# Academic Hand Book

***for***

# Bachelor of Technology Programme

***in***

## Electrical & Electronics Engineering

# National Institute of Technology Goa

## Farmagudi, Ponda, Goa - 403 401

# Semester-wise Credit Distribution

| Semester | Total Credits |
|---|---|
| I | 22 |
| II | 22 |
| III | 22 |
| IV | 21 |
| V | 22 |
| VI | 23 |
| VII | 20 |
| VIII | 18 |
| **Total Credits** | **170** |

# I Semester Details

| Sl. No | Sub. Code | Subjects | L-T- P | Credits |
|---|---|---|---|---|
| 1 | MA100 | Mathematics-I | 4-0-0 | 4 |
| 2 | PH100 | Physics | 3-0-0 | 3 |
| 3 | ME100 | Engineering Mechanics | 3-0-0 | 3 |
| 4 | CS100 | Computer Programming and Problem solving | 2-0-3 | 4 |
| 5 | HU100 | Professional Communication | 2-0-2 | 3 |
| 6 | ME101 | Engineering Drawing | 1-0-3 | 3 |
| 7 | PH101 | Physics Laboratory | 0-0-3 | 2 |
| | | **Total Credits** | | **22** |

# II Semester Details

| Sl. No | Sub. Code | Subjects | L-T- P | Credits |
|---|---|---|---|---|
| 1 | MA150 | Mathematics-II | 4-0-0 | 4 |
| 2 | PH150 | Material Science | 3-0-0 | 3 |
| 3 | CY150 | Chemistry | 3-0-0 | 3 |
| 4 | ME150 | Elements of Mechanical Engineering | 2-0-0 | 2 |
| 5 | EE151 | Basic Electrical Science | 3-0-0 | 3 |
| 6 | ME151 | Workshop Practices | 0-0-3 | 2 |
| 7 | CY151 | Chemistry- Laboratory | 0-0-3 | 2 |
| 8 | EE152 | Basic Electrical Science Lab | 0-0-3 | 2 |
| 9 | PE150 | Physical Education | 1-0-0 | 1 |
| | | **Total Credits** | | **22** |

# III Semester Details

| Sl. No | Sub. Code | Subjects | L-T- P | Credits |
|---|---|---|---|---|
| 1 | MA200 | Mathematics-III | 3-0-0 | 3 |
| 2 | EE200 | Electromagnetic Theory | 3-1-0 | 4 |
| 3 | EE201 | Analog Electronics | 3-0-0 | 3 |
| 4 | EE202 | Circuit Theory | 3-1-0 | 4 |
| 5 | EE203 | Electrical Measurements & Instrumentation | 3-1-0 | 4 |
| 6 | EE204 | Circuit Theory Lab | 0-0-3 | 2 |
| 7 | EE205 | Electrical Measurements and Instrumentation Lab | 0-0-3 | 2 |
| | | **Total Credits** | | **22** |

# IV Semester Details

| Sl. No | Sub. Code | Subjects | L-T- P | Credits |
|---|---|---|---|---|
| 1 | MA250 | Numerical Methods (Maths 4) | 3-0-0 | 3 |
| 2 | EE250 | Digital Electronics | 3-0-0 | 3 |
| 3 | EE251 | Electrical Power Generation | 3-0-0 | 3 |
| 4 | EE252 | Electrical Machines-I | 3-1-0 | 4 |
| 5 | HS250 | Economics | 3-0-0 | 3 |
| 6 | EE253 | Electrical Machines-I Lab | 0-0-3 | 2 |
| 7 | EE254 | Analog and Digital Electronics Lab | 0-0-3 | 2 |
| 8 | VE200 | Value Education | 1-0-0 | 1 |
| | | **TOTAL CREDITS** | | **21** |

# V Semester Details

| Sl. No | Sub. Code | Subjects | L-T- P | Credits |
|---|---|---|---|---|
| 1 | EE300 | Electrical Power Transmission and Distribution | 3-1-0 | 4 |
| 2 | EE301 | Electrical Machines-II | 3-1-0 | 4 |
| 3 | EE302 | Control Systems | 3-1-0 | 4 |
| 4 | EE303 | Microprocessors and Microcontrollers | 3-0-0 | 3 |
| 5 | EE304 | Electrical Machines-II Lab | 0-0-3 | 2 |
| 6 | EE305 | Microprocessors and Microcontrollers Lab | 0-0-3 | 2 |
| 7 | ES300 | Environmental Studies | 3-0-0 | 3 |
| | | **TOTAL CREDITS** | | **22** |

# VI Semester Details

| Sl. No | Sub. Code | Subjects | L-T- P | Credits |
|---|---|---|---|---|
| 1 | EE350 | Switchgear and Protection | 3-1-0 | 4 |
| 2 | EE351 | Power System Analysis | 3-1-0 | 4 |
| 3 | EE352 | Power Electronics | 3-1-0 | 4 |
| 4 | EE353 | Integrated circuits | 3-0-0 | 3 |
| 5 | EE5** | Open Elective | 3-0-0 | 3 |
| 6 | EE354 | Electrical Simulation Lab | 0-0-3 | 2 |
| 7 | EE355 | Control Systems Lab | 0-0-3 | 2 |
| 8 | EE356 | Mini Project/Training | | 1 |
| | | **TOTAL CREDITS** | | **23** |

# VII Semester Details

| Sl. No | Sub. Code | Subjects | L-T- P | Credits |
|---|---|---|---|---|
| 1 | EE400 | Electrical Drives | 3-0-0 | 3 |
| 2 | HU400 | Management | 3-0-0 | 3 |
| 3 | EE5** | Programme Specific Elective – 1 | 3-0-0 | 3 |
| 4 | EE5** | Programme Specific Elective – 2 | 3-0-0 | 3 |
| 5 | EE401 | Power Electronics & Drives Lab | 0-0-3 | 2 |
| 6 | EE402 | Seminar | 3-0-0 | 2 |
| 7 | EE403 | Programme Major Project-I | 0-0-4 | 4 |
| | | **TOTAL CREDITS** | | **20** |

# VIII Semester Details

| Sl. No | Sub. Code | Subjects | L-T- P | Credits |
|---|---|---|---|---|
| 1 | EE450 | High Voltage Engineering | 3-0-0 | 3 |
| 2 | EE451 | Power System Operation and Control | 3-0-0 | 3 |
| 3 | EE5** | Programme Specific Elective – 3 | 3-0-0 | 3 |
| 4 | EE5** | Programme Specific Elective – 4 | 3-0-0 | 3 |
| 5 | EE452 | Programme Major Project-II | 0-0-6 | 6 |
| | | **TOTAL CREDITS** | | **18** |

| **Subject Code**<br>**MA 200** | **Mathematics-III** | **Credits: 3 (3-0-0)**<br>**Total hours 42** |
|---|---|---|
| Objectives | This Mathematics course provides requisite and relevant background necessary to understand the other important engineering mathematics courses offered for Engineers and Scientists. Important topics of applied mathematics, namely complex analysis, power series solutions, fourier series and transforms and partial differential equations. | |
| **Module 1** | **Complex Analysis** | 18 hours |
| Complex Numbers, geometric representation, powers and roots of complex numbers, Functions of a complex variable, Analytic functions, Cauchy-Riemann equations; elementary functions, Conformal mapping (for linear transformation); Contours and contour integration, Cauchy's theorem, Cauchy integral formula; Power Series and properties, Taylor series, Laurrent series, Zeros, singularities, poles, essential singularities, Residue theorem, Evaluation of real integrals and improper integrals. | | |
| **Module 2** | **Power Series Solutions** | 9 hours |
| Differential Equations Power Series Method - application to Legendre equation, Legendre Polynomials, Frobenious Method, Bessel equation, Properties of Bessel functions, Sturm- Liouville BVPs, Orthogonal functions. | | |
| **Module 3** | **Partial Differential Equations** | 15 hours |
| Introduction to PDE, basic concepts, second order PDE and classification, D'Alemberts formula and Duhamel's principle for one dimensional wave equation, Laplace's and Poisson's equations, Laplace, Wave, and Heat equations using separation of variables. Vibration of a circular membrane. Heat equation in the half space. | | |
| **Texts/References** | 1. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999).<br>2. W. E. Boyce and R. DiPrima, Elementary Differential Equations (8th Edition), John Wiley (2005).<br>3. R. V. Churchill and J. W. Brown, Complex variables and applications (7th Edition), McGraw-Hill (2003). | |

| **Subject Code EE200** | **Electromagnetic Theory** | **Credits: 4 (3-1-0)** **Total hours: 56** |
|---|---|---|
| **Course Objective** | To understand the concepts of coordinate systems and realize the electromagnetic fields, charges and currents. To calculate electromagnetic field distribution and impart knowledge on vector fields - electrostatic and magneto static fields, electrodynamics and electromagnetic waves. | |
| **Module 1** | | **20 hours** |
| Introduction to Electric Fields: Coulomb's law and Electric Field Intensity, Electric Flux density, Gauss law, divergence theorem, definition of potential difference, potential gradient, dipole, Electric field intensity due to various forms of uniformly distributed charges, point charge, infinite line, circular ring, infinite plane sheet, dielectrics and capacitance, Poisson's law; Introduction to Steady Magnetic Fields: Charged particles in motion, Biot-Savart law, Ampere's Circuital law, curl, stokes theorem, Magnetic flux and Magnetic flux density due to infinite line, sheet carrying current, Scalar and vector Magnetic potentials, Lorentz force equation. | | |
| **Module 2** | | **12 hours** |
| Time varying fields and Maxwell's Equations: Faraday's law, displacement current, Maxwell's equations in point form, in integral form, in derivative form, EMF equation, Uniform plane waves in dielectrics and conductors, pointing theorem, skin effect. | | |
| **Module 3** | | **10 hours** |
| Transmission lines: Transmission Line Equations, Solutions to equations in phasor form, loss less and low-loss propagation, wave reflection at discontinuities, transmission lines of finite length, Smith chart. | | |
| **Module 4** | **14 hours** | |
| Guided waves between parallel planes, Transverse electric and transverse magnetic waves and its characteristics, Linear Elliptical and Circular Polarization, Wave equations for conducting medium, Wave propagation in conductors and dielectric, Depth of penetration, Reflection and Refraction of plane waves by conductor and dielectric, Poynting Vector and flow of power. | | |
| **Reference books** | 1. William H. Hayt Jr., JA Buck, "Engineering Electromagnetics" MGH, 7th Edition, 2013.<br>2. Kraus, Fleisch, "Electromagnetics with Applications" MGH, 5th Edition, 2010.<br>3. Nannapaneni Narayan Rao, "Elements of Engineering Electromagnetics" Pearson, 6th Edition, 2006.<br>4. Karl E. Lonngren, Savov and RJ Jost, "Fundamentals of Electromagnetics with MATLAB" PHI, 2nd Edition, 2007. | |

| **Subject Code EE201** | **Analog Electronics** | **Credits: 3(3-0-0) Total hours:42** |
|---|---|---|
| **Course Objectives** | To develop the skill of analysis and design of various Analog circuit building blocks like Current Mirrors, Amplifiers, Differential Amplifiers using BJT and MOSFET.<br>To understand the concept of Negative and Positive feedback. | |

| **Module 1** | **Hours 12** |
|---|---|
| Amplifiers:Introduction, Input and output impedance, Operating point analysis and design, Biasing schemes; Load line and Bias stability, Analyses and design of CC, CE and CB configurations; RC coupled and transformer coupled multistage Amplifiers; Thermal runaway in BJT Amplifiers.<br>MOSFET Amplifier: Analysis and Design of Common Source, Common Drain and Common Gate Amplifier configurations – Thermal runaway in MOS Amplifiers. | |
| **Module2** | **Hours 12** |
| Cascode stages and Current Mirrors: MOS Current Mirrors, Types of Current Mirrors, Simple, Cascade type. Differential Amplifiers: MOS Differential pair, Small and Large Signal analysis, Common Mode Rejection, Differential pair with Active load.<br>Power amplifiers:Push pull stage, Heat dissipation, Class A, B, AB, C, D, E& S Power Amplifiers - Harmonic distortion – Conversion efficiency and Relative performance. | |
| **Module 3** | **Hours 08** |
| Frequency response of Amplifiers: Hybrid $\pi$ equivalent circuit of BJT, Low and High Frequency BJT/MOSFET Model, Miller effect.<br>Noise in Amplifiers: Types of Noise, Noise representation, Noise in different circuits. | |
| **Module 4** | **Hours 10** |
| Feedback and Stability: Introduction to Negative feedback – Basic feedback concepts; Ideal Feedback Topologies - Voltage shunt, Voltage series, Current series and Current shunt Feedback Configurations; Loop gain – Stability of feedback circuit, Nyquist stability criterion, Phase and Gain margins; Oscillators : Basic principles of Oscillators, Analysis of RC Phase Shift, Wein bridge, Colpitts, Hartley and Crystal Oscillators. | |

| **Reference books** | 1. A S Sedra& K C Smith, "Microelectronic Circuits", Oxford University Press.1998.<br>2. BehzadRazavi, "Fundamentals of Microelectronics", John Wiley & Sons .2008.<br>3. Robert Boylestad& Louis Nashelsky ," Electronic Devices & Circuit Theory", PHI., 1995. |
|---|---|

| **Subject Code EE202** | **Circuit Theory** | **Credits: 4 (3-1-0) Total hours: 56** |
|---|---|---|
| **Course Objectives** | To develop an understanding of the fundamental elements of electric circuits. To develop the ability to apply the basic theorems to analyze a DC and AC electric circuit. Use mathematical methods such as Laplace and Fourier transforms and some linear algebra techniques and differential equations to solve circuits problems. Synthesize a network with stable condition. | |
| **Module 1** | | **Hours : 10** |
| Basic DC and AC circuits analysis:Kirchhoff's laws (KCL and KVL), DC and AC Circuits, Mesh current, node voltage method, super node and super mesh analysis for D.C and A.C. circuits. Source transformation, star-delta conversion.Complex Waves: RMS and average value of complex waves, circuit response to non-sinusoidal excitations. | | |
| **Module 2** | | **Hours : 12** |
| Network Theorems and topology:Thevenin'stheorem, Norton's theorem, Superposition theorem, Maximum power transfer theorem, Millman's theorem, Tellegen's theorem, Reciprocity theorem and compensation theorem. Concepts of Graph theory- Cut set and Tie set using Network topology, Network equilibrium equations, Duality. | | |
| **Module 3** | | **Hours : 12** |
| Resonance in AC Circuits:Series and parallel resonance, frequency response, Quality factor and Selectivity, Bandwidth, Characteristics, properties of resonance circuits, current locus diagrams.<br>Coupled Circuits:Self and mutual inductance, Coefficient of coupling, Tuned circuits, Single tuned circuits. Dot convention, Analysis of coupled circuits.<br>Transients in Electric circuits: DC and AC transients in R-L, R-C and R-L-C circuits using Differential equations and Laplace Transforms. | | |
| **Module 4** | | **Hours : 10** |
| Two-port Networks: Two-port network concept, Representation in T and π Configuration, Z, Y, h and ABCD parameters, image impedances, Interconnection of Two-port networks. Network Functions: Natural frequency of a network variable and a network, Network functions with examples and general properties, concept of complex frequency, poles, zeros and frequency response. | | |
| **Module 5** | | **Hours : 12** |
| Network Realisation and synthesis: Concept of poles and zeros-Hurwitz polynomials-Routh's criterion of stability of network functions-Synthesis of one port LC networks-Foster and Cauer methods-Synthesis of RL and RC one port networks-Foster and Cauer methods. | | |
| **Reference books** | 1. William H. Hayt, Jack E. Kemmerly, Steven M. Durbin, "Engineering Circuit Analysis," 6th Edition, TMH, 2002.<br>2. Charles A. Desoer, Ernest S. Kuh, "Basic Circuit Theory,"TMH, 1969.<br>3. M. E. Van Valkenberg, "Network analysis," PHI, 1990.<br>4. DeCarlo& Lin, "Circuit Theory: Linear Circuit Analysis", 2nd edition, Oxford press, 2004. | |

