &Travieso, G. (1996). Fundamentals of neural networks: By Laurene Fausett. Prentice-Hall, 1994, pp. 461, ISBN 0-13-334186-0.

Semester: VI Sem

Course Title: Power System and Electrical Design Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

MATLAB based assignments on the following topics:

1. Transmission Line Parameters.
2. Transmission Line Model and Performance.
3. Optimal Dispatch of Generation.
4. Load Flow Analysis.
5. Power System Stability.
6. Automatic Generation and Voltage Control.

Semester: VI Sem

Course Title: Electrical Drives Lab

Course Category: Program Core **Credit: 1 (0 0 2)**

List of Experiments:

ROTOR I

1. To test the four-quadrant operation of DC motor using chopper.
2. To verify the operation of Boost Rectifier with Power Factor Correction (PFC).
3. To analyze the performance of Non-Isolated Switch Mode DC-DC Converter.
4. To investigate the performance of Three Phase Diode Clamped Multilevel Inverter.
5. To perform open loop and closed loop speed control analysis of three-phase Induction motor.

ROTOR II

1. To verify the $120^0$and 180^0conduction mode operation of Three-Phase Inverter.
2. To verify the speed control of the DC motor drive using single-phase dual converter.
3. To perform speed control of separately excited DC motor drive by DC-DC chopper.
4. To study the speed control of a three-phase AC Induction Motor drive with spring balance load by V/f Control method.
5. To analyze and understand the operating principle of 12-pulse Multi-pulse Converter.

Semester: VII Sem

Course Title: Computer Aided Power System Analysis

Course Category: Program Elective **Credit: 4 (3 1 0)**

Three-Phase Networks: Introduction, Three-phase network elements, Three-phase balanced network elements. Transformation Matrices, Three-phase unbalanced network elements, incidence and network matrices for three-phase networks. Algorithm for formation of three phase bus-impedance matrix. Modification of the three-phase bus impedance matrix for changes in the network.

Short Circuit Studies: Short circuit calculations using Bus Impedance matrix, Short circuit calculations for balanced three- phase network using Bus Impedance matrix, Short circuit calculations using Loop Impedance matrix.

Sensitivity Analysis and Optimal Load Flow: Classification of System variables, Sensitivity Analysis-Sensitivity Matrix, Development of Gx and Gu, Optimal Load Flow, Optimisation Technique, Gradient method. Formulation of Optimal Load-flow Problem and its Solutions, Consideration of Inequality Constraints. Comparison with Classic Economic Dispatch Method.

Security Concept and Contingency Evaluation: Operating States of a Power System, Concept of security Monitoring. Techniques for Contingency Evaluation DC Load Flow, Fast Decoupled Load-flow, Preventive and corrective Measures.

Load Forecasting & State Estimation: Estimation of average, periodic, stochastic components of load, basic idea of state estimation of power system.

Text/ References Books:

1. Computer Techniques in Power System Analysis, M A Pai, Mc-Graw Hill.
2. Computer Methods in Power System Analysis, G.W. Stagg & A.H. El-Abiad, Mc-Graw Hill
3. Advanced Power System Analysis and Dynamics, L.P. Singh, Mc-Graw Hill.

Semester: VII Sem

Course Title: Optimal Control System

Course Category: Program Elective **Credit: 4 (3 1 0)**

Introduction to optimal control: Concepts of static and dynamic optimization; Static optimization: without and with equality constraints; Infinite dimensional optimization problem; Formulation of optimal control problem in dynamical systems; Selection of performance measures with examples.

Calculus of variations: Importance of variational calculus and fundamental concepts; Concept of functional and its variation; Optimum of functional; Development of Euler-Lagrange condition for optimality of functional involving single function; Discussions on Euler-Lagrange equation; Second variation (intuitive discussion) and its importance; Optimality of functionals with free end conditions; Euler-Lagrange conditions for optimality of functional involving multiple independent functions (intuitive discussion) with example.

Calculus of variations to optimal control design: Optimum of functional with equality constraints; Variational approach to optimal control design for dynamical systems (Hamiltonian formulation) to the fixed time, free end problems.

Dynamic programming: The principle of optimality and its application to decision making; Concept of dynamic programming; Determination of optimal control decisions for discretized systems based on recurrence equation; The Hamilton-Jacobi-Bellman equation.

Linear quadratic optimal control: Finite-time linear quadratic regulator, particularly time-invariant continuous and discrete-time cases; Solution to matrix differential and difference Riccati equation.

Text/ References Books:

Text-books:

1. Donald E. Kirk: Optimal Control Theory-An Introduction, Dover Publications, New York, 2004.
2. Daniel Liberzon: Calculus of Variations and Optimal Control Theory-A Concise Introduction, Princeton University Press, 2012.
3. Frank L. Lewis, Draguna L. Vrabie, and Vassilis L. Syrmos: : Optimal Control, John Wiley & Sons, Third Edition, 2012.

Reference Books:

1. DesineniSubbaram Naidu: Optimal Control Systems, CRC Press, 2003.
2. Brain D. O. Anderson, John Barratt Moore: Optimal control-Linear quadratic methods, Prentice-Hall International 2007.

Semester: VII Sem

Course Title: Advanced Electric Drives& Control

Course Category: Program Elective **Credit: 4 (3 1 0)**

Modeling of Machines: Generalized theory and Kron's machine model, Modeling of dc machines, Modeling of induction machine, Modeling of synchronous machine, Reference frame theory and per unit system.

DC Machines and its Control: Control of dc motor drives, Phase-controlled converters, Steady-state analysis of converter-controlled dc motor drive, Transfer functions, Chopper controlled dc motor drive, Steady-state analysis of chopper-controlled dc motor drive.

Induction Machines and its Control: Phase and frequency-control of induction motor drive, Scalar control of induction motor, Principle of vector control and field orientation, Sensorless control and flux observers, Multilevel converter-fed induction motor drive, Utility friendly induction motor drive.

Special Machines and its Control: Introduction to control of synchronous motor, Permanent magnet synchronous motor (PMSM), Brushless dc motor (BLDC), Switched reluctance motor (SRM), and Stepper motors.

Text/ References Books:

1. Krishnan, R., Electric Motor & Drives: Modeling, Analysis & Control, PHI Pvt. Ltd. (2001).
2. Mohan, N., Advanced Electric Drives: Analysis, Control, and Modeling Using Simulink, MNPERE (2001).
3. Bose B.K., Modern Power Electronics & AC Drives, PHI Pvt. Ltd., (2001)
4. Leonard, W., Control of Electric Drives, Springer-Verlag, New York, (1985).
5. Ion Boldea, Syed A. Nasar, *Electric Drives*, CRC Press, 2nd Edition, 2005.
6. J. M. D. Murphy & F. G. Turnbull, "Power Electric Control of AC Motors", Pergamon Press.
7. P.C. Krause, 'Analysis of Electrical Machines', McGraw Hill Book Company, 1987.
8. Peter Vas, 'Electrical Machines and Drives: A Space-vector Theory Approach', Clarendon Press, 1992.

Semester: VII Sem

Course Title: Power System Restructuring, Deregulation and Economics

Course Category: Program Elective **Credit: 4 (3 1 0)**

Traditional electricity supply systems: Historical growth and structure of the electricity supply industry, need for integrated and interconnected electricity supply systems, motivations for restructuring and competitive markets.

Restructured electricity supply systems: Components, functions and business models. Different industry structures for asset ownership/ management. Deregulation.

Interactions of new market entities:System Operators, Generation Companies, Network Utilities, Retailers, Aggregators, Distribution System Operators. Trading arrangements. Market models for competition: Wholesale and retail competition. Reregulation. Role of Open Access, Impact of industry restructuring on system operation, Ancillary Services, role of smart grids.

Electricity Pricing: Basics of electricity pricing, auctions, market clearing mechanisms and prices, network pricing, congestion management, dispatch-based pricing.

Market development and institutional scenario: Historical evolution, institutional development, contemporary systems, regulation, reforms, challenges, and future directions of key electricity markets; UK, South America, US, Scandinavia and Australia.

Electricity market development in India: Institutional structure, utilities, SO, LDCs, TSO & DSO. ERCs, traders, Power Exchanges. DSM mechanisms, Open access, Industry structure and regulatory framework, market development, Grid Codes, RE policies, RPO, National Electricity Plan, Tariff policies. Critical issues / challenges before the Indian power sector.

Text/ References Books:

1. Loi Lei Lai, “Power System Restructuring and Deregulation,” John Wiley & Sons, Ltd, England, 2001.
2. Mohammad Shahidehpour, MuwaffaqAlomoush, “Restructured Electrical Power Systems: Operation: Trading, and Volatility,” CRC Press, 2001.
3. Daniel S. Kirschen and Goran Strbac, “Fundamentals of Power System Economics,” John Wiley & Sons, 2004.
4. Geoffrey Rothwell, Tomas Gomez (Eds.), “Electricity Economics Regulation and Deregulation,” IEEE Press Power Engineering Series, John Wiley & Sons, 2003.
5. Steven Stoft, “Power System Economics: Designing Markets for Electricity,” IEEE Press & Wiley-Interscience, 2002.
6. Sally Hunt, “Making Competition Work in Electricity,” John Wiley & Sons, 2002.
7. Lorrin Philipson, H. Lee Willis, “Understanding Electric Utilities and De-regulation,” CRC Press, Taylor & Francis Group, 1998.

Semester: VII Sem

Course Title: High Voltage Engineering

Course Category: Program Elective **Credit: 4 (3 1 0)**

Breakdown in Gases: Mechanism of breakdown in gases; various related ionization processes, Townsends and Streamer theories, Paschen's Law. Breakdown in non-uniform fields. Effect of waveshape of impressed voltage on the breakdown strength. Breakdown of sphere gap and rod gap.

Breakdown in Liquid and Solids: Mechanism of breakdown in liquids; suspended particles, suspended water, cavitation and bubble and electronic breakdown theories. Mechanisms of breakdown of solids; intrinsic, electro- mechanical, erosion, surface, thermal and streamer. Relation between electric strength of solids and log time, intrinsic breakdown strength.

Impulse Generator: Specifications of an impulse voltage wave, standard impulse. Impulse generator (Mars circuit) circuit, working, earthing and tripping. Technique to observe wavefront on CRO.

Generation of High Voltage: Method of generation of power frequency high voltages-cascade transformers and resonance methods. Generation of high voltage-D.C. voltage multiplier circuit, Electrostatic generators, voltage stabilization. Tesla coil.

Measurement of High Voltage: Potential dividers; resistive, capacitive and mixed dividers for high voltage. Sphere gap; construction, mounting, effect of nearby earthed objects, effect of humidity and atmospheric conditions, effect of irradiation and of polarity. Electrostatic voltmeter; principle and classification. Constructional details of an absolute electrostatic voltmeter. Oscilloscope and their application in high voltage measurements.

High Voltage Testing: Measurement of insulation resistance of cables. Wet and dry flashover tests of insu1ators. Testing of insulators in simulated pollution conditions. Testing of transformers. Measurement of breakdown strength of oil. Basic techniques of non-destructive testing of insulators; measurement of loss angle and partial discharge measurement techniques.

Text/ References Books:

1. C.L. Wadhwa, 'High Voltage Engineering' New Age International Publishers, 1994.

2. M.S. Naidu, V. Kamaraju, 'High Voltage Engineering' Tata McGraw Hill, 1995.

3. D.VRazevig, 'High Voltage Engineering' Khanna Publishers, 1990

Semester: VII Sem

Course Title: Electrical Machine Design

Course Category: Program Elective **Credit: 4 (3 1 0)**

General: Factors and limitations in design. Output coefficients, classification of magnetic materials and allowable flux densities. Calculation of magnetic circuits, magnetizing current, coils for given temperatures. Real and apparent flux densities. Tapered teeth. Carter's coefficient, leakage fluxes reactances. Classifications of insulation materials and the temperature ranges.

Armature Winding: General features of armature windings, single layer, double layer and commutator windings, integral and fractional slot windings, winding factors. Harmonics, eddy current losses in conductors.

Heating, Cooling and Ventilation: Heat dissipation, heat flow, Heating cooling curves. Heating cooling cycles, estimation of maximum temperature rise, cooling media. Quantity of cooling media, Types of enclosures. Ratings, heat dissipation. Methods of ventilation.

Design of Machines: Application of above design principles for the design of Power Transformers and Synchronous Machines.

Text/ References Books:

1. A.K. Sawhney: A Course in Electrical Machine Design, Dhanpat Rai & Co.

2. R.K. Agarwal: Principles of Electrical Machine Design, S.K. Kataria& Sons.

3. M. G. Say: Design and Performance of A.C. Machines, CPS Publishers.

Semester: VII Sem

Course Title: Utilization of Electrical Power

Course Category: Program Elective **Credit: 4 (3 1 0)**

Electric Heating, Welding: Different methods of electric heating. Principle of high frequency induction and di-electric heating. Construction, operation, performance and applications of arc furnace and induction furnaces, Microwave heating.