| **Subject Code EE203** | **Electrical Measurements and Instrumentation** | **Credits: 4 (3-1-0) Total hours:56** |
|---|---|---|
| **Course Objectives** | Students will be able to understand about the operation of an indicating instrument and use them for measurement of electrical quantities. To obtain adequate knowledge of comparison methods of measurement and also various transducers and data acquisition system. | |
| **Module 1** | | **Hours:14** |
| General principles of measurements, units, dimensions, standards and calibration of meters, characteristics of instruments: qualities and errors of measurements and its analysis, principle, construction, operation, torque equation, calibration and application of D'Arsonval Galvanometer.<br>Direct Deflecting Instruments: Moving coil, moving iron, dynamo meter, induction, thermal, electrostatic and rectifier type meters, shunts and multipliers, various types of galvanometers. (principle, construction, operation, torque equation and comparison). | | |
| **Module2** | | **Hours:12** |
| Measurement of Current, Voltage and resistance, Wheatstone bridge, Kelvin double bridge, Carey Foster slide wire bridge, bridge current limitations, insulation resistance, earth resistance, earth tester localization of cable fault by Murray and Varley loop tests. measurement of power and energy: dynamometer type wattmeter, error and compensation, ampere hour meter, single and three phase energy meters (induction type), calibration, phantom loading, current transformer and potential transformer: construction, theory operation, phasor diagram, characteristics, error elimination and its application. Tri-vector meter, frequency meters, power factor meters. | | |
| **Module 3** | | **Hours: 10** |
| DC Potentiometer: Crompton potentiometer, Vernier potentiometer, Diesselhorst potentiometer, method of use, use of potentiometer for measurement of resistance, current and voltage and power. applications of DC potentiometers<br>A.C. Potentiometers: applications of AC potentiometers, various A.C. bridges and measurement of inductance & capacitance and frequency. | | |
| **Module 4** | | **Hours: 10** |
| Magnetic Measurements: Classification, magnetometer measurement, ballistic galvanometer flux meter, magnetic potentiometer, Hall effect devices, B.H. curve and permeability measurement, hysteresis measurement, Hibbert's magnetic standard, core loss measurement.<br>Illumination: Laws of Illumination, standards of luminous intensity, measurement of luminous intensity, distribution of luminous intensity, MSI, Rousseau's construction, integrating sphere, illumination photometers | | |
| **Module 5** | | **Hours:10** |
| Cathode ray oscilloscope, theory and working, measurements using CRO, types of CRO, time base generator circuit, applications. | | |
| **Reference books** | 1. A. K Sawhney, "Electrical and Electronic Measurements and Instrumentation", DhanpathRai& Co.,2012<br>2. E.W. Golding,"Electrical Measurements & Measuring Instruments", 5th Edition , Reem Publications,2009<br>3. W.D Cooper, "Modern Electronics Instrumentation and Measurement Techniques", Prentice Hall of India, 1st Edition,2011 | |

| **Subject Code**<br>**EE204** | **Circuit Theory Lab** | **Credits: 2 (0-0-3)**<br>**Total hours:45hr** |
|---|---|---|
| **Course Objective** | Laboratory exercises and assignments based on experiments and PSPICE and/or MATLAB simulation to supplement EE200. | |
| | **Experiments lists**<br>1. Verification of Reciprocity and Milliman's theorem.<br>2. Find Z and Y parameters for a given circuit.<br>3. ABCD parameters for a given circuit.<br>4. Series and parallel resonant circuits.<br>5. Measurement of Self and Mutual Inductance.<br>6. MATLAB Simulation model for DC, AC network transient analysis.<br>7. MATLAB Simulation model to plot poles and zeros of a network.<br>8. PSPICE simulation model to verify Mesh and Nodal analysis to find branch voltages and currents<br>9. PSPICE Simulation model to find response for a network with DC, AC voltage sources.<br>10. Modelling of electrical circuits | |
| **Reference books** | 1. William H. Hayt, Jack E. Kemmerly, Steven M. Durbin, "Engineering Circuit Analysis," TMH, 6th Edition, 2002.<br>2. Muhammad H.Rashid, "Inroduction to PSPICE using ORCAD for Circuits and Electronics", PHI, 2008. | |

| **Subject Code EE205** | **Electrical Measurements and Instrumentation Lab** | **Credits: 2 (0-0-3) Total Hours:45 Hrs** |
|---|---|---|
| **Course Objective** | Laboratory exercises and assignments to supplement EE253. | |
| | **Experiments lists**<br>1. Calibration of 1-ph Energy meter using phantom loading.<br>2. Measurement of low resistance using Kelvins Double bridge.<br>3. Measurement of low resistance using Wheatstone bridge<br>4. Measurement of self-inductance using Anderson- bridge<br>5. Measurement of capacitance using Schering bridge<br>6. Measurement of inductance using Maxwell- bridge<br>7. Measurement of pressure using Piezoresistive transducer.<br>8. Measurement of strain using Piezoresistive transducer<br>9. Calibration of power factor meter<br>10. Measurement of power using two wattmeter method | |
| **Reference books** | (1) A. K Sawhney, "Electrical and Electronic Measurements and Instrumentation", DhanpathRai& Co.,2007<br>(2) E.W. Golding,"Electrical Measurements & Measuring Instruments", 5edition , Reem Publications,2009<br>(3) W.DCooper, "Modern Electronics Instrumentation", Prentice Hall of India, 1996 | |

| **Subject Code MAT250** | **Numerical Methods** | **Credits: 3(3-0-0) Total hours: 42** |
|---|---|---|
| **Course Objective** | To get familiarized with the numerical solution of linear and non-linear systems, Numerical solution of ordinary differential equations and partial differential equations. | |
| **Module 1** | | **Hours : 10** |
| Solution of linear system: Gauss elimination and Gauss-Jordan methods, LU decomposition methods, Jacobi and Gauss-Seidel iterative methods, sufficient conditions for convergence, power method to find the dominant Eigen value and eigenvector. | | |
| **Module 2** | | **Hours : 12** |
| Solution of nonlinear equation: Bisection method, Secant method, Regular-Falsi method, Newton- Raphson method- order of convergence, interpolation curve fitting, method of least squares, numerical differentiation and integration and numerical solution of ordinary differential equations. | | |
| **Module 3** | | **Hours : 11** |
| Numerical solution of ordinary differential equations: Euler's method, Euler's modified method, Taylor's method and Runge-Kutta method for simultaneous equations and 2nd order equations, multistep methods, Milne's and Adams' methods. | | |
| **Module 4** | | **Hours : 12** |
| Numerical solution of partial differential equations: Liebmann's method, solution of one dimensional heat flow equation, Bender - Schmidt recurrence relation, Crank-Nicolson method, solution of one dimensional wave equation | | |
| **Reference Books** | 1. M.K. Jain, S. R. K Iyengar and R.K. Jain, "Numerical Methods for Scientific and Engineering Computation," New Age Publishers, 6th Edition, 2012.<br>2. Erwin Kreyszig, "Advanced Engineering Mathematics," 8th Edition, Wiley India Pvt. Ltd. (Reprint 2010).<br>3. G.D Smith, "Numerical solution of Partial Differential Equations," Oxford University Press.<br>4. Peter V. ONeil, "Advanced Engineering Mathematics," 5th Edition, Thomson, Book/Cole. (2003).<br>5. B. S. Grewal, "Higher Engineering Mathematics," 42nd Edition. Khanna Publications, 2013. | |

| **Subject Code EE250** | **Digital Electronics** | **Credits: 3-0-0 (3) Total hours:42** |
|---|---|---|
| **Course Objectives** | This subject exposes the students to Digital Fundamentals. After studying this subject the student will be able to Design, Analyze and Interpret Combinational and Sequential Digital Circuits. | |

| **Module 1** | **Hours 10** |
|---|---|
| Number Systems and Boolean Algebra, Simplification of functions using Karnaugh map and QuineMcCluskey Method, Boolean Function Implementation, Minimization and Combinational Design, Examples of Combinational Digital Circuits, Hazards in Combinational Circuits, Hazard free realization. | |
| **Module2** | **Hours 10** |
| Introduction to Sequential circuits: Latches and Flip-Flops (RS, JK, D, T and Master Slave), Design of a Clocked Flip-Flop, Flip-Flop conversion, Practical Clocking aspects concerning Flip-Flops.<br>Counters: Design of Single Mode and Multimode Counters, Ripple Counters, Synchronous Counters, Shift Registers, Shift Register Counters and Random Sequence Generators. | |
| **Module 3** | **Hours 12** |
| Design and Analysis of Sequential Circuits: General model of Sequential Networks, State Diagram, Analysis and Design of Synchronous Sequential Circuits; Finite Sate Machine, State Reduction, Minimization and Design of the Next State Decoder. Asynchronous Sequential Logic: Analysis and Design, Race conditions and Cycles.<br>Practical Design Aspects: Timing and Triggering considerations in the Design of Synchronous Circuits, Set up time, Hold time, Clock skew. | |
| **Module 4** | **Hours 10** |
| Logic Families: Fundamentals of ECL, TTL, CMOS Logic family, Transfer Characteristics, Input and Output Characteristics,TristateLogic,Wired Logic and Bus Oriented structure, Practical Aspects, MOS gates, MOS Inverter, CMOS inverter, Rise and fall time in MOS and CMOS gates, Speed Power Product, Interfacing BJT and CMOS gates. | |

| **Reference books** | 1. Wakerly J F, "Digital Design: Principles and Practices", Prentice-Hall, 2nd Ed., 2002<br>2. Mano M. M., "Digital Logic Design", Prentice Hall 1993. |
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| **Subject Code**<br>**EE251** | **Electrical Power Generation** | **Credits: 3 (3-0-0)**<br>**Total hours: 56** |
|---|---|---|
| **Course Objectives** | Electrical Power plays significant role in day to day life of entire mankind. This course concerns the generation of power along with the economic aspects. Principle of operation, Performance of electric power generation plants (Hydel, Thermal and nuclear). | |
| **Module 1** | | **Hours : 9** |
| Generation of electrical energy by conventional methods, Comparison of different sources of power. Nonconventional sources of energy.<br>Hydro Electric Generation: Classification of hydro plant, Selection of site, Estimation of power available, Selection of turbine and modelling of turbine. Plant layout, Governors and Hydro plant auxiliaries. | | |
| **Module 2** | | **Hours : 9** |
| Thermal Power Plant: Line diagram of the plant. Boilers: working and classification. Super-heaters, Re-heaters, economizers, air-heaters, draft system, feed water heaters and evaporators, cooling water supply and cooling towers. Speed governing and governors. Station auxiliaries. Generator cooling and exciters. | | |
| **Module 3** | | **Hours : 9** |
| Nuclear Power Generation: Principle of energy production by nuclear fission, schematic of nuclear power plant, nuclear fuels and fertile materials, nuclear reaction construction. Chain reaction, Moderator, coolants, control of fission, Reactor operation, different types of reactors, Problem of nuclear power plants. | | |
| **Module 4** | | **Hours : 9** |
| Economics of Power Generation: Cost of electrical energy, Methods of determining depreciation, straight line, diminishing value and sinking found method. Types of Tariffs influence of load and power factor on tariff, economics of power factor improvement. Commissioning and Testing of Transformers and Alternators: Transformer connections, arrangement of transformer, commissioning and testing of transformers and alternators, supply system to station auxiliaries. | | |
| **Module 5** | | **Hours : 9** |
| Problems with conventional energy, possible options for use as non-conventional sources. Solar Energy: solar thermal & photovoltaic conversion of solar energy, applications of solar | | |

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|---|---|
| energy. Wind energy: Betz limit, wind energy conversion devices: classification, characteristics, and applications. Hybrid systems, safety and environmental aspects. | |
| **Reference books** | 1) Soni, Gupta, Bhatnagar and Chakrabarti, "A text book on Power Systems Engineering," DhanpatRai and Sons, New Delhi, 1997.<br>2) C.L.Wadhwa,"Generation, Distribution and Utilization of Electrical Energy," Wiley Eastern Ltd, N.D.1992.<br>3) M.V. Deshpande, "Elements of Electrical Power station Design Pitman," NewDelhi, TMH , 1990.<br>4) G. D.Rai, "Non-conventional Energy Sources", Khanna Publishers, New Delhi, 2007. |

| **Subject Code**<br>**EE 252** | **Electrical Machines-I** | **Credits: 4 (3-1-0)**<br>**Total hours: 56** |
|---|---|---|
| **Course Objectives** | Understand the basic concepts about the dc machines and transformers. Learn the various tests for studying the performance of the machines. Learn about the various tests on transformers and its performance. | |
| **Module 1** | | **Hours 15** |
| D.C. Generator- Construction, principle of operation, windings, emf equation, armature reaction, methods of limiting effects of armature reaction, commutation process, methods of improving commutation, operating characteristics of shunt, series, compound generator O.C.C, internal and external characteristics, power flow diagram, testing of d.c generators applications. | | |
| **Module 2** | | **Hours 15** |
| D.C Motor- Principle of operation, torque equation, characteristics of shunt, series, compound motors, speed regulation, starters, speed control methods – voltage control, armature resistance control and field control methods, braking – regenerative braking, rheostatic braking and plugging, testing of d.c motors - brake test, Swinburne's test, Hopkinson's test, retardation test, fields test, applications. | | |
| **Module 3** | | **Hours 15** |
| 1-Ø transformers - construction, principle of operation, emf equation, no-load and on-load phasor diagrams, equivalent circuit, losses, testing of transformers – load test, OC and SC test, separation of core losses, efficiency, voltage regulation, all-day efficiency, parallel operation of transformers with equal and unequal voltage ratios, sumpner test, auto transformers, pulse transformers, instrument transformers. | | |
| **Module 4** | | **Hours 11** |
| 3-Ø transformers –construction, operation, different connections of three phase transformers - v-v connection, scott connection, on -load and off-load tap changers, different types of cooling. | | |
| **Reference books** | 1. A.E Fitzgerald, Charles Kingsley, Stephen D Umans"Electrical Machinery" 6th Edition, Tata McGraw Hill, 2003.<br>2. Clayton, Hancock, "Performance & Design Of DC Machines" CBS, 3rd Edition, 2001<br>3. S.J Chapman, "Electric Machinery Fundamentals" McGraw Hill, 4th Edition, 2010.<br>4. I.J.Nagarath, D.P Kothari, "Electric Machines" Tata McGraw Hill, 4th Edition, 2010.<br>5. P. S Bimbhra, "Electrical Machinery" 7th Edition, Khanna Publishers, 2008. | |

| **Subject Code HU250** | **Economics** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | The fundamental objective of this course aims at providing a comprehensive perspective in the broad area of engineering economics and its economic scenario. The course aspires to bring the students into the light of financial decision makings, taking up decisions that are economically viable and ultimately facilitates excellent grip in management issues. It also enhances their marketability in this dynamic world. | |
| **Module 1** | | **Hours : 2** |
| An overview of financial management: what is engineering economics, scope of economics and finance, financial system, agency problems manager vs shareholders goal. | | |
| **Module 2** | | **Hours : 8** |
| Concept of time value money: present value, future value, value of annuity, multi-period compounding, present value & rate of return. | | |
| **Module 3** | | **Hours : 8** |
| Valuation of Bonds and Shares: features of Bond, Bond value and yield, Bond values & interest rate, term structure of interest rate, valuation of ordinary and preference share, equity capitalization rate, price-earnings ratio & its significant. | | |
| **Module 4** | | **Hours : 6** |
| Risk, return and overview of capital market theory: risk and return from single asset, measurement of risk, measurement of return, concept of expected return and risk. | | |
| **Module 5** | | **Hours : 6** |
| Portfolio theories and asset pricing model: two asset case, portfolio risk & return: n asset case, diversification of risk, capital asset pricing model. | | |
| **Module 6** | | **Hours : 6** |
| Depreciation analysis: straight line method of depreciation, declining balance method of depreciation, sum of the years method of depreciation, sinking fund method of depreciation, service output method of depreciation. | | |
| **Module 7** | | **Hours : 4** |
| Evaluation of public alternatives: benefits per year, benefit-cost ratio, benefit-cost comparison. | | |
| **Module 8** | | **Hours : 5** |
| Inflation adjusted decisions: procedure to adjust inflation, inflation adjusted economic life of machine, economic life determination with and without inflation. | | |
| **Reference books** | 1. I. M. Pandey, "Financial Management," Vikas Publication House, 2010.<br>2. R. Panneerselvam, "Financial Management," PHI Learning, 2009.<br>3. J. L. Riggs, D. D. Bedworth & S. U. Randhawa, "Engineering Economics," TATA McGraw-Hills, 2011. | |

| **Subject Code: VE200** | **Value Education** | **Credits: 1 (1-0-0) Total hours: 14** |
|---|---|---|
| Course Objectives | It aims at Holistic Development | |
| **Module 1** | **Ethics in Engineering** | 4 hours |
| Concepts of Values and Ethics, History and Purposes, Utilitarianism, Duties, Rights, Responsibility, Virtue, Honesty, Moral Autonomy, Obligations of Engineering Profession and moral Propriety | | |
| **Module 2** | **Engineer's Moral responsibility** | 3 hours |
| Engineer's Moral responsibility for Safety and Human Rights, Risk Assessment and Communication, Product Liability, Engineers-Employers Liaison, Whistle-Blowing and Its Moral Justification | | |
| **Module 3** | **Computer Ethics** | 3 hours |
| Social Impact of Computer, Gender-Issues and Privacy, Cyber Crime, Ethical use of Software | | |
| **Module 4** | **Intellectual property** | 4 hours |
| Definition, Types, Rights and Functions, Patents, Trademark, Grant of Patent in India, Surrender and Revocation of Patents, Compulsory Licensing, Acquisition of Inventions by the Government, Contents of draft application of Patents, WTO | | |
| Texts: | 1. Vinod V. Sople, Managing Intellectual Property: The Strategic Imperative, PHI,2006<br>2. Govindarajan, Natarajan&Senthil Kumar, Engineering Ethics, PHI<br>3. Robin Attfield, A Theory of Value and Obligation, London: Croomhelm, 1987<br>4. Jones and barlett, " Cyber Ethics: Morality and Law in Cyber Space | |
| Reference | Case Studies from Newspapers | |

| **Subject Code**<br>**EE 253** | **Electrical Machines- I Lab** | **Credits: 2 (0-0-3)**<br>**Total hours:45** |
|---|---|---|
| **Course Objectives** | Laboratory exercises and assignments based on hardware to supplement EE205. | |
| | 1. Open circuit and short circuit test on single phase transformer.<br>2. Direct load test on single phase transformer<br>3. Sumpner's test on single phase transformer<br>4. Scott connection of two single-phase transformers<br>5. Parallel operation of two different KVA 1-phase transformers<br>6. Magnetization characteristics of dc shunt generator<br>7. Performance characteristics of dc shunt generator<br>8. Performance characteristics of dc compound generator<br>9. Performance characteristics of dc series generator<br>10. Swinburne's test on dc shuntmotor<br>11. Speed control of dc shunt motor<br>12. Load characteristics of dc shunt motor<br>13. Performance characteristics of dc compound motor<br>14. Retardation test on dc motor<br>15. Field test on dc series motor | |
| **Reference books** | 1. A.E Fitzgerald, Charles Kingsley, Stephen D Umans "Electrical Machinery" 6th Edition, Tata McGraw Hill, 2003.<br>2. Clayton, Hancock, "Performance & Design Of DC Machines" CBS, 3rd Edition, 2001<br>3. S.J Chapman, "Electric Machinery Fundamentals" McGraw Hill, 4th Edition, 2010.<br>4. I.J.Nagarath, D.P Kothari, "Electric Machines" Tata McGraw Hill, 4th Edition, 2010. | |

| **Subject Code EE254** | **Analog and Digital Electronics Lab** | **Credits: 2 (0-0-3)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | Laboratory exercises and assignments based on hardware and SPICE simulation to supplement EE251 and EE252. | |
| | 1. Testing of Diode clipping (Single/Double ended) circuits for peak clipping, peak detection<br>2. Testing of Clamping circuits: positive clamping /negative clamping.<br>3. Testing of a transformer less Class – B push pull power amplifier and determination of its conversion efficiency.<br>4. Testing of Half wave, Full wave and Bridge Rectifier circuits with and without Capacitor filter. Determination of ripple factor, regulation and efficiency.<br>5. Wiring and Testing for the performance of BJT-RC Phase shift Oscillator for f0 ≤ 10 KHz<br>6. Testing for the performance of BJT – Hartley &Colpitts Oscillators for RF range f0 ≥100KHz.<br>7. Testing for the performance of BJT -Crystal Oscillator for f0 > 100 KHz<br>8. Study of BASIC Gates<br>9. Study of Universal Gates<br>10. Study of Full & Half Adder &Subtractor using Gates<br>11. Study of Magnitude Comparator<br>12. Study of Multiplexer<br>13. Study of Demultiplexer<br>14. Implementation of Flip-Flops using NAND & Study of 7476<br>15. Study of Shift Register | |
| **Reference books** | 1. M.Morris Mano, "Digital Electronics", Prentice Hall PTR, New Jersey, 3rd Edition, 2001.<br>2. J.F. Wakerly, "Digital Design Principles and Practices", PHI, 1999.<br>3. R.J.Tocci, "Digital Systems – Principles & Applications", Prentice Hall India, New Delhi, 10th Edition , 2008.<br>4. A S Sedra& K C Smith ,"Microelectronic Circuits", Oxford University Press.2005<br>5. Donald A. Neamen, "Electronic Circuit Analysis and Design", MCGraw Hill 2003, 2nd Edition | |

| **Subject Code EE300** | **Electrical Power Transmission and Distribution** | **Credits: 4 (3-1-0) Total hours: 56** |
|---|---|---|
| **Course Objectives** | This course is an extension of electric power generation course. It deals with basic theory of transmission lines modelling and their performance analysis. Also this course gives emphasis on mechanical design of transmission lines, cables and insulators. | |

| **Module 1** | **Hours : 12** |
|---|---|
| Basic structure of power system, transmission voltages, and bundled conductors, transmission line parameters: resistance, inductance and capacitance calculations - single phase and three phase lines, double circuit line, effect of earth on transmission line capacitance. performance of transmission lines: representation of lines, classification of transmission lines, short transmission line, medium (Nominal-T, Nominal-π, End condenser method) length transmission line, long transmission line, evaluation of ABCD parameters, surge impedance and SIL of long lines, wave length and velocity of propagation of waves, incident, reflected and refracted waves, representation of Long Lines - Equivalent T and Π models. | |
| **Module 2** | **Hours : 14** |
| Mechanical design of overhead lines: general consideration, line supports, span conductor configuration, spacing and clearances, sag and tension calculations with equal and unequal heights of towers, effect of wind and ice on weight of conductor, stringing chart and sag template and its applications. Skin effect, proximity effect, Ferranti effect, corona: The phenomenon of corona, corona loss, factors and conditions affecting coronal loss, corona in bundled conductor lines. Interference between power and communication lines. Overhead line insulators: insulator materials, types of insulators, voltage distribution over insulator string, improvement of string efficiency, insulator failure, testing of insulators. Capacitance grading and static shielding. | |
| **Module 3** | **Hours : 12** |
| Underground cables: classification of cables, types of cables, construction, types of insulating materials, calculations of insulation resistance and stress in insulation. Capacitance of single and 3-core belted cables. Grading of cables - capacitance grading, description of inter-sheath grading.Design of transmission lines: choice of voltage, selection of conductor size, choice of span, number of circuit, conductor, configuration. Power system earthing. | |
| **Module 4** | **Hours : 10** |
| Power system transients: circuit closing transient, sudden symmetrical short circuit of alternator, recovery transient due to removal of short circuit, travelling or propagation of surges, attenuation, distortion, reflection and refraction coefficients. Termination of lines with different types of conditions, open circuited line, short circuited line, T-Junction, lumped reactive junctions. Bewley's lattice diagrams. Arcing grounds, line design based on direct strokes, surge arrestors insulation coordination. Extra high voltage transmission: need for EHV transmission, use of bundled conductors, radio noise from EHV lines, shunt compensation static-var systems, series compensation, EHV systems in India. | |

| **Module 5** | **Hours : 8** |
|---|---|
| Distribution: comparison of various distribution systems, voltage drop in distribution, Kelvin's Law, general design consideration, load estimation. | |

1) Soni, Gupta, Bhatnagar and Chakrabarti, "A text book on Power Systems Engineering," DhanpatRai and Sons, New Delhi, 1997.
2) C.L.Wadhwa,"Generation, Distribution and Utilization of Electrical Energy," Wiley Eastern Ltd, N.D.1992.
3) W.D. Stevenson Jr., "Elements of Power System Analysis", McGraw,Hill, 1968.

| **Subject Code EE 301** | **Electrical Machines-II (Induction Machines & Synchronous Machines)** | **Credits: 4 (3-1-0) Total hours: 56** |
|---|---|---|
| **Course Objectives** | To learn the basic concepts about the different types of induction and synchronous machines. To understand the speed control and the starting operations. | |

| **Module 1** | **Hours 15** |
|---|---|
| Induction Machines- construction, principle of operation, types of induction motors, phasor diagram, rotor MMF, rotor frequency, rotor current and production of torque, slip, equivalent circuit. torque-slip characteristics, maximum torque, no-load and blocked rotor tests, losses and efficiency, circle diagrams, starters, direct on line starters, star-delta and auto transformer starters. | |
| **Module 2** | **Hours 15** |
| Slip ring induction motor, double cage induction motor, cogging and crawling, speed control of three phase induction motors, induction generator. Single phase induction motors, double field revolving theory, equivalent circuit, starting methods, applications. | |
| **Module 3** | **Hours 15** |
| Alternators - construction, principle of operation, winding factors, generated emf, phasor diagram, armature reaction, voltage regulation, methods of predetermination of regulation – EMF, MMF and ZPF methods, two reaction theory, power-angle characteristics, synchronization and synchronizing power, transient, sub transient and steady state reactance, parallel operation and load sharing, effect of change in excitation and mechanical input. | |
| **Module 4** | **Hours 11** |
| Synchronous motor -principle of operation , method of starting, equivalent circuit, effect of increased load with constant excitation, effect of changing excitation with constant load. V curves and inverted V curves, power developed, power circles, hunting, different starting methods. | |

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|---|---|
| **Reference books** | 1. A.E Fitzgerald, Charles Kingsley, Stephen D Umans "Electrical Machinery" 6th Edition, Tata McGraw Hill, 2003.<br>2. Clayton, Hancock, "Performance & Design Of DC Machines" CBS, 3rd Edition, 2001<br>3. S.J Chapman, "Electric Machinery Fundamentals" McGraw Hill, 4th Edition, 2010.<br>4. P. S Bimbhra, "Electrical Machinery" 7th Edition, Khanna Publishers, 2008. |

| **Subject Code EE 302** | **Control Systems** | **Credits: 4 (3-1-0)** **Total hours: 42** |
|---|---|---|
| **Course Objectives** | To be familiar with basic control configurations and also to be competent in mathematic modelling of physical systems and analyze their time and frequency response. | |

| **Module 1** | **Hours 12** |
|---|---|
| Mathematical modelling: Introduction of Open loop and Closed loop systems, Mathematical modelling of Physical systems, Mechanical and Electrical systems, Transfer functions, Block diagrams, Block diagram reduction rules, Signal flow graphs, Mason's Gain formula, Feedback characteristics of closed loop system. | |
| **Module 2** | **Hours 12** |
| Time response Analysis: Standard test signals, Time response of First and Second order systems, Steady-state Errors and Error constants and Dynamic Error coefficients, Effect of addition of poles and zeroes on response of system, Response with P, PI and PID controllers, Performance Indices**.** Control system components, Stepper motors, Tacho-generators, DC and AC Servomotors. | |
| **Module 3** | **Hours 10** |
| Concept of stability: Necessary conditions and Routh Criterion, Relative stability analysis, Concept of Root locus and Construction, Gain margin and Phase margin, Addition of poles and zeroes on root locus. | |
| **Module 4** | **Hours 12** |
| Frequency domain Analysis:Frequency response specifications, Frequency and Time domain correlation, Bode plot, Polar plot, Nyquist criterion, Closed loop frequency response from Open loop Transfer Functions. | |
| **Module 5** | **Hours 10** |
| Compensation Techniques: Design of Lead, Lag, Lead-Lag Compensation.State variable Analysis: Concept of State, State Variables and State Model, State representation of Continuous-time systems, State equation, Solution of State equations, Concept of Controllability and Observability. | |

| **Reference books** | 1. J. Nagrath M. Gopal, "Control Systems Engineering", New Age Int., 4th Edition.<br>2. K. Ogata, "Modern Control Engineering", PHI, 3rd Edition.<br>3.M.Gopal, "Control Systems, Principles and Design", Tata McGraw Hill,4th Edition. |
|---|---|