Classification of Electric Welding: Electric Arc welding. Electric supply for arc welding, welding transformers. Resistance welding.

Electric Drives: Characteristics of load. Review of starting and running characteristics of ac and dc industrial motors. Relative study of efficiency, power factor, size and costs. Starting, speed control of motors. Electric braking- Plugging, Rheostatic and regenerative braking. Behaviour of motor during starting, acceleration, braking and reversing operations. Speed-time relations. Determination of motor rating for intermittent loads. Drives for machine tools, lifts, cranes, paper mills, printing machinery, rolling mills etc.

Electric Traction: Systems of electric traction, power supply systems for track-electrification. Comparison and application of different systems.

Traction Methods: Types of service, speed time and speed distance curves, average and schedule speed. Tractive effort. Estimation of power and energy requirements: specific energy consumption. Mechanics of train movement. Coefficient of adhesion, adhesive and effective weight.

Traction Motor Control: DC and AC traction motors, special requirements of selection of type, speed, torque and current characteristics. Various methods of starting and speed control of DC and AC drives used in traction. Series parallel starting. Shunt and bridge transition. Drum and contactor type controllers. Metadyne control. Multiple unit control and master controllers.

Means of Supplying Power and Train Lighting: Overhead equipment, current collection. System of train lighting, special requirements, methods of obtaining unidirectional polarity and constant output voltage.

Text/ References Books:

1. H. Pratab: Utilisation of Electric Power

2. H. Pratab: Modern Electric Traction

3. M.V. Suryanarayana: Utilisation of Electric Power & Electric Traction.

Semester: VII Sem

Course Name: Robotics

Course Category: Program Elective **Credit: 4 (3 1 0)**

Introduction – brief history; types; classification and usage; science and technology of robots.

Elements of Robot Hardware – Drive System; actuators; and sensors:Drive systems (Differential; Car-type; Synchronous; Omni type; Legged Locomotion; Undulating).Differentkinds of actuators–Characteristics of various actuating systems; Comparison of actuating systems; Hydraulic; Pneumatic and Electric actuators (stepper; DC servo and AC motors; model of a DC servo motor); Introduction to various end effectors.Micro-Controllers and IC's (Different families with associated applications and specifications).Sensors - Internal and external sensors; common sensors – encoders; tachometers; and strain gauge-based force-torque sensors; proximity and distance measuring sensors; and vision.

Mathematical Representation of Robots: Representation of joints; constraints; link representation using D-H parameters; 4 x 4 transformation matrix for a link; examples. Homogeneous transformations; Rotation matrices; Mathematical Singularities; Robot kinematic modeling; Forward kinematics; Inverse kinematics problem: closed-form and numerical solutions; Concept of decoupling.

Rigid Body Motion; Robot Kinematics of Velocity; and Robot Statics: Translational and rotational velocities; Velocity transformations; Jacobian transformations; Derivatives of homogeneous transformation matrices; Forward kinematics; Inverse kinematics of velocity; Static force/torque transformations; Recursive equations of motion and static force/torque relationships.

Robot Dynamics and Control: Euler-Lagrange equations; Lagrangian approach to robot dynamics; Actuator dynamics; Properties of the robot dynamic model: inertial coefficients; Newton-Euler formulation of robot dynamics; Point -to-point vs. Continuous motion. Polynomials. Linear functions with parabolic blends. via points. Cartesian paths. Kinematic control; Independent joint control: based on PD and PID compensators; based on feed forward control; State-space modeling and analysis; Multi-variable PD control; Computed-Torque control; Cartesian based control schemes; Robust control methods; Adaptive control methods.

Introduction to Computer vision and Artificial Intelligence: Feature Extraction (Edge Map; Grouping; Lines; curves; regions); Pattern Recognition (Specific Objects; Segmentation; Connected component analysis); Labeling; Histograms and Matching; Tracking and Motion; Fuzzy logic; neural network; evolutionary computing.

Text/ References Books:

1. Phillipe Collet; "Robotic Technology"; Prentice Hall.
2. Y. Koren; "Robotics for Engineers"; McGraw Hill.
3. K.S. Fu; R.C. Gonzalez &CSG Lee; "Robotics"; McGraw Hill International.
4. J.J. Craig; "Robotics"; Addison-Wesley.

5. Groover; Mitchell Weiss; Nagel Octrey; "Industrial Robots";McGraw Hill.
6. Asfahl; "Robots & Manufacturing Automation"; Wiley Eastern.

Semester: VII

Course Title: Computer Architecture and Organization

Course Category: Program Elective **Credit: 4 (3 1 0)**

Basic Computer Organization: Register transfer, bus and memory transfer, arithmetic micro- operation, logic micro – operations, shift micro – operations. Instruction code, computer registers, memory reference instructions, input – output and interrupts.

Central Processing Unit: General register organization, stack organization, instruction format, addressing modes, data transfer & manipulation.

Computer Arithmetic: Addition, subtraction, multiplication and division operation for fixed point signed magnitude data and 2's complement data, floating point arithmetic operation, decimal arithmetic operations.

Input – Output Architecture: Peripheral device, input- output interface, asynchronous data transfer, direct memory access. Priority interrupt – Daisy Chain Priority Interrupt and Parallel Priority interrupt.

Memory and Storage: Processor v/s memory speed, memory hierarchy, main memory, associative memory, auxiliary memory, cache memory, virtual memory management hardware.

Text/Reference Books:

1. M. Morris Mano: Computer System Architecture, III Edition, PHI.
2. M. Morris Mano: Digital Logic and Computer Design, PHI.
3. John P. Hayes: Computer Architecture and Organization, McGraw Hill, International Editions.
4. V. Carl Hamacher: Computer Organization McGraw Hill, International Z.G. Vranesic, S. G. Zaky Editions.

Semester: VII Sem

Course Name: Basics of Image Processing

Course Category: Program Elective **Credit: 4 (3 1 0)**

Essential Fundamental of Image Processing: Image Acquisition, Spatial Operation, Gray-Level Mapping, Gamma Mapping, Logarithmic Mapping, Exponential Mapping, The Image Histogram, Histogram Stretching, Histogram Equalization, and Thresholding.

Features Extraction: Histogram, Co-occurrence Matrix, Fourier Transform, Wavelet Transform, Local Binary Patterns, Local Ternary Patterns, Harris Corner Detection, SIFT Features.

Segmentation: Local Segmentation, Global Segmentation, Region-based, Boundary-based, Edge Based, Canny Edge Detector, Marr and Hildreth Edge Operator, Prewitt operators, Roberts cross-gradient operators, Sobel operators, Harris Corner Detection.