<table>
<tr><td>Subject Code<br>EE303</td><td>Microprocessors and Microcontrollers</td><td>Credits: 3(3-0-0)<br>Total hours:42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">To introduce the student with knowledge about architecture, interfacing and programming with 8086 microprocessors and 8051 microcontrollers. Also to give a brief introduction to ARM 7 and ARM 9 micro controllers. After studying this subject, the student should be able to design Microprocessor/Microcontroller based system.</td></tr>
<tr><td colspan="2">Module 1</td><td>Hours 10</td></tr>
<tr><td colspan="3">Introduction: History of Microprocessors, Basics of computer architecture, CISC and RISC; 8085 Microprocessor Family Overview, 8085 Architecture, Assembly Language Programming (ALP), and Program development.</td></tr>
<tr><td colspan="2">Module2</td><td>Hours 12</td></tr>
<tr><td colspan="3">8086 Microprocessor: Main features, pin Diagram Description, Internal Architecture, 8086 Microcomputer System, Program development steps, Implementing Standard Program Structure in 8086 ALP, Strings, Procedures, Macros.</td></tr>
<tr><td colspan="2">Module 3</td><td>Hours 10</td></tr>
<tr><td colspan="3">Interfacing: Input and Output Modes and Interfacing, Interrupts, Hardware Interrupt Applications, 8254 Programmable Timer/Counter, 8255 Programmable Peripheral Interface, 8259 Priority Interrupt Controller, DMA controller, 8279 Programmable Keyboard/ Display Interface, ADC, DAC Interfacing.</td></tr>
<tr><td colspan="2">Module 4</td><td>Hours 10</td></tr>
<tr><td colspan="3">Intel 8051 Microcontroller: Architecture, Memory Space, Data Types and Directives, Register Banks and Stack, Assembly Language Programming, Introduction to ARM processors –features of ARM 7 and 9 processors.</td></tr>
<tr><td>Reference books</td><td colspan="2">1. Hall D.V., “Microprocessors and Interfacing”, McGraw Hill<br>2. Ramesh Gaonkar, “Microprocessor Architecture, Programming and Applications with 8085”, Penram International Publishing, Fifth edition<br>3. Muhammad Ali Mazidi, Janice GillispieMazidi and Rolin D Mckinlay,“ 8051 Microcontroller and Embedded systems”, Pearson Education.</td></tr>
</table>

| **Subject Code EE 304** | **Electrical Machines Lab-II** | **Credits: 2 (0-0-3) Total hours: 45** |
|---|---|---|
| **Course Objectives** | Laboratory exercises and assignments based on hardware to supplement EE254. | |
| | 1. Load characteristics of single phase capacitor start & run motor<br>2. Direct load test on 3phase squirrel cage induction motor<br>3. No load and block rotor test on three phase induction motor<br>4. Circle diagram of 3-phase induction motor- performance evaluation.<br>5. Voltage regulation of an alternator by emf and mmf method.<br>6. Synchronization of the alternator with infinite bus bar<br>7. Voltage regulation of an alternator by zpf method<br>8. V' and inverted 'V' curves of a synchronous motor | |
| **Reference books** | 1. A.E Fitzgerald, Charles Kingsley, Stephen D Umans "Electrical Machinery" 6th Edition, Tata McGraw Hill, 2003.<br>2. Clayton, Hancock, "Performance & Design Of DC Machines" CBS, 3rd Edition, 2001<br>3. S.J Chapman, "Electric Machinery Fundamentals" McGraw Hill, 4th Edition, 2010.<br>4. I.J. Nagarath, D.P Kothari, "Electric Machines" Tata McGraw Hill, 4th Edition, 2010. | |

| | | |
|---|---|---|
| **Subject Code**<br>**EE305** | **Microprocessor and Microcontrollers Lab** | **Credits: 2(0-0-3)**<br>**Total hours:3hrs/week** |
| **Course Objectives** | To give hands on experience on 8085/8086 and 8051 programming | |
| **List of Experiments** | | |
| **Experiment No. 1**<br>8085 and 8086 kit familiarization and basic experiments<br>**Experiment No. 2**<br>Programming exercise : sorting ,searching and string<br>**Experiment No. 3**<br>Interfacing with A/D and D/A converters<br>**Experiment No. 4**<br>Interfacing with stepper motors<br>**Experiment No. 5**<br>keyboard interfacing to 8086<br>**Experiment No. 6**<br>8255 interface to 8086<br>**Experiment No. 7**<br>Assembly language programming of 8051<br>**Experiment No. 8**<br>Timer programming of 8051 ,using interrupts<br>**Experiment No. 9**<br>LCD interfacing to 8051<br>**Experiment No. 10**<br>Mini-Project | | |

| **Subject Code**<br>**ES300** | **Environmental Studies** | **Credits: 3 (3-0-0)**<br>**Total hours: 44** |
|---|---|---|
| **Course Objective** | Understanding environment, its constituents, importance for living, ecosystem, human developmental activities vs environment, climate change, national and international environment related developments, need for public awareness, its protection and conservation activities. | |

| **Module 1** | **Hours : 2** |
|---|---|
| Multidisciplinary nature of environmental studies:Definition, scope and importance, Need for public awareness. | |

| **Module 2** | **Hours : 8** |
|---|---|
| Renewable and non-renewable Natural resources : Natural resources and associated problems; Forest resources : Use and over-exploitation, deforestation, case studies, Timber extraction, mining, dams and their effects on forest and tribal people; Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems; Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies; Food resources : World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies; Energy resources : Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources, Case studies; Land resources : Land as a resource, land degradation, man induced landslides, soil erosion and desertification; Role of an individual in conservation of natural resources; Equitable use of resources for sustainable lifestyles. | |

| **Module 3** | **Hours : 10** |
|---|---|
| Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the Following ecosystem, Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries). | |

| **Module 4** | **Hours : 12** |
|---|---|
| Biodiversity and its conservation: Introduction – Definition : genetic, species and ecosystem diversity, Bio geographical classification of India, Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, India as a mega-diversity nation, Hot-sports of biodiversity, Threats to biodiversity : habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity, Eco-cultural heritage of India-various festivals related to Environment, Tradition of community conserved areas-Sacred forests, sacred tanks, sacred mountains, sacred rivers. | |

<table>
<tr><td>Module 5</td><td>Hours : 12</td></tr>
<tr><td colspan="2">National and International Environment related developments<br>Environmental ethics : Issues and possible solutions, Climate change, global warming, acid rain, ozone layer depletion, nuclear, accidents and holocaust, Environment related Acts, Issues involved in enforcement of environmental legislation, Public awareness, Wasteland reclamation, Consumerism and waste products, UN Frame Convention Climate Change, Kyoto protocol, concept of carbon credits, latest CoP meet Agenda; Filed Work(equal to 5 lecture hours): Visit to a local area to document environmental assets river/forest/grassland/hill/mountain/sacred groves/sacred forests, Visit to a local polluted site-Urban/Rural/Industrial/Agricultural, Study of common plants, insects, birds, Study of simple ecosystems-pond, river, hill slopes, etc.</td></tr>
<tr><td>Reference books</td><td>1. Textbook for Environmental Studies For Undergraduate Courses of all Branches of Higher Education (online book -UGC Website), Erach Bharucha, University Grants Commission , India.<br>2. Anil Agarwal, Dying Wisdom, Publisher: Centre for Science and Environment, Edi:1st,1997<br>ISBN-13 9788186906200; ISBN-10 8186906207<br>3. R. Rajagopalan, Environmental Studies from Crisis to Cure, Oxford IBH Pub., 2005.<br>4. Benny Joseph, Environmental Science and Engineering, Tata McGraw Hill, 2006.<br>5. Erach Bharucha, Text Book for Environmental Studies, Pub., Universities Press, 2005.<br>6. Masters, Gilbert M., Introduction to Environmental Engineering and Sciences, Prentice<br>Hall India, 1991</td></tr>
</table>

| **Subject Code EE350** | **Switchgear and Protection** | **Credits: 4 (3-1-0) Total hours: 56** |
|---|---|---|
| **Course Objectives** | This course introduces all varieties of circuit breakers and relays for protection of generators, transformers and feeder bus bars from over voltages and other hazards. It emphasis on neutral grounding for overall protection. | |
| **Module 1** | | **Hours : 10** |
| Fuses: Types of fuses, application of HRC fuses. Neutral Grounding: grounded and un-grounded neutral systems. effects of ungrounded neutral on system performance. Methods of neutral grounding: solid, resistance, reactance and arc suppression coil or peterson coil. arcing grounds. | | |
| **Module 2** | | **Hours : 10** |
| Circuit Breakers: Arcs, Interruption, RRRV, current chopping, interruption of capacitive current, resistance switching. Types of circuit breakers (minimum and bulk oil circuit breakers, air blast circuit breakers, vacuum and SF6 circuit breakers), Circuit Breaker ratings, Auto reclosure. | | |
| **Module 3** | | **Hours : 14** |
| Protective relaying: Need for power system protection, evolution of protective relays, zones of protection, protective relays and schemes. Electromagnetic relays, microprocessor based protective relays. Over current protection, distance protection, auto re-closing. Pilot relaying schemes, bus zone protection, protection of generators, static relays, microprocessor based relays, advantages, over current relays, directional relays, distance relays. | | |
| **Module 4** | | **Hours : 12** |
| Protection of generator: Protection against abnormal condition, stator and rotor protection. restricted earth fault and inter-turn fault protection. Protection of transformers: Incipient fault,differential protection, percentage differential protection, restricted earth fault protection, Buchholtz relay Protection. | | |
| **Module 5** | | **Hours : 10** |
| Protection against over voltages: Causes of over voltage ground wires, surge absorbers and diverters, insulation coordination:BIL, impulse ratio, standard impulse test wave, volt-time characteristics. Bus bar protection: Frame leakage scheme, translay scheme, circulating current scheme introduction to protection against surges. | | |
| **Reference books** | 1) Ravindranath, Chander, "Power System Protection and Switchgear," Wiley Eastern, 1994.<br>2) C. L. Wadhwa, "Electrical Power Systems," 2nd Edition, PHI, 1993.<br>3) Arun G. Phadke, S H Horowitz, "Power System Relaying, 2nd Edition, John Wiley, 1995.<br>4) Badriram, D. N. Vishwakarma, "Power System Protection and Switchgear," TMH, 1995.<br>5) J. L. Blackburn and T. J. Domin, "Protective Relaying: Principles & Applications," CRC Press, 2006.<br>6) S. S. Rao, "Switch gear and protection," Khanna publishers, 1997.<br>7) T. S. MadhavaRao, "Power system protection: Static Relays," Tata McGraw Hill, 1989<br>8) Y. G. Paithangar, "Fundamentals of power system protection," PHI | |

| **Subject Code EE 351** | **Power System Analysis** | **Credits: 4 (3-1-0) Total hours: 56** |
|---|---|---|
| **Course Objectives** | To learn the fundamentals of power system for designing a system that meets specific need. To analyse the phasor techniques in the analysis of power systems. To know the necessity of load flow in a regulated system. To examine the need of various analysis like fault analysis, short circuit analysis stability analysis, steady state and transient analysis. | |
| **Module 1** | | **Hours 10** |
| Modelling of power system components: representation of power system components, single phase representation of balanced three phase networks, single line diagram, per unit quantities, impedance diagram, reactance diagram, steady state model of synchronous machine, power transformer, representation of loads, formulation of bus impedance and admittance matrix. | | |
| **Module 2** | | **Hours 12** |
| Power flow Analysis: Network model formulation, load flow problem, Gauss Seidel, Newton Raphsonand fast decoupled methods, comparison of load flow methods, control of voltage profile: excitation control, VAR generators, tap changing transformers, load flow for DC links. | | |
| **Module 3** | | **Hours 10** |
| Symmetrical fault Analysis: Transients on a transmission line, Short circuit analysis of synchronous machine, symmetrical fault analysis in the network, fault analysis through impedance matrix, circuit breaker rating,selection of circuit breakers, current limiting reactors | | |
| **Module 4** | | **Hours 12** |
| Unsymmetrical fault analysis: Symmetrical components, Concept of sequence impedances and sequence networks of synchronous machine, transmission lines, transformers, power system, LG, LL, LLG and open circuit faults analysis through sequence components, Digital methods for fault analysis | | |
| **Module 5** | | **Hours 12** |
| Stability Analysis Angle stability dynamics of a synchronous machine, swing equation, power angle equation, steady state and transient stability, equal area criterion, numerical solution of swing equation, multi machine stability analysis,<br>Voltage stability: Reactive power flow and voltage collapse, mathematical formulation of voltage stability problem, voltage stability analysis. | | |
| **Reference books** | 1. D P Kothari,I J Nagrath, "Power System Engineering", Tata Mc,Graw 2nd Edition<br>2. C.L.Wadhwa,"Electrical Power Systems",NewAge International Publishers, 6th Edition<br>3. W.D.Stevenson Jr. "Elements of Power System Analysis", McGraw, Hill, 1968.<br>4. I.J.Nagrath,D.P.Kothari, "Modern Power System Analysis", Tata Mc,Graw Hill, 4th Edition ,2011 | |

| **Subject Code EE 352** | **Power Electronics** | **Credits: 4 (4-0-0)** **Total hours: 56** |
|---|---|---|
| **Course Objectives** | Learn the static and dynamic characteristics of power semiconductor devices. Understand the principles of operation of power electronic converters. Study the various control strategies of various power converters. Study the design parameters for control circuitry requirement of various converters. | |
| **Module 1** | | **Hours 12** |
| Introduction- power diodes, types of power semiconductor switches and V-I characteristics, Thyristors: structure, static and dynamic characteristics, device specifications and ratings, methods of turning on (gate firing circuits), methods of turning off (commutation circuits), IGBTs- basic structure and V-I characteristics. MOSFETs - basic structure and V-I characteristics. | | |
| **Module 2** | | **Hours 12** |
| Phase Controlled Rectifiers: single phase, half wave rectifier with R, RL and RLE loads, full wave half controlled and fully controlled converters with R, RL and RLE loads, input side harmonics and power factor, effect of source inductance. Three phase-half wave rectifier with R and RL loads. Full wave half controlled and fully controlled converters with R, RL loads, single-phase and three-phase dual converters. | | |
| **Module 3** | | **Hours 10** |
| A.C. Voltage controllers: operation of controllers for R, R-L loads, current and power factor. Cyclo-converters: single phase mid-point and bridge configuration with R, R-L loads, circulating current mode of operation | | |
| **Module 4** | | **Hours 12** |
| Choppers: principle of operation, time ratio control and current limit control, step-up and step-down choppers with R, RL and RLE loads. Switching regulators: buck regulators, boost regulators, buck-boost regulators. Switched mode power supply: principle of operation and analysis. | | |
| **Module 5** | | **Hours 10** |
| Inverters: principle of operation, series inverter, parallel inverter, single phase bridge inverters. Three phase bridge inverters- $120^0$ and $180^0$ degrees mode of operation, single, multiple and sinusoidal pulse width modulation. | | |
| **Reference books** | 1. M.H. Rashid, "Power Electronics - Circuits, Devices and Applications",PHI, 3rd Edition,2003.<br>2. Ned Mohan,Undelandand P Robin, "Power Electronics Converters, Applications and Design", John Wiley & Sons,3rd Edition,2007<br>3. G.K.Dubey, "Thyristorised Power Controllers", Wiley Eastern Ltd, 1993.<br>4. .P.S.Bimbhra, "Power Electronics" , Khanna Publishers, New Delhi, 2002 | |

| **Subject Code EE353** | **Integrated Circuits** | **Credits: 3(3-0-0) Total hours:42** |
|---|---|---|
| **Course Objectives** | To develop the skill of analysis and design of various circuits using operational Amplifiers. To develop design skills to design various circuits using different data conversion Systems | |

| **Module 1** | **Hours 12** |
|---|---|
| Operational Amplifier and its Linear application: Ideal Op Amp circuit Analysis, Inverting and Non-Inverting Configuration, Differentiator, Integrator, The Negative resistance converter, Negative Feedback, Feedback in Op Amp circuit, Loop gain. Circuits with Resistive Feedback: Current-to-Voltage Converters, Voltage-to-Current converters, Current Amplifiers, Difference Amplifiers, Instrumentation Amplifiers and Applications. | |
| **Module2** | **Hours 08** |
| Active filters: First and Second order filter Transfer function, Butterworth response, Second-order Passive filters (RC, RLC), Emulation of Inductor using Op-Amps-R-C, Salen-Key Biquad, Tow-Thomas Biquad, Realization of higher order filters, All-pass filter. | |
| **Module 3** | **Hours 10** |
| Nonlinear circuits: Voltage Comparators, Comparator Applications, Zero-crossing detector, Precision rectifiers, Schmitt trigger (Inverting &Non Inverting),AstableMultivibrator, Triangular wave generator. Non idealities of Op-Amps and their effects. NE555 Timer circuits: Internal architecture, Schmitt trigger, AstableMultivibrator,MonostableMultivibrator, Saw-Tooth Wave generator. | |
| **Module 4** | **Hours 12** |
| Digital to Analog (D/A) Converters: Types of D/A converters, Accuracy, Resolution and Conversion speed, Offset error, Gain error, Integral and Differential Nonlinearity. Analog to digital (A/D) converters: A/D conversion techniques and their Nonlinearity's.<br>Phase Locked Loop: Block schematic and Analysis of PLL, Lock range and Capture range, Typical applications of PLL, Basic Principles of operation of VCO and timer (555) and their applications. | |

| **Reference books** | 1. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", McGraw Hill Book Company 1998.<br>3.Sedra A.S. & Smith K.C., "Microelectronic Circuits", Oxford University Press 1998<br>4.RamakanthGaykward, "Op Amps and Linear Integrated Circuits", Pearson Education, 1999. |
|---|---|