Frequency Domain Filtering: Fourier Series, Sampling Theorem,1-D Fourier Transform, 2-D Fourier Transform, 2-D Filters, Filtering,Butterworth Filter, Gaussian Filter.

Geometry transformation: Affine Transformations, Translation, rotation, scaling, Shearing, Combining the Transformations, Backward Mapping, Interpolation, Hough Transform.

Text/ References Books:

1. Digital Image Processing by Rafael C. Gonzalez and Richard E. Woods
2. Fundamentals of Digital Image Processing: A Practical Approach with Examples in MATLAB" by Chris Solomon and Toby Breckon.
3. Fundamentals of Digital Image Processing" by Sanjay Sharma.

Semester: VIII

Course Title: Modelling and Analysis of Distribution System

Course Category:Program Elective **Credit: 3 (3 0 0)**

Introduction to the Distribution System: The Distribution System, Distribution Substations, Radial Feeders, Distribution Feeder Electrical Characteristics

Modelling of Distribution System Components: Overhead lines, feeders and cables, Single and three-phase distribution transformers, Voltage regulators, Load model, Capacitor banks, Distributed generation.

Nature of Loads: Definitions, Individual Customer Load (Demand, Maximum demand, Average Demand, Load Factor), Distribution Transformer Loading Feeder (Diversified Demand, Maximum Diversified Demand, Load Duration Curve, Maximum Noncoincident demand, Utilization factor, Load Diversity), Feeder Load

Approximate Methods of Analysis: Computation of transformer and feeder loading, "K" Factors, voltage drop and power loss calculations, Distribution of loads, and Lumping load in various geometric configurations.

Distribution System Analysis: Three phaseLoad flow analysis, Backward/forward sweep, Direct approach, Direct approach for weakly meshed systems flow analysis: Gauss Implicit Z-matrix Method

Short-circuit analysis: Sequence-components vs. phase-variable, LG, LLG, LLLG, and LL Faults, Short-circuit analysis for the Weakly meshed system, Applications of distribution system analysis.

Text/ References Books:

1. W. H. Kresting, Distribution System Modeling and Analysis, CRC Press, New York, 2002.
2. A. A. Sallam and O. P. Malik, Electric Distribution System, IEEE Press, Piscataway, NJ, 2011.
3. Pabla, Electric Power Distribution [6th edition], McGraw Hill Education (India) Power Limited, 2017.
4. M. Bollen and F. Hassan, Integration of Distributed Generation in the Power System, IEEE Press Editorial Board, 2011.

Semester: VIII

Course Title: Power System Reliability

Course Category:Program Elective **Credit: 3 (3 0 0)**

Introduction: Reliability definitions and concepts, indices and criteria, Reliability and availability, Absolute and relative reliability, evaluation techniques, Reliability economics, monitoring and growth, Probability concepts, Probabilistic reliability criteria, statistical and probabilistic measures, adequacy and security, reliability cost and reliability worth.

Power Plants Reliability: Reliability Evaluation of Thermal, Nuclear, Hydro, Solar, Wind power plants: Capacity outage probability table, recursive algorithm, Loss of Load Expectation, Loss of energy indices, expected energy not supplied, energy limited system, scheduled outages, Load forecast and Forced outage rate uncertainty. Frequency and Duration Methods. Interconnected System Reliability: effect of tie capacity, tie line reliability, number of tie lines, interconnection agreements.

Unit commitment and Operating Reserve Reliability: Outage replacement rate, unit commitment risk, rapid start units, hot reserve units, Response risk: Effect of distributing spinning reserve, hydro-electric units, rapid start unit and Interconnected system.

Composite generation and transmission systems: Radial configurations, Conditional probability approach, Network configurations, System and load point indices, Independent outages and dependent outages.

Distribution System Reliability: Customer Orientated indices, Load and Energy Oriented Indices, Radial systems, Effect of lateral distributor protection, Disconnects, protection failure and transferring loads, Parallel and Meshed Networks: Inclusion of Bus bar failures and scheduled maintenance, coordinated and uncoordinated maintenance.

Reliability of Substations and Switching Stations: Effect of short circuits and breaker operation, operating and failure of system components, open and short circuit failures, Active and passive failures, Malfunction of normally closed breakers, Malfunction of alternative supplies.

Text/Reference Books:

1. "Reliability Evaluation of Engineering Systems, Concepts and Techniques", Roy Billiton, Ronald N. Allan, Second Edition
2. "Assessment of Power System Reliability: Methods and Applications", Prof. Dr. Marko Cepin

3. “Reliability Evaluation of Power Systems”, Roy Billinton, Ronald N. Allan, Second Edition
4. “Power Distribution System Reliability: Practical Methods and Applications”, Ali A. Chowdhury and Don O. Koval
5. “Reliability Engineering and Risk Analysis: A practical guide”, Mohammad Modarres, Mark P. Kaminskiy, VasiliyKrivtsov (2016) 3rd edition, Publisher: CRC Press.

Semester: VIII

Course Title: Smart Grid Systems

Course Category:Program Elective/Open Elective/PLEAS **Credit: 4 (3 1 0)**

Introduction to Smart Grids: Need of smart grids, its definition, concepts and characteristics, key drivers, benefits and challenges, NIST conceptual framework, SG architecture layers: application, communication and power system. National SG Mission.

Smart Transmission Systems: Need for automation, SCADA systems: components and functions. Substation Automation. Energy Management Systems. Limitations of SCADA, Wide-Area Monitoring, Protection and Control Systems: concept, benefits, architecture, components, functions. Intelligent Electronic Devices, Phasor Measurement Units.

Smart Distribution Systems: Challenges with existing distribution management systems, Advance distribution management systems: Volt/Var control, fault location, isolation, and service restoration, Outage Management Systems, Geographic Information Systems.

Advanced Metering Infrastructure (AMI): AMI: architecture, components and functions, Smart meters, communication infrastructure: HAN, NAN and WAN, Meter Data Acquisition System, Head End Systems, Meter Data Management System. Policies, regulations and standards.

Demand Side Energy Management: Demand Response programs and their applications, Smart Home Energy Management Systems, Integration of distributed active components: DER integration, Energy Storage management, Vehicle to Grid, Grid to Vehicle.

Communication, Standards and Security: Role of communication in enabling SG, types of wired and wireless communication technologies. SG communication infrastructure's major challenges: interoperability and security. Cybersecurity in SG, CIA triangle. Cyber incidences, threats and vulnerabilities. SG standards and communication protocols.

Text/ References Books:

1. Stuart Borlase (Ed.), "Smart Grids: Infrastructure, Technology, and Solutions", CRC Press, United Kingdom, 2016.
2. J. B. Ekanayake, K. M. Liyanage, N. Jenkins, J. Wu, A. Yokoyama, "Smart Grid: Technology and Applications. Germany: Wiley, 2016.
3. A. Phadke, J. S. Thorp, J. Thorp, "Synchronized Phasor Measurements and Their Applications", Germany: Springer US, 2008.
4. K. C. Budka, M. Thottan, J. G. Deshpande, "Communication Networks for Smart Grids: Making Smart Grid Real", Springer London, Germany, 2014.
5. Smart Grid Handbook, Vol. 3, Wiley, United Kingdom, 2016.

Semester: VIII

Course Title: Power System Stability

Course Category: Program Elective **Credit: 4 (3 1 0)**

Introduction to Power System Stability Problem: Basic Concepts and Definitions, Classification of Stability, Rotor Angle Stability, Voltage Stability, Dynamic Stability

Small Signal Stability: State-Space Representation, Stability Analysis of a Dynamic System, Linearization, Eigenvalues, Eigenvectors, Modal Matrices, Small Signal Stability of SMIB System, Sub-Synchronous Resonance, Small Signal Stability of Multi-Machine System.

Transient Stability: Swing equation, Equal Area Criteria, Numerical Integration Methods, Euler Method, Runge-Kutta Method, Implicit Integration Method, Direct Method of Transient Stability Analysis, Transient Energy Function Approach, Transient Stability of Large Systems.

Voltage Stability: P-V curves, Q-V curves, Sensitivity and Continuation Method, Voltage Stability Indices, Local and Global Bifurcations, Voltage Collapse.

Text/ References Books:

1. Power System Voltage Stability, C W Taylor, McGraw-Hill
2. Power System Stability and Control, P Kundur, McGraw-Hill
3. Voltage Stability of Electric Power Systems, T V Cutsem, Springer

Semester: VIII

Course Title: High Power Converters

Course Category:Program Elective **Credit: 4 (3 1 0)**

Devices and Standards: Introduction to silicon-based and wide band gap devices and corresponding gate driver circuit design, operation of series-connected devices, relevant IEEE and IEC standards for high power converters.

Converters Configurations: Different topologies of high-power converters, voltage source and current source converter, 2-Level converters, 3-Level NPC converters, cascaded H-bridge multilevel converters, flying capacitor converters, modular multilevel converters.

Advanced Modulation Techniques: Pulse width modulation techniques for high power converters: SHEPWM, Third-harmonic Injection, Space-vector PWM, DPWM, Level-shifted PWM, POD, PD, staircase, Hysteresis controller.

Component and Filter Design: Design of high-power converter components, operational issues, fault tolerant operation, reliability, mechanical design, thermal analysis and heat sink design considerations, design of filters on AC and DC side of converters.

Text/ References Books:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics, Converters, Applications and Design", Wiley, 2017.

2. Mohammad H. Rashid, "Power Electronics Circuits, Devices and Applications", Prentice Hall of India Pvt. Ltd, 2017.

3. Bin Wu, "High-Power Converters and AC Drives", IEEE Press, 2017. 4. D. G. Holmes and T. A. Lipo, "Pulse Width Modulation for Power Converters", IEEE Press, 2003.

5. R. E. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Kluwer Academic Publishers, 2004.

6. IEEE Research Papers.

7. Sergio Alberto Gonzalez, Santiago Andres Verne, Maria Ines Valla, "Multilevel Converters for Industrial Applications", CRC Press, 2017.

Semester: VIII

Course Title: Electric Vehicle Technology

Course Category:Program Elective/Open Elective **Credit: 4 (3 1 0)**

Overview of Electric Vehicles: Modern Electrical Drives: An Overview: Introduction, Drive Technology Trends: Electrical Machines, Power Converters, Embedded Control and Communication Links, Drive Design Methodology.

EV Technology and Battery Chargers: EV and PHEV Battery Chargers: Power Factor Correction Stage, Bidirectional Battery Chargers, Three-Phase Pulse Width Modulator with Pulse Centering, Three-Phase Converter with Pulse Width Modulator, Three-Phase Simplified Converter without PWM, Other Charger Topologies, Wireless Charging, V2G and G2V, Bi-directional power flow.

Development of Batteries in Electric Drive Vehicles: Trends in Development ofthe Batteries, Application Issues of LIBs, Significance of Battery Management Technology, battery parameter estimation, Development of Battery Management Technologies: No Management, Simple Management, Comprehensive Management, thermal issues with batteries, BMS Key Technologies.

Indian Government Policies: NITI Aayog Involvement, FAME Scheme and its Phases, Rate of Deployment of EV Off-board Chargers, Cost Effective Policies. Case Studies of Popular EVs on the Road.

Text/ References Books:

1. Seth Leitman and Bob Brant,” Build Your Own Electric Vehicle”, Mc Grew Hill, 2009.

2. SerefSoylu, “Electric Vehicles- The Benefits and Barriers”, Intech Open Access Publisher, 2011.

3. Rik De Donccker, Duco W. J. Pulle, and Andre` Veltman, “Advanced Electric Drives: Analysis, Modeling, Control”, Springer, 2011.

4. Jiuchun Jiang and Caiping Zhang, “Fundamentals and Applications of Lithium-Ion Batteries in electric Drive Vehicles”, Wiley, 2015.

5. Chris M., M. Abul Masrur and David Wenzhong Gao, “Hybrid Electric Vehicles Principles and Applications with Practical Perspectives”, Wiley, 2011.

Semester: VIII

Course Title: Applications of Power Electronics in Power Systems

Course Category: Program Elective **Credit: 4 (3 1 0)**

Steady State and Dynamic Problems in AC Systems: Flexible AC transmission systems (FACTS), Principles of series and shunt compensation, Description of static VAR compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC),

Modelling and Analysis of FACTS Controllers: Control strategies to improve system stability, Power Quality problems in distribution systems.

Harmonics: harmonics creating loads, modelling, harmonic propagation, Series and parallel resonances, harmonic power flow, Mitigation of harmonics, filters, passive filters, Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker, Mitigation of power quality problems using power electronic conditioners, IEEE standards, Need for HVDC, AC vs DC, Comparative advantages, Converters and their characteristics, Control of the converters (CC and CEA), Parallel and series operation of converters.

Text / References Books:

1. N. G. Hingorani& Laszlo Gyugyi, Understanding FACTS, IEEE Press, 2000.

2. E. F. Fuchs & Mohammad A.S. Masoum, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press 2008.

3. K. R. Padiyar, FACTS controllers in power transmission and distribution, New Age International publishers, New Delhi, 2007.