<table>
<tr><td>Subject Code<br>EE354</td><td>Electrical Simulation Lab</td><td>Credits: 2 (0-0-3)<br>Total Hours:45 Hrs</td></tr>
<tr><td>Course Objective</td><td colspan="2">Laboratory exercises and assignments based on hardware and MATLAB simulation to supplement EE352.</td></tr>
<tr><td colspan="3">Experiments lists<br>1) Simulation of 1- Φ half wave controlled rectifier with R and R-L load using MATLAB.<br>2) Simulation of 1- Φ full wave controlled bridge rectifier and semi-controlled bridge rectifier with R and R-L load.<br>3) Simulation of 3-Φ full wave controlled rectifier with R and R-L load.<br>4) Simulation of a basic series inverter.<br>5) Simulation of parallel inverter.<br>6) Simulation of dual converter.<br>7) Simulation of step down/buck chopper and step up/boost chopper.<br>8) Simulation of $120^o$ and $180^o$ modes of operation of inverter.<br>9) Simulation of sinusoidal pulse width modulation.<br>10) Simulation of hysteresis band pulse width modulation.<br>11). Simulation of speed control schemes for DC and AC motors.<br>12. Mathematical modeling of Power Electronic Systems.</td></tr>
<tr><td>Reference books</td><td colspan="2">1. M.H. Rashid, “Power Electronics - Circuits, Devices and Applications”,PHI, 3rd Edition,2003.<br>2. Ned Mohan,Undelandand P Robin, “Power Electronics Converters, Applications and Design”, John Wiley & Sons,3rd Edition,2007<br>3 .P.S.Bimbhra, “Power Electronics” , Khanna Publishers, New Delhi, 2002</td></tr>
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<table>
<tr><td>Subject Code<br>EE355</td><td>Control Systems Lab</td><td>Credits: 2 (0-0-3)<br>Total Hours:45 Hrs</td></tr>
<tr><td>Course Objective</td><td colspan="2">Laboratory exercises and assignments based on hardware and MATLAB simulation to supplement EE302.</td></tr>
<tr><td colspan="3">Experiments lists<br>1. Determination and analysis of transfer function for Speed control characteristics of DC motor<br>2. Determination and analysis of transfer function of DC servo-motor<br>3. Determination and analysis of transfer function of AC servo-motor<br>4. Characteristics of Stepper motor<br>5. Characteristics of Synchrotransmitter / receiver<br>6. Design of PI and PID controller<br>7. Timeresponse analysis of first and second order systems using MATLAB/SIMULINK<br>8. Frequency response analysis of second order system using MATLAB/SIMULINK<br>9. Design of lag-lead compensator<br>10. Simulink model for servo system<br>11. Simulink model for speed control of motors</td></tr>
<tr><td>Reference books</td><td colspan="2">1. I.J. Nagrath, M. Gopal, “Control Systems Engineering”, New Age International, 4th Edition<br>2. K. Ogata, “ Modern Control Engineering”, PHI, 3rd Edition.<br>3. M.Gopal, “Control Systems, Principles and Design”, Tata McGraw Hill,4th Edition.</td></tr>
</table>

| **Subject Code EE 400** | **Electrical Drives** | **Credits: 3 (3-0-0) Total hours: 56** |
|---|---|---|
| **Course Objectives** | Understand the classification and characteristics of drives. Analyse the various types and operations of DC drives. Analyse the various types and operations of induction motor drives | |
| **Module 1** | | **Hours 10** |
| Introduction: Electrical drives, parts of electrical drives, selection of power rating for drives, dynamics of electrical drives, fundamental torque equation, components of load torques, speed-torque characteristics of various types of motors and loads, condition of steady state stability. DC shunt motor and series motor speed-torque characteristics in different quadrants | | |
| **Module 2** | | **Hours 10** |
| Controlled rectifier fed DC drives:1-phase fully and half controlled converter fed dc separately shunt and dc series motor, mathematical analysis of 1-phase converter fed dc motors, 1-phase dual converter- waveforms, operations with and without circulating current. Steady state analysis of three phase fully and half controlled DC motor drive. Power factor considerations of converters, power factor improvement of phase controlled converters. | | |
| **Module 3** | | **Hours 8** |
| Chopper controlled fed DC drives: Single-quadrant chopper controlled drives, evaluation of performance parameters for separately excited and series motor drives. Two quadrant and four quadrant chopper controlled drives. Closed loop control of dc drives. | | |
| **Module 4** | | **Hours 10** |
| Stator voltage control of 3-phase induction motors by AC voltage controllers. VSI fed induction motor drives, constant v/f control, constant flux control, constant slip-speed control, torque pulsation, effect of harmonics and its control, PWM control, flux weakening operation, Current Source Inverter (CSI) fed induction motor drives.<br>Rotor side control of induction motors: static rotor resistance control, slip power recovery scheme, static scherbius drive, static Kramer's drive and their performance, speed- torque characteristics | | |
| **Module 5** | | **Hours 07** |
| Control of synchronous motor**: s**eparate control &self-control of synchronous motor drive by VSI and CSI. Load commutated CSI fed synchronous motor, speed torque characteristics, closed loop control operation of synchronous motor drives, solar and battery powered drives. | | |
| **Reference books** | 1. G.K.Dubey, "Fundamentals of Electrical Drives", Narosa Publications, 1995<br>2. M.H. Rashid, "Power Electronics - Circuits, Devices and Applications", PHI, 2002.<br>3. G.K.Dubey, "Thyristorised Power Controllers", Wiley Eastern Ltd, 1993. | |

| **Subject Code HU400** | **Management** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | Managerial economics helps in enhancing analytical skills and promotions rational thoughts towards the solution of managerial problems. It deals with firm behaviour and applies micro-economic tools to make business decisions in allocation of resources and pricing of goods and services. It is an art to practice theoretical knowledge of economic environment and science of making decisions with scarce resources with alternative applications. | |
| **Module 1** | | **hours 8** |
| Circular flow of economic activities, nature of the firm, economics & decision making, economic profit and market system. Individual & market demand. Total and marginal revenue price, income and cross elasticity of demand. | | |
| **Module 2** | | **hours14** |
| Regression analysis estimating coefficients & testing parameters. Development of theoretical models. Problems with regression analysis: omitted variable, identification, multi-collinearity, autocorrelation. Sources of data trend analysis, exponential smoothing, barometric forecasting, input& output analysis. | | |
| **Module 3** | | **hours 12** |
| Production function-with one variable input and two variable input, economies of scale and scope, estimation of production function. Economic concept of cost, production and cost, short run & long run cost function special topics in cost theory, estimation of cost function. | | |
| **Module 4** | | **hours 11** |
| Perfect competition monopoly, monopolistic competition, oligopoly. Introduction of game theory game theory and oligopoly, present vs future pricing, the value of bad reputation establishing commitment, preemptive action | | |
| **Reference books** | 1) C.H. Petersen, W. C. Lewis and S. K. Jain, Managerial Economics, 4th Ed., Pearson Ed.<br>2) Samuelson P. A. and Nordhans W.D, Economics 15th ed., McGraw Hill, New York, 1995<br>3) Roberts S. Pindyck, D.L. Rubinfeld and P.L. Mehta, Microeconomics, 7th ed, Pearson Education Asia, New Delhi | |

| **Subject Code EE401** | **Power Electronics and Drives Lab** | **Credits: 2 (0-0-3) Total Hours:45 Hrs** |
|---|---|---|
| **Course Objective** | Laboratory exercises and assignments based on hardware and MATLAB simulation to supplement EE303. | |
| | **Experiments lists**<br>1. Static characteristics of SCR.<br>2. Static characteristics of MOSFET and IGBT<br>3. SCR turn - on circuit using synchronized UJT relaxation oscillator<br>4. SCR digital triggering circuit for a single – phase controlled rectifier and AC voltage controller<br>5. Series inverterwith R & R L loads<br>6. Parallel inverter with R & R L loads<br>7. Buck Converter<br>8. Boost converter<br>9. Single – phase controlled full wave rectifier with R and R-L loads<br>10. AC voltage controller using TRIAC and DIAC<br>11. MOSFET or IGBT based single-phase full-bridge inverter connected to R load<br>12. Speed control of universal motor using AC voltage controller<br>13. Speed control of a separately excited D.C.motor using an IGBT or MOSFET chopper<br>14. Speed Control of D.C. motor using single semi converter | |
| **Reference books** | 1. M.H. Rashid, "Power Electronics - Circuits, Devices and Applications", PHI, 2002.<br>2. Mohan Undeland Robin, "Power Electronics - Converters, Applications and Design", John Wiley & Sons,2002<br>3. P.S.Bimbhra, "Power Electronics" , Khanna Publishers, New Delhi, 2002.<br>4. G.K.Dubey, "Thyristorised Power Controllers", Wiley Eastern Ltd, 1993. | |

| **Subject Code EE450** | **High Voltage Engineering** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | Introducing the dynamics of HV generation, transmission and working, HV testing, measurement. | |
| **Module 1** | | **6 hours** |
| Electro static fields: Electric field intensity, electric strength. generation of high dc and ac voltages, cockcroftwalton voltage multiplier circuit, insulation protection, impulse and switching voltages, generation of high impulse currents, applications. | | |
| **Module2** | | **10 hours** |
| High voltage transmission, ratings, protection mechanism, cost advantage, measurement of high ac, dc, impulse voltages, definitions, measurement accuracy, sphere gap method, peak voltmeters method, potential divider method, rod gap method, high speed CRO, digital techniques measurement techniques | | |
| **Module 3** | | **10 hours** |
| Measurement of high currents, impulse currents, dielectric breakdown in gases, liquids, solids, dielectric strength, dielectric partial discharges, corona discharges. | | |
| **Module 4** | | **10 hours** |
| high voltage testing of circuit breakers, insulators, bushings and surge diverters, standards and specifications, high voltage testing of electrical equipment, non-destructive test techniques, high voltage Schering bridge, breakdown mechanism of gaseous liquid and solid insulating materials, introduction, Townsend's first ionization coefficient. | | |
| **Module 5** | | **09 hours** |
| Causes of over voltage, types, over voltages effects on power system components, surge diverters, EMI and EMC protection against over voltages, insulation coordination. | | |
| **Reference books** | 1. C.L. Wadhwa, “High voltage engineering”, Wiley Eastern Limited, New Delhi, 1994.<br>2. M.S. Naidu, and V.Kamaraju,, “High Voltage Engineering” Tata McGraw Hill Publishing Company, New Delhi, 2nd Edition, 1994.<br>3. E Kuffel, and W.S. Zaengl “High Voltage Engineering Fundamentals” Pergamon press, Oxford, London, 1986. | |

| **Subject Code EE 451** | **Power System Operation and Control** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | To explain the performance of supervision and control systems of electric power and describe their main functions. To acquaint students with the principles of state estimation. To acquaint students with the problem of system control centre and automatic control. To acquaint students with the performance of electronic systems of control and equipment's of electrical networks | |
| **Module 1** | | **Hours 10** |
| Economic Load Dispatch (ELD): Characteristics of power generation units, input output characteristics, cost curves, incremental fuel cost curves, formulation of ELD problem, ELD neglecting losses, ELD including losses, transmission loss coefficients in terms of real power, concept of penalty factor, solution methods for ELD, Lambda iteration method, non smooth cost functions, dynamic programming. | | |
| **Module 2** | | **Hours 07** |
| Unit Commitment (UC): Problem formulation and constraints, UC solution methods, priority list method, dynamic programming, reliability in optimal uc problems, security constraints. | | |
| **Module 3** | | **Hours 10** |
| Load Frequency Control (LFC):LF problem, modelling of components of generating systems, speed governing system, turbine, generator, load, LFC in single area and two area, steady state and dynamic state analysis, analysis of integral control, tie line bias control, AGC in a restructured power system. | | |
| **Module 4** | | **Hours 08** |
| Power System Security (PSS): Factors affecting PSS, concept of system security, contingency analysis, Lyapunov method, pattern recognition, security enhancement | | |
| **Module 5** | | **Hours 10** |
| State estimation in power system and load forecasting: state estimation, least squares estimation, maximum likelihood criterion, detection and identification of bad data, state estimator linear model, load forecasting techniques, short term and long term load forecasting techniques | | |
| **Reference books** | 1. D P Kothari,I J Nagrath , "Power System Engineering", Tata Mc,Graw, 2nd Edition<br>2. C.L.Wadhwa,"Electrical Power Systems", ,New Age International Publishers, 6th Edition<br>3. W.D. Stevenson Jr., "Elements of Power System Analysis", McGraw,Hill, 1968.<br>4. I.J.Nagrath ,D.P.Kothari, "Modern Power System Analysis", Tata Mc,Graw Hill, 4th Edition ,2011 | |