4. K. R. Padiyar, HVDC Power Transmission Systems, New Age International publishers, New Delhi, 1999.

Semester: VIII

Course Title: Intelligent Systems & Control

Course Category: Program Elective **Credit: 4 (3 1 0)**

Introduction: Approaches to intelligent control; Architecture for intelligent control; Symbolicreasoning system; rule-based systems; AI approach; Knowledge representation; Expert systems.

Fuzzy Logic Control System: Motivation and basic definitions; Fuzzy arithmetic and Fuzzyrelations; Fuzzy logic modelling and control; Fuzzy knowledge and rule bases; Fuzzy modellingand control schemes for nonlinear systems; Self-organizing fuzzy logic control; Fuzzy logiccontrol for nonlinear time-delay system; Stabilization using fuzzy models; Fuzzy estimators;Adaptive fuzzy control.

ANN Based Controllers and Estimators: Concept of Artificial Neural Networks and its basicmathematical model; McCulloch-Pitts neuron model; simple Perceptron; Adaline and Madaline;Feed-forward Multilayer Perceptron; Learning and Training the neural network;

DataProcessing: Scaling; Fourier transformation; principal-component analysis and wavelettransformations; Hopfield network; Self-organizing network and Recurrent network; NeuralNetwork based controllers and estimators.

Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps;Adjustment of free parameters; Solution of typical control problems using genetic algorithm;Concept on some other search techniques like tabu search and ant-colony search techniques forsolving optimization problems; Evolutionary Fuzzy logic controllers.

Case Studies: Identification and control of linear and nonlinear dynamic systems usingMATLAB-Neural Network toolbox; Stability analysis of Neural-Network interconnectionsystems; Implementation of fuzzy logic controller using MATLAB fuzzy-logic toolbox; Stabilityanalysis of fuzzy control systems.

Texts / References Books:

1. Padhy. N.P.: ‘Artificial Intelligence and Intelligent System’, Oxford University Press.

2. Kosko; B.: ‘Neural Networks and Fuzzy Systems’, Prentice-Hall of India Pvt. Ltd.

3. Jacek M. Zurada: ‘Introduction to Artificial Neural Systems’, Jaico Publishing House.

4. Klir G.J. & Folger T.A.: ‘Fuzzy sets; uncertainty and Information’, Prentice-Hall of India Pvt. Ltd.

5. Zimmerman H.J.: ‘Fuzzy set theory-and its Applications’, Kluwer Academic Publishers.

6. Driankov; Hellendroon: ‘Introduction to Fuzzy Control’, Narosa Publishers.

7. Goldberg D.E.: ‘Genetic algorithms in Search; Optimization and Machine learning’, Addison Wesley.

8. Stanislaw H. Zak: ‘Systems and Control’ Oxford University Press

Semester: VIII Sem

Course Title: Industrial Drives & Control

Course Category: Program Elective **Credit: 4 (3 1 0)**

Vector and Direct Torque Control of Induction Machines (IM): Rotor-flux-oriented control, Stator-flux-oriented control, Magnetizing-flux-oriented control, Sensorless control of induction motors, Direct torque control (DTC) of induction machines.

Vector and Direct Torque Control of Synchronous Machines: Control of synchronous motor, Self-controlled synchronous motor, Vector control of PMSM, Vector control of synchronous reluctance machines and synchronous machines, Direct torque control (DTC) of synchronous motors.

Torque Control of Switched Reluctance Motor (SRM): Switched reluctance motor drive fundamentals; main techniques of position-sensorless implementations, Position-sensorlessSRM drives, Torque-controlled SRM drive.

Other Industrial Machines and its Control: Brushless dc motor (BLDC) control, Stepper motors and control.

Text/ References Books:

1. Krishnan, R., 'Electric Motor & Drives: Modeling, Analysis & Control', PHI Pvt. Ltd. 2001.
2. Peter Vas, 'Sensorless Vector and Direct Torque Control', Oxford University Press, 1998.
3. Ion Boldea, Syed A. Nasar, '*Electric Drives'*, CRC Press, 2nd Edition, 2005.
4. Peter Vas, 'Electrical Machines and Drives: A Space-vector Theory Approach', Clarendon Press, 1992.
5. Leonard, W., 'Control of Electric Drives', Springer-Verlag, New York, 1985.
6. J. M. D. Murphy & F. G. Turnbull, 'Power Electric Control of AC Motors', Pergamon Press.
7. P.C. Krause, 'Analysis of Electrical Machines', McGraw Hill Book Company, 1987.

Semester: VIII Sem

Course Title: Biomedical Signal Processing

Course Category: Program Elective **Credit: 4 (3 1 0)**

Biomedical Signal Processing: Overview of Biomedical signals, Sources of bioelectric potential, resting potential, action potential, propagation of action potentials in nerves, signal characteristic in biomedical signal, Sensors and transducers for biomedical signal acquisition, Electrodes, amplifiers, and other measurement devices, Application and challenges in biomedical signal processing.

Different Biomedical Signals: Electroencephalography (EEG): evoked responses, EEG recording techniques, pattern recognition of alpha, beta, theta and delta waves in EEG waves, sleep stages, epilepsy detection, Electrocardiography (ECG):pre-processing, wave form recognition, morphological studies and rhythm analysis, ECG compression, Electromyography (EMG): EMG electrodes, signal acquisition and amplification, motor unit action potential, myoelectric signal recording, applications of EMG, imaging techniques: ultrasound, MRI, CT, and PET.

Biomedical Signal Processing Techniques: Filtering techniques: FIR, IIR, and adaptive filters, common filters for noise removal and artifact reduction, Signal denoising and artifact removal techniques, Feature extraction and classification: Dimensionality reduction techniques, Feature selection and extraction algorithms, Pattern recognition and classification methods,Machine learning and deep learning in biomedical signal processing, Emerging trends and future directions.

Text/ References Books:

1. D C Reddy “Biomedical Signal Processing: Principles and Techniques”, Tata McGraw-Hill Publishing Co. Ltd, 2005.
2. E. N. Bruce, Biomedical Signal Processing and Signal Modelling, John Wiley and Sons, 2001.
3. Biomedical signal analysis-A Case-Study Approach, Rangaraj M Rangayan (Wiley-Interscience, John Wiley & Sons, Inc)
4. C Raja Rao, S K Guha “Principles of Medical Electronics and Biomedical Instrumentation”, Universities Press, 2001
5. R M Rangayyan “Biomedical Signal Analysis: A case Based Approach”, IEEE Press, John Wiley & Sons. Inc, 2002 M

SYLLABUS -B.TECH. WITH HONOURS (ELECTRICAL ENGINEERING)

Semester: V

Course Title: Modelling & Simulation of Power Electronics System

Course Type: Honours **Credit: 3 (3 0 0)**

Computer Simulations: Challenges in computer simulations, simulation process, types of analysis, model, model types, use of models, mechanics of simulation, circuit-oriented simulators(PSPICE/LTSPICE/PSIM), equation solvers, comparison of circuit-oriented simulators and equation solvers, discretization of time, transient analysis, numerical methods for solving ordinary differential equations, stability of numerical methods, application of numerical methods to solve primitive electric circuits, implementation of numerical methods in MATLAB script files.

Simulation of Power Electronic Converters: Concepts of volt-sec and amp-sec balance, understanding of switched-networks, KCL and KVL violations in switched-network, power loss of practical switching devices and simulation verification, understanding of BUCK, BOOST, and BUCK-BOOST converter startup, transient and steady-state through circuit simulations, development and simulation of differential equation-based simulation models of BUCK, BOOST, and BUCK-BOOST converter.

Case Studies: P-cell and N-cell unification of BUCK, BOOST, and BUCK-BOOST converter, switched and average model simulation of BUCK, BOOST, and BUCK-BOOST converter, modeling of dc motor, design of current and speed controller for a dc motor, simulation of closed-loop control of dc motor, mathematical modeling of three-phase inverter and high-power factor boost AC to DC converter.

Text/ References Books:

1. N. Mohan, T.M. Udeland, and W.P. Robbins, "Power Electronics: Converters, Applications, and Design," J. Wiley and sons, New York, 1994.
2. P.C. Krause, "Analysis of electric machinery", McGraw Hill, New York, 1986.
3. M. Godoy Simoes, Felix A. Farret, “Modeling Power Electronics and Interfacing Energy Conversion Systems”, Wiley-IEEE Press, 2016.
4. Seddik Bacha Iulian Munteanu AntonetaIulianaBratcu, “Power Electronic Converters Modeling and Control”, Springer, 2014.
5. Weidong Xiao, “Power Electronics Step-by-Step Design, Modeling, Simulation, and Control”, Mc Graw Hill, 2021.
6. M B patil, V. Ramanarayanan, V T Ranganathan, “Simulation of Power Electronic Circuits”, Narosa, 2009.
7. Relevant IEEE Transactions and Journals.

Semester: V

Course Title: Special Electrical Machines and Applications

Course Category: Honours **Credit: 3 (3 0 0)**

Special Induction Machines: Dual winding Squirrel cage induction generator (SCIG), Soft starters, reactive power compensation for SCIG, Wound rotor induction generator (WRIG), Doubly fed induction generator (DFIG), Brushless doubly fed induction generator, application prospects of DFIG to wind energy conversion system, effect of time harmonics in supply voltage, space harmonics in field flux, single phasing, harmonic synchronous and induction torques, noise and its reduction.

Special Synchronous Machines: Wound rotor synchronous generators for renewable energy applications, Wound rotor synchronous generators and Permanent magnet synchronous generators in large and small direct drive wind turbines, Transient performance of synchronous machines. Analysis of three phase symmetrical short circuit. Various inductances and time constants of synchronous machines, models for transient analysis. Transient Power/Angle characteristics, Vector diagrams for steady and transient conditions.

Fractional Horse-Power and other Special Machines: Qualitative treatment of stepper, hysteresis Linear Induction motors, MEGLEVS, BLDC, PMSM, Servomotors, Synchros.

Application Specific Machines: Selection of motors for electric vehicle, drone, healthcare, transportation, and industrial applications.

Text/ References Books:

1. Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro, Power Conversion and Control of Wind Energy Systems, Wiley-IEEE Press, 2011.
2. Paul C. Krause; Oleg Wasynczuk; Scott D. Sudhoff, Analysis of Electric Machinery and Drive Systems, Wiley-IEEE Press, 2002.
3. Seung-Ki Sul, Control of Electric Machine Drive Systems, Wiley-IEEE Press, 2011.
4. M.E. El-Hawary, Principles of Electric Machines with Power Electronic Applications, Wiley-IEEE Press, 2002.
5. E. Fitzgerald, Charles Kingsley and Stephen D Umans: Electric Machinery, McGraw Hill Publication.
6. S. Langsdorf: Theory of Alternating Current Machinery, Tata McGraw Hill.

Semester: VI

Course Title: Advanced Power System Protection

Course Category: Honours **Credit: 3 (3 0 0)**

Prerequisite: Knowledge of UG level course on Switchgear and Protection

Protective Current & Potential Transformers: Steady state performance, Accuracy, burden, standard class designation, Polarity marking and Transient performance of Current transformers. Potential transformer, Steady state and transient performance of capacitor voltage transformer.

Review of Electromagnetic Relays: relay terminology, basic protection schemes, overcurrent relays, distance relays, differential relays. Relay Coordination.

Static Relays: Basic elements, Functional circuits, Generalised theory of two input comparators, Amplitude and Phase comparators, Realization of different relays using comparators. Types of static comparators. Protection of transmission lines power transformers, alternators, induction motors. Bus zone protection.

Digital protection: Introduction and Fundamental of digital relays. Digital relaying algorithms.

Text Books/ References:

1. Power System Protection & Switchgear By B. Ram, McGraw Hill
2. Protective Relay, Their Theory & Practices Vol. 1 By A.R.C. Warrington, Chapman & Hall UK
3. Power System Protection- Static Relays By T.S.M. Rao Tata McGraw Hill
4. Fundamentals of Power System Protection By Y.G. Paithankar and S.RBhide, Prentice-Hall of India, 2003.
5. Digital Protection- Protective Relaying from Electromechanical to Microprocessor By L. P. Singh, New Age International
6. Power System Protection By Patra Basu& Choudhary, Oxford &IBH
7. Power system Protection & Switchgear, Oza, Nair, Mehta, Makwana, Mc-Graw Hill

Semester: VI

Course Title: Nonlinear Control Systems

Course Category: Honours **Credit: 3 (2 1 0)**

Fundamental tools for nonlinear systems: Linear vs Nonlinear State Space Models; Nonlinear Phenomena; Physical Interpretation of Norm, Eigenvalues and Eigenvectors; Existence and uniqueness of solutions of dynamical systems; Continuous dependence on initial conditions and parameters; Comparison principles.