# Elective Subjects

| **Subject Code EE 501** | **Data Structures and Algorithms** | **Credits: 3 (3-0-0) Total hours:45** |
|---|---|---|
| **Course Objectives** | Following this course, students will be able to: Assess how the choice of data structures and algorithm design methods impacts the performance of programs. Choose the appropriate data structure and algorithm design method for a specified application. Solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, tournament trees, binary search trees, and graphs and writing programs for these solutions. Solve problems using algorithm design methods such as the greedy method, divide and conquer, dynamic programming, backtracking, branch and bound and writing programs for these solutions. | |
| **Module 1** | | **6 Hours** |
| Introduction to data structures and objectives, basic concepts Arrays: one dimensional, multi-dimensional, Elementary Operations | | |
| **Module 2** | | **7 Hours** |
| Stacks: Representation, elementary operations and applications such as infix to postfix, postfix evaluation, parenthesis matching; Queues: simple queue, circular queue, dequeue, elementary operations and applications | | |
| **Module 3** | | **8 Hours** |
| Linked lists: Linear, circular and doubly linked lists, elementary operations and applications such as polynomial manipulation | | |
| **Module 4** | | **10 Hours** |
| Trees: Binary tree representation, tree traversal, complete binary tree, heap, binary search tree, height balanced trees like AVL tree and 2-3 tree, tries and other operations and applications of trees | | |
| **Module 5** | | **15 Hours** |
| Graphs: Representation, adjacency list, graph traversal, path matrix, spanning tree; introduction to algorithm analysis and design techniques, algorithms on sorting: selection sort, bubble sort, quick sort, merge sort, heap sort, searching, linear and binary search | | |
| **Reference books** | (1) Alfred V Aho, John E Hopcroft, Jeffrey D. Ullman, "Data structures & Algorithms", Addison Wesley. 2003<br>(2) Horowitz and Sahni , "Data Structures and Algorithms using C/C++", 2003<br>(3) Michael T. Goodrich, Roberto Tamassia, "Data Structures and Algorithms in Java", 4th Edition, John Wiley & Sons, Inc. | |

| **Subject Code EE502** | **Electronic Instrumentation** | **Credits: 3(3-0-0)** **Total hours:45** |
|---|---|---|
| **Course Objectives** | To understand the basic principles of instruments and measurements and various practical issues related to measurement. | |
| **Module 1** | | **Hours 14** |
| Measurement of voltage, current, power, noise, resistance, capacitance, inductance, time, frequency, charge and pulse energy | | |
| **Module2** | | **Hours 7** |
| Designing for EMC: EMC regulations, typical noise path, methods of noise coupling, and methods of reducing interference in electronic systems. | | |
| **Module 3** | | **Hours 10** |
| Capacitive coupling, inductive coupling, effect of shield on capacitive and inductive coupling, effect of shield on magnetic coupling, magnetic coupling between shield and inner conductor, shielding to prevent magnetic radiation, shielding a receptor against magnetic fields, shielding properties of various cable configurations, coaxial cable versus shielded twisted pair, braided shields, ribbon cables. | | |
| **Module 4** | | **Hours 14** |
| Safety grounds, signal grounds, single-point ground systems, multipoint-point ground systems, hybrid grounds, functional ground layout, practical low frequency grounding, hardware grounds, grounding of cable shields, ground loops, shield grounding at high frequencies, guarded instruments.<br>Protection Against Electrostatic Discharges: Static generation, human body model, static discharge, ESD protection in equipment design. | | |
| **Reference books** | 1. Clyde F JrCoombs,"Electronic Instrument handbook", Amazon, 1999<br>2. Joseph J. Carr,"Elements of Electronic Instrumentation and Measurements", 3rd Ed, Prentice Hall, 1995<br>3. Kim R. Fowler,"Electronic Instrument Design", Oxford University Press, 1996.<br>4. Henry W.Ott,"Noise Reduction Techniques in Electronic Systems", 2nd Ed; John Wiley & Sons, 1988. | |

| **Subject Code EE 503** | **Elements of Analog and Digital Communication** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | To give a basic insight to Basic Communication Engineering | |
| **Module 1 Introduction to Analog and Digital Communication** | | **Hours 12** |
| Bandwidth and information capacity, transmission modes, signal analysis, noise considerations. modulation and demodulation concepts (AM, FM, PM), TDM and FDM concepts, Classification of amplifiers (Class A, B, and C), tuned amplifiers, oscillators, amplitude modulation, demodulation circuits, mixer, TRF, super heterodyne and direct conversion receivers, monochrome TV transmitter and receivers. | | |
| **Module 2 Digital and data communication** | | **Hours 12** |
| Sampling theorem, coding and decoding, pulse modulation, waveform coding techniques, pulse code modulation, channel noise and error probability, quantisation noise, signal to noise ratio, FSK, PSK, modem. | | |
| **Module 3 Serial and parallel interface** | | **Hours 09** |
| Computer network configurations and protocols, OSI reference model, Internet protocol, IP protocol: forwarding and addressing in the internet, routing algorithms, packet switching. | | |
| **Module 5 Satellite ,Mobile and optical fibre communication** | | **Hours 12** |
| Orbital patterns, geostationary satellites, frequency band allocation, digital telephony, PSTN and cellular telephony, Optical fibre communication: Mode of signal transmission, signal sources and detectors, attenuators and channel capacity. | | |
| **Reference books** | 1. Wayne Tomasi, "Electronic Communication Systems", Pearson Education, 4th Edition, 2002<br>2. Kennedy, "Communication Systems", 4th edition.<br>3. Gary Miller, "Modern Electronic Communication", 7th Edition.<br>4. Andrew S. TanenBaum, "Computer Networks", 3rd Edition.<br>5. William C. Y. Lee, "Mobile Cellular Telecommunication", 2nd Edition. | |

| **Subject Code EE 504** | **Digital Signal Processing** | **Credits: 3 (3-0-0) Total hours: 56** |
|---|---|---|
| **Course Objectives** | Basic concepts of discrete time signals and systems, interconnection of the systems and filtering. Transform analysis of LTI systems; system functions; All pass systems, minimum phase systems, linear systems with generalized linear phase; structures for discrete time systems, lattice structures; FIR and IIR filter design techniques; The discrete fourier transform, computational aspects and fast algorithms; miscellaneous topics. | |
| **Module 1** | | **8 hours** |
| Review of signals and systems: Motivation and introduction to the course, Basic concepts of signals and systems, interconnection of the systems and filtering, Z – transform and the Region of convergence of the system, Complex convolution theorem, and system described by difference equations, Frequency response of LTI systems and system functions. | | |
| **Module2** | | **10 hours** |
| Structures for Discrete Time systems: Representation of system described by Linear Constant Coefficient Difference Equations, digital filter structures, relation between magnitude and phase, All pass systems, Minimum phase systems, Lattice Structures, Linear Systems with Generalized Linear Phase. | | |
| **Module 3** | | **10 hours** |
| Filter Design Techniques: Design of IIR filters and different transformations, IIR filter design techniques, FIR filter by windowing, FIR filter by the Kaiser window, and Optimum approximation of FIR Filters. | | |
| **Module 4** | | **9 hours** |
| The Discrete Fourier Transform and Computational Aspects: Orthogonal transform, discrete Fourier transform (DFT), Relation between Fourier transform and DFT, Circular Convolution, DFT properties, Computation of DFT, Linear Convolution using the DFT, Fast computation of DFT. | | |
| **Module 5** | | **8 hours** |
| DSP Algorithm implementation and Finite Wordlength Effect: Number representation and overflow, Quantization Process and Errors, fixed and floating point numbers, coefficient quantization, A/D conversion noise analysis, Low sensitivity digital filters, Limit Cycle oscillations in IIR digital filters. | | |
| **Reference books** | 1. A. V. Oppenheim and Schafer, "Discrete time Signal processing," 3rd Edition, PHI.<br>2. S. K. Mitra, "Digital Signal Processing," 3rd Edition, TMH. | |

| **Subject Code**<br>**EE505** | **Digital Computer Organization and Architecture (COA)** | **Credits: 3 (3-0-0)**<br>**Total hours:45** |
|---|---|---|
| **Course Objectives** | To develop an understanding of the nature and characteristics of the architecture and design of the modern computer systems. | |
| **Module 1** | | **6 Hours** |
| Introduction to computer architecture and organization: digital components, Von Neumannmachine architecture, Flynn classification register transfer language: micro operations, data transfer operations, arithmetic, logic and shift micro operations and their hardware implementations as a simple arithmetic and logic unit. | | |
| **Module 2** | | **13Hours** |
| CPU Organization: Addressing techniques, instruction set design, example for zero address, one address, two address and three address machines, stack, accumulator and general purpose register organization. Arithmetic algorithms: Arithmetic and Logic Unit, adders, multiplication, add and shift method, Booth's Multiplier, m -array multiplier, division, restoring and non restoring method. | | |
| **Module 3** | | **12 Hours** |
| Pipelining: Pipeline structure, pipeline performance measures, pipeline types, memory organization, memory device characteristics, RAM organization, virtual memory, paging and segmentation, high speed memories. | | |
| **Module 4** | | **14 Hours** |
| Control unit design, hardwired and micro programmed control unit design, implementation techniques, memory hierarchies, input-output design, IO interface, bus structure, modes of data transfer, interrupts, input output processor, serial communication. | | |
| **Reference books** | 1. J.L. Hennessy and D.A. Patterson, "Computer Architecture: A Quantitative Approach", 4th Edition, Elsevier.<br>2. M. Morris Mano, "Computer System Architecture", PHI.<br>3. Carl Hamacher, "Computer Organization", McGraw-Hill, 5th Ed.<br>4. J.P Hayes, Computer Architecture & Organization, McGraw-Hill. | |

| **Subject Code EE 506** | **Advanced Control Systems** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | To incite a wide knowledge on the description and stability of non-linear system. To examine the conventional technique of non-linear system analysis. To solve the analysis discrete time systems using conventional techniques. To understand the analysis of digital control system using state-space formulation. To look at the formulation and analysis of multi input multi output (MIMO) system | |
| **Module 1** | | **Hours 11** |
| Discrete control system: Introduction to discrete time control system, block diagram of a digital control system, sampling process, data reconstruction and hold circuits, zero and first order hold, review of z- transforms and inverse z- transforms, solution of difference equations, pulse transfer function, pulse transfer function with dead time, system time response, realization of pulse transfer functions, stability studies. | | |
| **Module 2** | | **Hours 10** |
| State variable analysis of discrete system: Concept of controllability and observability for a linear time invariant discrete time control system, condition for controllability and observability, state feedback, condition for arbitrary pole placement, design via pole placement, state observers. | | |
| **Module 3** | | **Hours 12** |
| Non Linear system: Characteristics of non- linear systems, types of non-linearity, phase plane analysis, construction of phase trajectory, Isocline method and delta method ,singular points and classification, describing function analysis, basis of describing function approach, describing functions of common non- linearity namely dead zone saturation, ideal relay, combined dead- zone and saturation, relay with hysteresis | | |
| **Module 4** | | **Hours 12** |
| Stability of non-linear systems: Liapunov Methods, Liapunov stability, definition of stability, asymptotic stability and instability, quadratic forms and sign definiteness of scalar function, Liapunov stability theorems, Liapunov stability analysis of LTI continuous and discrete time systems methods of construction of Liapunov function for non- linear systems. | | |
| **Reference books** | 1. M.Gopal, "Control System Principles and Design",TataMcGraw Hill,4th edition<br>2. I. J. Nagrath, M. Gopal, "Control Systems Engineering" New Age International, 4th Edition<br>3. K. Ogata, "Modern Control Engineering", PHI, 3rd Edition<br>4. K. Ogata, "Discrete Time Control Systems", Pearson Education, 2nd Edition | |

| **Subject Code EE507** | **Travelling Waves on Transmission System** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | To understand the various types of travelling waves on transmission system. | |
| **Module 1** | | **Hours : 12** |
| The line equations: The ideal (no-loss) line, the distortion-less line, line with small losses, exact solution of the infinite line, line of finite length, attenuation and distortion of traveling waves. Reflection of traveling waves: behaviour of a wave at a transition point, dissimilar voltage and current waves, typical cases, current-limiting reactors. Successive reflections: the reflection lattice, construction and use of the lattice-diagram, charging of a line from various sources, reflection between a capacitor and a resistor, effect of short lengths of cable, effect of insulator capacitance. | | |
| **Module 2** | | **Hours : 10** |
| Traveling waves on multi conductor systems: The general differential equations of traveling waves, transition points on multi conductor circuits, multi velocity waves, surge tests on transmission lines, physical concept of multi velocity waves, two-conductor system, multi conductor system. | | |
| **Module 3** | | **Hours : 10** |
| Theory of ground-wires: Direct stroke to a tower, effect of reflections up and down the tower, tower grounding. The counterpoise: Multi velocity waves on the counterpoise, tests on the counterpoise, successive reflections on the insulated counterpoise. | | |
| **Module 4** | | **Hours : 13** |
| Induced lightning surges: The field gradient, induced surges with ideal ground wires. Arcing grounds: normal frequency arc extinction - single-phase and three-phase, oscillatory-frequency arc extinction, high-frequency effects, interruption of line-charging currents, cancellation waves, initiated waves, steady-state waves, recovery voltage, restriking phenomena. | | |
| **Reference books** | 1) L. V. Bewley, "Traveling Waves on Transmission Systems," John Wiley and Sons, 1951.<br>2) H. H. Skilling, "Electric Transmission Lines," TMH, 1951.<br>3) F. Woodruff, "Principles of Electric Power Transmission," John Wiley and Sons, 1952 . | |

| **Subject Code EE 508** | **Utilisation of Electrical Energy** | **Credits: 3 (3-0-0)** **Total hours:45** |
|---|---|---|
| **Course Objectives** | Understand concept of illumination systems, heating and welding systems. Learn the requirements of traction systems. | |
| **Module 1** | | **Hours 14** |
| Electric traction: requirements of an ideal traction system, systems of traction, requirements of ideal traction motors, comparison and control of traction motors, mechanics of train movement, tractive effort for acceleration ,train resistance, gradient, coefficient of adhesion, speed time curves, specific energy consumption. | | |
| **Module 2** | | **Hours 12** |
| Electric heating: advantages, classification of heating equipment's, methods of heat transfer, resistance heating, design of heating element, induction heating, eddy current heating, dielectric heating. | | |
| **Module 3** | | **Hours 12** |
| Electric welding: resistance welding, arc welding. Electrolytic processes: Faraday's laws of electrolysis, calculation of current required and related definitions, factors governing the character of deposits, preparation of work for electroplating, electro-extraction and refining of copper and aluminium. | | |
| **Module 4** | | **Hours 7** |
| Illumination: definition, illumination standards, laws of illumination, lighting calculations, polar curves, Rousseau's construction, illumination measuring devices, various illumination devices. | | |
| **Reference books** | 1. Partab , Art and Science of Utilization of Electrical Energy.<br>2. E. O. Taylor, Utilization of Electric Energy.<br>3. C. L Wadhwa , Generation ,Distribution and Utilization of Electrical Energy. | |

| **Subject Code EE509** | **Introduction to Database management Systems** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | This course covers the relational database systems RDBS - the predominant system for business, scientific and engineering applications at present. | |
| **Module 1** | | **6 Hours** |
| Introduction & need for database systems, views of data, data models, database system architecture, database users and administrator. | | |
| **Module 2** | | **10 Hours** |
| Entity relationship model (E-R model), E-R diagrams, introduction to relational databases, keys, relational algebra,domain, relational calculus, tuple relational calculus. | | |
| **Module 3** | | **15 Hours** |
| SQL: A relational database language, data definition in SQL. SQL queries: The form of a basic SQL query, union, intersect, and except, aggregate operators, specifying constraints,view and joins in SQL, specifying constraints, introduction to nested queries. | | |
| **Module 4** | | **14 Hours** |
| Functional dependencies, non-loss decomposition, first, second, third normal forms, Boyce Codd normal form, transaction concepts, transaction recovery, ACID properties, Concurrency.<br>Storage: overview of physical storage media, magnetic disks, RAID, tertiary storage,file organization, organization of records in files, indexing and hashing, database security. | | |
| **Reference books** | (1) Korth, Silberschatz, "Database System Concepts", 4th Ed., TMH, 2003.<br>(2) Elmsari and Navathe, "Fundamentals of Database Systems", 4th Ed., A. Wesley, 2004.<br>(3) Raghu Ramakrishnan , Johannes Gehrke, " Database Management Systems", 3rd Edition, , McGraw- Hill, 2003.<br>(4) J D Ullman, "Principles of database systems", 2001. | |

| **Subject Code**<br>**EE 510** | **Computer Networks** | **Credits: 3 (3-0-0)**<br>**Total hours: 45** |
|---|---|---|
| **Course Objectives** | This course focuses on understanding the design of computer networks, assimilating hubs into a personal network. | |
| **Module 1** | | **8 Hours** |
| Introduction to computer networks, overview of OSI reference model. Topology design, problems and protocols, practical local area network design and implementation. IEEE LAN standards, logical link control protocols, HDLC, ALOHA, SLOTTED ALOHA, FDDI, client server model and related softwares. Computer networks and internet, network edge, network core, network access, delay and loss. | | |
| **Module 2** | | **16 Hours** |
| Transport layer services, UDP, TCP, new transport layer protocols, congestion control and resource allocation, new versions of TCP, network layer services, routing, IP, routing in internet, router, IPV6, multicast routing. | | |
| **Module 3** | | **10 Hours** |
| Link layer services, error detection and correction, multiple access protocols, ARP, ethernet, hubs, bridges, switches, wireless links, mobility, PPP, ATM, MPLS, VLAN. | | |
| **Module 4** | | **11 Hours** |
| Multimedia networking, streaming stored audio and video, real-time protocols, security, Cryptography, authentication, integrity, key distribution, network management, firewalls, brief functioning of upper layers, e-mail and other application. | | |
| **Reference books** | 1. J. F. Kurose and K. W. Ross, "Computer Networking: A Top-Down Approach Featuring Internet", 3/e, Pearson Education, 2005.<br>2. Peterson L.L. & Davie B.S., "Computer Networks, A systems approach", 3/E, Harcourt Asia, 2003.<br>3. Andrew. S. Tanenbaum, "Computer Networks", Prentice Hall of India, 5th Edn, 2002.<br>4. Fred Halsall, "Data Communications, Computer networking on OSI", Addison Wesley Publishing Co., 2nd Edition, 2002.<br>5. William Stallings, "Data & Computer Communications", 2nd Edition, Maxwell, MacMillan International Edn. 2003.<br>6. Behrouz A. Forouzan, "Data Communications & Networks", 3rd Ed., TMH. | |

| **Subject Code EE 511** | **Embedded Systems** | **Credits: 3(3-0-0) Total hours:45** |
|---|---|---|
| **Course Objectives** | To give ideas about embedded systems and system development.<br>To impart knowledge about real time operating systems and microcontrollers | |
| **Module 1** | | **Hours 10** |
| Introduction to embedded systems: embedded system examples, parts of embedded system-processor, power supply, clock, memory interface, interrupt, I/O ports, buffers, programmable devices, ASIC,etc. interfacing with memory and I/O devices. memory technologies – EPROM, Flash, OTP, SRAM,DRAM, SDRAM etc. | | |
| **Module2** | | **Hours 8** |
| Embedded system design: embedded system product development life cycle (EDLC), hardware development cycles, specifications, component selection, schematic design, PCB layout, fabrication and assembly. Product enclosure design and development.<br>Embedded system Development Environment – IDE, cross compilation, simulators/emulators, hardware debugging. hardware testing methods like boundary scan, In Circuit Testing (ICT) etc.<br>Bus architectures like $I^2C$, SPI, AMBA, CAN etc. | | |
| **Module 3** | | **Hours 12** |
| Operating systems: concept of firmware, operating system basics, real time operating systems, tasks, processes and threads, multiprocessing and multitasking, task scheduling, task communication and synchronisation, device drivers. | | |
| **Module 4** | | **Hours 15** |
| System design examples : system design using ARM/PSoC/MSP430 processor | | |
| **Reference books** | 1. J.W. Valvano, Embedded Microcomputer System: Real Time Interfacing, Brooks/Cole, 2000.<br>2. David Simon, An Embedded Software Primer, Addison Wesley, 2000.<br>3. Shibu K.V.: Introduction to Embedded Systems, Tata McGraw Hill, 200 | |

| **Subject Code EE512** | **High Voltage DC (HVDC) Transmission** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | The course aims at use of high voltages as the key to efficient transmission and distribution of electrical power. To have an overview about different forms of insulation and their behaviour, over voltage conditions and protection of equipment's. To analyse the malfunctioning of converters and protection. | |
| **Module 1** | | **Hours : 8** |
| Historical development of HVAC and HVDC links, comparison, economics of power transmission, technical performance, reliability, limitations, application of dc transmission, description of DC Transmission System, types of DC links and converter station, planning for HVDC transmission. modern trends in DC transmission. | | |
| **Module 2** | | **Hours : 10** |
| Thyristor valve: Introduction, thyristor devices, thyristor valve, valve test, recent trends. analysis of HVDC converters; pulse number, choice of converter configuration, Simplified analysis of Graetz circuit, convertor bridge characteristics, characteristics of a twelve pulse converters, detailed analysis of converters. | | |
| **Module 3** | | **Hours : 8** |
| Converter and HVDC system control: general, principles of dc link control, converter control characteristics, system control hierarchy firing angle control, current and extinction angle control, starting and stopping of dc link, power control, higher level controllers, telecommunication requirements. | | |
| **Module 4** | | **Hours :9** |
| Converter faults and protection: introduction, converter faults, protection against over currents over voltages in a converter station, surge arrests, protection against over voltages. smoothing reactor and dc line; introduction, smoothing reactors, dc line, transient over voltages in dc line, protection of dc line, dc breakers, monopolar operation, effects of proximity of ac and dc transmission lines. | | |
| **Module 5** | | **Hours : 10** |
| Reactive power control; introduction, reactive power requirements in steady state, sources of reactive power, static var systems, reactive power control during transients, harmonics and filters; introduction, generation of harmonics, design of ac filters, dc filters, carrier frequency and RI noise, multi terminal dc systems; introduction, potential applications of MTDC systems, types of MTDC systems, control and protection of MTDC systems, control and protection of MTDC Systems study of MTDC systems. | | |
| **Reference books** | 1) K. R. Padiyar, "HVDC Power transmission System," New age International, 1996.<br>2) J. Arrillaga, "HVDC transmission," IET, 1998.<br>3) E.X. Kimbark, "Direct Current Transmission," Vol. I, Wiley Interscience, Newyork, 1971. | |

| **Subject Code EE513** | **Flexible AC Transmission Systems** | **Credits: 3 (3-0-0) Total hours: 56** |
|---|---|---|
| **Course Objectives** | To enhance the transmission capability of transmission system by shunt and series compensation using static controllers. To understand the concept of flexible AC transmission and the associated problems. To review the static devices for series and shunt control. To study the operation of controllers for enhancing the transmission capability. | |
| **Module 1** | | **Hours : 10** |
| FACTS concepts and general system consideration: Power flow in AC Systems. Definition of FACTS, power flow control, constraints of maximum transmission line loading. Benefits of FACTS transmission line compensation: uncompensated line, shunt compensation. series compensation, phase angle control. | | |
| **Module 2** | | **Hours : 9** |
| Static shunt compensators: SVC: Static Var Compensator, and STATCOM: static synchronous compensator. operation and control of TSC:Thyristor Switched Capacitor, TSR: Thyristor Switched Reactor, TCR: Thyristor Controlled Reactor, and STATCOM, compensator control, comparisons between SVC and STATCOM. | | |
| **Module 3** | | **Hours : 9** |
| Static series compensation: TSSC:Thyristor Switched Series Capacitor, SSSC: static Synchronous Series Compensator, Static voltage and phase angle regulators TCBR: Thyristor Controlled Braking Resistor, TCPAR: Thyristor Controlled Phase Angle Regulator. Operation and control applications. | | |
| **Module 4** | | **Hours : 9** |
| Unified Power Flow Controller: circuit arrangement, operation and control of UPFC, basic principle of P and Q control, independent real and reactive power flow control, applications, introduction to interline power flow controller. | | |
| **Module 5** | | **Hours : 8** |
| Introduction to APF technology, solutions for mitigation of harmonics, classification of power filters- passive filters, active filters, hybrid filters; active filters applications depending on power quality issues; selection of power filters; categorization of active power filter, converter based categorization, topology based categorization, supply system based categorization, selection considerations of APFS; technical and economic considerations. | | |
| **Reference books** | 1) N.G Hingorani, L. Gyugyi,"Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.<br>2) P.Kundur , "Power System Stability and Control", McGraw-Hill EPRI Power System Engineering Series,<br>3) K. R. Padiyar, "Power System Dynamics, Stability and Control", 2nd Edition, B.S. Publishers. 1994.<br>4) T.J.E Miller, "Reactive Power Control in Electric Systems", Wiley | |

| **Subject Code EE514** | **Soft Computing Techniques** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | This course presents the basics of neural networks and essentials of artificial neural networks with single layer and multilayer feed forward networks. Also deals with fuzzy sets and fuzzy logic system components. The neural network and fuzzy network system application to electrical engineering is also presented. | |
| **Module 1** | | **Hours : 10** |
| Introduction to biological and artificial neuron models, operations of artificial neuron, types of neuron activation function, history of artificial neural systems development, Mcculloch-Pitts neuron model, ANN architectures, neural dynamics (activation and synaptic), neural processing,, learning strategies, learning rules. | | |
| **Module 2** | | **Hours : 10** |
| Classification model, features, and decision regions, discriminant functions, models of Artificial Neural Networks: feed forward network, feedback network, single and multilayer feed forward neural networks- introduction, perceptron models: discrete, continuous and multi-category, training algorithms: discrete and continuous perceptron networks, perceptron convergence theorem, limitations of the single layer perceptron model (XOR Problem), Applications; credit assignment problem, generalized delta rule, Back Propagation Algorithm (BPA), learning difficulties and improvements. | | |
| **Module 3** | | **Hours : 8** |
| Associative memories: Hebbian learning, general concepts of associative memory (associative matrix, association rules, hamming distance, Bidirectional Associative Memory (BAM) architecture, architecture of Hopfield network: discrete and continuous versions, storage and recall algorithm. Counter propagation networks, Full CPN, Forword only CPN, Training Phases, ADALINE and MADALINE networks. Neural network applications: process identification, control, fault diagnosis and load forecasting. Applications of neural networks. | | |
| **Module 4** | | **Hours : 12** |
| Introduction to classical sets - properties, operations and relations; fuzzy sets, membership, uncertainty, operations, properties, fuzzy relations, cardinalities, membership functions. Fuzzification, membership value assignment, development of rule base and decision making system, fuzzy inference systems: Mamdani max-min and max-product composition scheme, defuzzification to crisp sets, defuzzificationmethods:centroid of area, bisector of area, mean, smallest, and largest of maximum. Design of control rules: trapezoidal MF, triangular MF and Gaussian MF. Rule base fuzzy logic applications: fuzzy logic control and fuzzy classification. Applications of fuzzy systems. | | |
| **Module 5** | | **Hours : 5** |
| Introduction to Type-2 FLC: The structure of Type-2 FLC, Type-2 fuzzy inference system with different fuzzy MFs (Trapezoidal membership function, Triangular MF and Gaussian MF). | | |
| **Reference books** | 1) J. M. Zurada, "Introduction to artificial neural networks,"Jaico publishing, 1997.<br>2) Simon Haykin, "Neural Networks A Comprehensive Foundation," PHI, 1999.<br>3) J. S. R. Jang, C. T. Sun , E. Mizutani, "Neuro-Fuzzy and Soft Computing A Computational Approach to Learning and Machine Intelligence," PHI, 2002.<br>4) Timothy J Ross, "Fuzzy Logic with Engineering Applications," TMH, 2007.<br>5) B.Kosko, "Fuzzy Engineering," Prentice Hall, 1997 | |

| **Subject Code EE515** | **Renewable Energy Systems** | **Credits: 3 (3-0-0) Total hours:45** |
|---|---|---|
| **Course Objectives** | To explain concept of various forms of renewable energy and to outline the utilization of renewable energy sources for both domestic and industrial applications | |

| **Module 1** | **Hours: 10** |
|---|---|
| Introduction to renewable energy, various aspects of energy conversion, principle of renewable energy systems, environment and social implications<br>Solar Energy: Solar radiation its measurements and prediction, solar thermal flat plate collectors, concentrating collectors, applications, heating, cooling, desalination, power generation, drying, cooking etc, principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. Photovoltaic applications: battery charger, domestic lighting, street lighting, and water pumping, power generation schemes. | |
| **Module2** | **Hours: 9** |
| Wind Energy: Atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Betz limit, aerodynamics of wind turbine rotor, site selection, wind resource assessment, wind energy conversion devices: classification, characteristics, and applications. Hybrid systems, safety and environmental aspects. | |
| **Module 3** | **Hours: 9** |
| Bio-Energy: Biomass resources and their classification, chemical constituents and physicochemical characteristics of biomass, biomass conversion processes, thermo chemical conversion: direct combustion, gasification, pyrolysis and liquefaction. Biochemical conversion: anaerobic digestion, alcohol production from biomass.Chemical conversion process: hydrolysis and hydrogenation. Biogas: generation, types of Biogas Plants, applications | |
| **Module 4** | **Hours:9** |
| Hydrogen And Fuel Cells: Thermodynamics and electrochemical principles, basic design, types, and applications, production methods,Biophotolysis: Hydrogen generation from algae biological pathways, storage gaseous, cryogenic and metal hydride and transportation. Fuel cell: principle of working, various types, construction and applications. | |
| **Module 5** | **Hours: 8** |
| Other Types Of Energy: ocean energy resources: principles of ocean thermal energy conversion systems, ocean thermal power plants,and principles of ocean wave energy conversion and tidal energy conversion, microhydelpower, site selection, construction, environmental issues.Geothermal energy, types of geothermal energy sites, site selection and geothermal power plants. MHD Power Generation. | |

| **Reference books** | (1) G. D.Rai, "Non-conventional Energy Sources", Khanna Publishers, New Delhi, 2007.<br>(2) S.P.Sukhatme, "Solar Energy", Tata McGraw - Hill Education India Private Limited,New Delhi, 2006.<br>(3) Godfrey Boyle, "Renewable Energy: Power for a sustainable future", Oxford University press, Second edition. |
|---|---|