Nonlinear models and behaviour: Examples of nonlinear systems; Concept of equilibrium point; Qualitative behaviour of 2-dimensional systems; Phase plane analysis; Describing function approach.

Nonlinear system analysis: Idea of stability-Concept of internal and input-output stability for lineaer systems; Lyapunov stability of autonomous and nonautonomous systems; LaSalle's invariance principle; Converse Lyapunov theorems; Effects of Perturbations.

Systems with inputs and outputs: Input-to-state stability and related notions; Lyapunov characterizations; Stability of feedback systems.

Nonlinear Control Design: Control Lyapunov functions; Universal formulas for feedback stabilization and Backstepping; Feedback Linearization.

Text-books:

1. Hassan K. Khali: Nonlinear Systems, Prentice Hall, Third Edition 2002.
2. Jean-Jacques E. Slotine, and Weiping Li: Applied Nonlinear Control, Pearson Education-Prentice Hall, 2002.
3. H. K. Khalil: Nonlinear control, New York: Pearson, 2015.
4. Chi-Tsong Chen: Linear System Theory and Design, Oxford University Press, Fourth Edition 2013.
5. Isidori, A: Nonlinear control systems II. Springer London, 2013.

Reference(s):

1. William L. Brogan: Modern Control Theory, Pearson Education Third Edition 2011.
2. Sastry, Shankar: Nonlinear systems: analysis, stability, and control, Vol. 10. Springer Science & Business Media, 2013.

Semester: VII

Course Title: Power System Dynamics

Course Category: Honours **Credit: 3 (3 0 0)**

Dynamic models of synchronous machines, excitation system, loads.

Modelling of single machine-infinite bus system. Mathematical modelling of multi-machine system. Dynamic and transient stability analysis of single machine and multi-machine systems.

Power system stabilizer design for multi-machine systems. Dynamic equivalencing. Voltage stability Techniques for the improvement of stability. Direct method of transient stability analysis: Transient energy function approach.

Effect of renewables on dynamics of power systems.

Text/ References Books:

1. Power System Stability and Control, P. Kundur Mc-Graw Hills

2. Computer Techniques in Power System Analysis, M A Pai, Mc-Graw Hill

3. Advanced Power System Analysis and Dynamics, L.P. Singh, Mc-Graw Hill

Semester: VIII

Course Title: Switched Mode Power Conversion

Course Category: Honours **Credit: 3 (3 0 0)**

Introduction: Overview of linear voltage regulators, shunt and series regulators, characteristics of Ideal and practical switch, introduction of switching circuits, harmonic concepts, power computations

Non-Isolated Switch-Mode DC-DC Regulators: Buck, Boost, Buck-Boost converters, Cuk converter, SEPIC converter, Zeta converter, small-signal modelling and analysis.

Isolated Switch-Mode DC-DC Converters: Transformer circuit configurations, half-bridge, full-bridge, flyback, forward, push-pull configurations.

Resonant Converters: Concept of soft-switching, classification and types of converters, ZCS and ZVS based buck and boost converter topologies.

Controller design: Concept of feedback control for output voltage regulation, voltage mode and current model control of switch mode dc-dc converters, PI and sliding mode controller design concepts.

Text/ References Books:

1. Rashid M. H., "Power Electronics Circuits Devices and Applications", 3rd Ed., Pearson Education.
2. Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics-Converters, Applications and Design", 3rd Ed., Wiley India.
3. Whittington H.W., Aflynn B.W. and Macpherson D.E., "Switch Mode Power Supplies – Design and Construction", John Wiley and Songs.
4. Hart Daniel W., "Introduction to Power Electronics", Prentice Hall International Edition
5. Issa Batarseh, "Power Electronic Circuits", Wiley India

Open Elective Courses (For the Students of Other Departments)

Course Title: Energy Conservation and Management
Course Category: Open Elective **Credits: 4 (3-1-0)**

Energy Conservation: Introduction, Motivation for Energy Conservation, Principles of Energy Conservation, Energy Conservation Planning, Energy Conservation in Industries, Electrical Energy Conservation in Small Scale Industries, Energy Conservation in Electrical Generation, Transmission and Distribution, Energy Conservation in Household and Commercial Sectors, Energy Conservation in Transport, Energy Conservation in Agriculture, Energy Conservation Legislation.

Cogeneration: Definition and Scope, Topping and Bottoming Cycles, Benefits, Industries Suitable for Cogeneration, Industrial Suitable for Cogeneration, Agricultural Uses of Waste Heat, Aquacultural Uses of Waste Heat, Use of Power Plant Reject Heat for Waste Water Treatment, Integrated Energy System, Potential of Cogeneration in India.

Energy Audit: Aim of Energy Audit, Energy Flow Diagram, Strategy of Energy Audit, Comparison with Standards, Energy Management Team, Considerations in Implementing Energy with Conservation Programmes, Periodic Progress Review, Instruments for Energy Audit, Energy Audit of Illumination System, Energy Audit of Electrical System, Energy Audit of Buildings.

Demand Side Management: Introduction, Scope of Demand Side Management, Evolution of DSM Concept, DSM Planning and Implementation, Load Management as a DSM Strategy, Applications of Load Control, End use Energy Conservation, Tariff Options for DSM, Customer Acceptance, Implementation Issues, Implementation Strategies, DSM and Environment, International Experience with DSM.

Energy and Sustainable Development: Introduction, Energy Problems, Energy use Trends in Developing Countries, Prospects of Changes in Energy Supply, Agenda for Sustainable Development.

Captive Power Generation: Introduction, Advantages, Constraints, Captive Generation Options, Government Polices, Types of Captive Power Plants, Future Prospects of Captive Power Generation in India, Captive Power Plants in India – Some Statistics, Energy Banking, Promotion of Captive Power Generation.

Environmental Aspects of Electric Energy Generation: Environment and its Quality, Man's Right to Modify Environment, Energy and Environment, Air Pollution, Stack Emissions, Cooling Tower Impacts, Aquatic Impacts, Nuclear Plant Impacts, Hydro-Plant Impacts, Social and Economic Impacts.

Text/Reference Books:

1. Gupta B. R.: Generation of Electrical Energy, Eurasia Publishing House Pvt. Ltd., New Delhi, 2001 IV Edition.

2. Durgesh Chandra &: Energy Scope, South Asian Publishers Pvt. Ltd, New Delhi.
3. M.V. Deshpande: Electrical Power System, Tata McGraw-Hill Publishing Company Limited, New Delhi.
4. J. Nanda and D.P. Kothari: Recent Trends in Electric Energy Systems, Prentice Hall of India Pvt. Ltd, New Delhi.