| **Subject Code EE 516** | **Static Relays** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | To understand the causes of abnormal operating conditions (faults, lightning and switchingsurges) of the apparatus and system.To understand the characteristics and functions of static relays and protection schemes and to give an insight on Static Relay protection schemes. | |
| **Module 1** | | **Hours 09** |
| Power system protection and its requirements, conventional Vs static relays, steady state and transient performance of signal deriving elements signal mixing techniques and measuring techniques, construction and characteristics function of static relays, static relay components. | | |
| **Module 2** | | **Hours 12** |
| Phase comparator directional units, amplitude comparator directional units, poly phase directional relays, differential relays: operating characteristics, restraining characteristics, types of differential relays, analysis of electromagnetic and static differential relays, static relay scheme. | | |
| **Module 3** | | **Hours 12** |
| Principle and practical circuits of Instantaneous over current relays, time current relays, time over current relays. Distance relays: standard three zone protection, characteristics and types, switched distance scheme, poly phase distance relays, operating time characteristics, static distance relay scheme. | | |
| **Module 4** | | **Hours 12** |
| Pilot wire and carrier current schemes, pilot relaying scheme, selection of suitable static relaying scheme for transmission lines. Implementation of over current, directional, impedance and mho relays using Microprocessor/Microcontroller. | | |
| **Reference books** | 1. MadhavaRao, T.S., "Power System Protection, Static Relays", McGraw Hill, New Delhi, 1991.<br>2. Van.C.Warrington, "Protective Relays, Their Theory and Practice", Vols. I & II, Chapman & Hall Ltd. London, 1994.<br>3. Ram.B., "Fundamentals of Microprocessors and Microcomputers", M/s. DhanpatRai& sons, New Delhi, 1992. | |

| **Subject Code EE517** | **Photovoltaic and its applications** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | 1. Learn the fundamentals of solar energy conversion systems, available solar energy and the local and national needs, solar engineering applications, emerging technologies,<br>2. Understand the interdisciplinary approach for designing stand-alone PV systems, predicting performance with different systems, Implementing design with cost analysis. | |

| **Module 1** | **Hours: 5** |
|---|---|
| Solar energy: solar insolation vs world energy demand, current energy consumption from different sources, environmental and health effects.<br>Sustainable Energy: production and storage, resources and utilization. | |

| **Module2** | **Hours: 10** |
|---|---|
| Solar thermal conversion: Low, medium and high temperature collectors, types of solar energy collectors; heat storage, storage media, steam accumulator, other storage systems, heat exchangers and applications of stored energy.<br>Thermoelectric systems: Thermoelectricity, Peltier effect, Seebeck effect; Thermoelectric materials, Bismuth telluride, automotive thermoelectric generators, radioisotope thermoelectric generator; thermoelectric power generators, thermoelectric refrigerators and heat pumps. | |

| **Module 3** | **Hours: 10** |
|---|---|
| Photovoltaic (PV): Fundamentals of solar cells: types of solar cells, semiconducting materials, band gap theory, absorption of photons, excitation and photoemission of electrons, band engineering, Solar cell properties and design, p-n junction photodiodes, depletion region, electrostatic field across the depletion layer, electron and holes transports, device physics, charge carrier generation, recombination and other losses, I-V characteristics, output power, single junction and triple-junction solar panels, metal-semiconductor heterojunctions and semiconducting materials for solar cells.<br>solar cell applications: pv cell interconnection, module structure and module fabrication, equivalent circuits, load matching, efficiency, fill factor and optimization for maximum power; design of stand-alone PV systems, system sizing, device structures, device construction, installation, measurements; DC to AC conversion, inverters, on-site storage and grid connections; Solar cell manufacturing processes: material resources, chemistry and environmental impacts; low cost manufacturing processes. | |

| **Module 4** | **Hours: 10** |
|---|---|
| Optical engineering: Optical design, anti-reflection coatings, beam splitters, surface structures | |

<table>
<tr><td colspan="2">for maximum light absorption, operating temperature Vs. conversion efficiency, types of solar energy concentrators, fresnel lenses and fresnel reflectors, operating solar cells at high incident energy for maximum power output.Cost analysis and environmental issues: Cost analysis and pay back calculations for different types of solar panels and collectors, installation and operating costs; environmental and safety issues, protection systems, performance monitoring.</td></tr>
<tr><td>Module 5</td><td>Hours: 10</td></tr>
<tr><td colspan="2">Thin film solar cells: Single crystal, polycrystalline and amorphous silicon solar cells, cadmium telluride thin-film solar cells, conversion efficiency; current trends in photovoltaic research and applications; nanotechnology applications, quantum dots, solution based processes solar cell production.Photo electrochemical cells for hydrogen production: photo electrochemical electrolysis, photoelectron chemical cells for hydrogen production, solar hydrogen efficiency, hydrogen storage, hydrogen economy.</td></tr>
<tr><td>Reference books</td><td>(1) Jasprit Singh, “Semiconductor Devices,Basic Principles” , Wiley,(2001)<br>(2) Jenny Nelson “The Physics of Solar Cells” , Imperial College Press (2003)<br>(3) Stephen J. Fonash “Solar Cell Device Physics”, 2nd edition ,Academic Press (2010)</td></tr>
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| **Subject Code EE 518** | **Power System Restructuring** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | To provide in-depth understanding of operation of deregulated electricity market systems and examine topical issues in electricity markets and how these are handled world-wide in various markets. To analyse various types of electricity market operational and control issues using new mathematical models | |
| **Module 1** | | **Hours 08** |
| Introduction: Market models, entities , key issues in regulated and deregulated power markets, electricity markets, California market, New England ISO, Midwest ISO, Nordic pool, power market in China. components of restructured system | | |
| **Module 2** | | **Hours 10** |
| Operational and planning activities of a generation company: electricity pricing and forecasting, price based unit commitment design, security constrained unit commitment design. , ancillary services for restructuring, Automatic Generation Control. | | |
| **Module 3** | | **Hours 10** |
| Open access Transmission system: transmission pricing in open access system, open transmission system operation, congestion management in open access transmission systems, FACTS in congestion management, open access, coordination strategies, power wheeling transmission | | |
| **Module 4** | | **Hours 07** |
| Cost allocation methods open access distribution, changes in distribution operations, the development of competition, maintaining distribution planning | | |
| **Module 5** | | **Hours 10** |
| Power Market Development: Electricity Act, 2003, key issues and solution, developing power exchanges suited to the Indian market, challenges and synergies in the use of it in power, competition, Indian power market, Indian energy exchange, Indian power exchange, infrastructure model for power exchanges, congestion management, day ahead market, online power trading. | | |
| **Reference books** | 1. Loi Lei Lai, "Power System Restructuring and Deregulation", John Wiley & son LTD, New York, 2001.<br>2. Mohammad Shahidehpour, HatimYamin, "Market operations in Electric power systems", John Wiley & son LTD, Publication, 2002.<br>3. LorrinPhilipson, H. Lee Willis, "Understanding Electric Utilities and Deregulation" Taylor & Francis, New York 2006.<br>4. MohammadShahidehpour, MuwaffaqAlomoush, "Restructured Electrical Power Systems", Marcel Dekker, INC., New York, 2001. | |

| **Subject Code EE 519** | **Distribution automation and Smart Grid** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | To understanding the distribution automation and smart grid architecture, working. | |
| **Module 1** | | **4 hours** |
| Distribution system Planning and forecasting techniques, load characteristics, definitions, tariffs and metering of energy, distribution transformers, types, distribution sub-stations and primary system. | | |
| **Module2** | | **12 hours** |
| Voltage drop and power loss calculations, distribution feeder costs, capacitors in distribution systems, justification for capacitors, distribution system automation, automation communication systems. | | |
| **Module 3** | | **12 hours** |
| Introduction to smart grid, smart grid functions, advantages, Indian smart grid, key challenges for smart grid, smart grid architecture, components, architecture of smart grid design - transmission & distribution. | | |
| **Module 4** | | **12 hours** |
| Automation computational intelligence techniques, distribution generation technologies, introduction to renewable energy technologies, Micro grids, storage technologies, Electric vehicles and plug in hybrids, synchrophasor measurement Units (PMUs), Wide Area Measurement Systems (WAMS), control of smart power grid system. | | |
| **Module 5** | | **5 hours** |
| Renewable Integration, Electric Vehicles and plug - in hybrids, indian smart grid. Case studies | | |
| **Reference books** | 1. TuranGonen, "Electric Power Distribution Systems", CRC Press, 2006.<br>2. Pabla, A. S, "Electric Power Distribution", 6th Edition, Tata McGraw-Hill Education, 2011.<br>3. M. V. Deshpande, "Electrical Power System Design", Tata McGraw-Hill Education, 2001.<br>4. Gil Masters, "Renewable and Efficient Electric Power System", Wiley-IEEE Press, 2004.<br>5. A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2010. | |

| **Subject Code EE520** | **Power Quality** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | To study the various issues affecting power quality, their production, monitoring and suppression. To understand about the concepts of power quality problems and mitigation techniques. To be familiarise with various control strategies and controllers. | |
| **Module 1** | | **Hours : 12** |
| Introduction to power quality: terms and definitions: overloading, under voltage, over voltage. Concepts of transients: short duration variations such as interruption, long duration variation such as sustained interruption. Voltage sag, voltage swell, voltage imbalance, voltage fluctuation, over voltages, under voltages, power frequency variations. Harmonics: harmonic sources from commercial and industrial loads, locating harmonic sources. Power system response characteristics: harmonics Vs transients. Effect of harmonics, harmonic distortion, voltage and current distortion, harmonic indices, inter harmonics, resonance. Harmonic distortion evaluation, devices for controlling harmonic distortion, passive and active filters. IEEE and IEC standards of power quality, | | |
| **Module 2** | | **Hours : 10** |
| Introduction to APF technology, solutions for mitigation of harmonics, classification of power filters- passive filters, active filters, hybrid filters; active filters applications depending on power quality issues; selection of power filters; categorization of active power filter: converter based categorization, topology based categorization, supply system based categorization, selection considerations of APFS; technical and economic considerations. | | |
| **Module 3** | | **Hours : 10** |
| Introduction to active power filter control strategies. shunt active filter basic compensation principle, Clark's transformations, parks transformations, active power filter control strategies, signal conditioning, current control techniques for derivation of gating signals, generation of gating signals to the devices of the APF, hysteresis current control scheme and adaptive hysteresis current control scheme, derivation of compensating signals, compensation in frequency domain, compensation in time domain. | | |
| **Module 4** | | **Hours : 13** |
| Control strategies Instantaneous active and reactive power (p-q) control strategy, Instantaneous active and reactive current ($I_d$-$I_q$) control strategy, and perfect harmonic cancellator.<br>Introduction to Dc link voltage regulation: Dc link voltage regulation with PI Controller, Type-1 fuzzy logic controller, Type-2 fuzzy logic controller, and neural networks. | | |
| **Reference books** | 1) H. Akagi, "Instantaneous Power Theory and Applications to Power Conditioning," IEEE Press, 2007.<br>2) G.T. Heydt, "Electric Power Quality," 2nd Edition, West Lafayette, IN, Stars in a Circle Publications, 1994.<br>3) M.H.J Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions," NewYork: IEEE Press, 1999. | |

| **Subject Code EE521** | **Real Time Control of Power System** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | To learn basics of SCADA and to develop skills to work on SCADA features. Aims to build good understanding about the basics of industrial automation using SCADA, PLC and HMI. | |
| **Module 1** | | **Hours : 8** |
| Introduction to Factory & Process Automation, PLC, Networking standards. Vertical Integration of Industrial Automation, field bus and Ethernet. HMI Systems: Necessity and Role in Industrial Automation, Text display, operator panels, Touch panels, Panel PCs, Integrated displayers (PLC & HMI). | | |
| **Module 2** | | **Hours : 14** |
| Supervisory Control and Data Acquisition (SCADA), introduction to SCADA: grid operation and Control. remote terminal unit (RTU) and communication practices: Major Components. Sub-load dispatch center (SUB-LDC): Work Stations, FEPS: Function of FEPS (Front End Processors), Routers. Real time software: classification of programs. computer control of electrical power systems. southern regional load dispatch center (SRLDC): functions and responsibilities of SRLDC. Developer and runtime packages, architecture, tools, tag, internal & external graphics, alarm logging, tag logging, structured tags, trends, history, report generation, VB & C Scripts for SCADA application. | | |
| **Module 3** | | **Hours : 11** |
| Distributed Control Systems (**DCS**), difference between SCADA system and DCS, architecture, local control unit, Programming language, communication facilities, operator interface, engineering interfaces. | | |
| **Module 4** | | **Hours : 12** |
| Applications of SCADA & DCS, Case studies of process plants using SCADA & DCS, advanced features / options in SCADA & DCS, role of PLC in DCS and SCADA, comparison, field devices (Transducers, drives etc.) in DCS/SCADA. | | |
| **Reference books** | 1) John W. Webb, Ronald A. Reis, "Programmable Logic Controllers," Prentice Hall of India, New Delhi, 1995.<br>2) Michael P. Lukas, "Distributed Control Systems," Van NostrandReinfold Company, 1995.<br>3) Hassan Bevrani, "Robust Power System Frequency Control Power Electronics and Power Systems," Springer, 2009.<br>4) T. Cegrell, "Power System Control - Technology," Prentice Hall International Ltd., 1986. | |

| **Subject Code EE 522** | **Optimization Techniques** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | Students will be able to state the different types of optimization problems, their formulation and solution techniques. Students will be able to understand the mechanisms of various traditional and modern optimization techniques. Students will be able to apply the optimization techniques for practical applications | |
| **Module 1 Linear models** | | **Hours 12** |
| Introduction to optimisation ,classification of optimisation problems, linear programming, problem formulation, maximization and minimization problems, graphical method, simplex method, Big M, two phase method, duality in linear programming, dual simplex method, sensitivity analysis | | |
| **Module 2 Network models and Dynamic programming** | | **Hours 09** |
| Shortest path, maximum flow and minimum cost problems, dynamic programming: multistage decision processes, linear programming as a case of dynamic programming, application of dynamic programming in resource allocation, production scheduling. | | |
| **Module 3 Nonlinear programming-Unconstrained** | | **Hours 12** |
| Single variable optimization, region elimination methods, point estimation methods, gradient based methods, multivariable optimization, direct search methods and gradient search methods | | |
| **Module 4 Nonlinear programming-Constrained** | | **Hours 12** |
| Constrained optimization, Kuhn Tucker conditions, transformation methods, Lagrangian multiplier methods, penalty function methods, gradient projection method, Applications of non-linear programming in Engineering design | | |
| **Reference books** | 1. S.S.Rao , "Engineering Optimization", New Age International Publishers,Third edition,2013<br>2. Fletcher, "Optimization techniques", John Wiley and Sons.<br>3. K.V.Mittal, "Optimization Methods", Wiley Eastern, 2003.<br>4. H.A.Taha, "Operations Research", Pearson, 2007.<br>5. Kalyanmoy Deb, "Optimization for Engineering Design",PHI | |

| **Subject Code EE 523** | **Simulation and Modelling of Power Converters** | **Credits: 3 (3-0-0)** **Total hours:45** |
|---|---|---|
| **Course Objectives** | To study the basics of static and dynamic models of power electronic switches. And learn usage of the software tools like MATLAB, PSPICE & PSIM for various power electronic devices. Understand the different types of power electronic converters using the simulation tools. | |
| **Module 1** | | **Hours 12** |
| Computer simulation of continuous time dynamic systems using transfer function models: electromechanical, hydraulic and pneumatic systems. Introduction to simulation tools. | | |
| **Module 2** | | **Hours 12** |
| Solution of nonlinear equations, methods to the solution of electrical networks, general-purpose circuit simulators, introduction to machine modelling : induction, DC, and synchronous machines | | |
| **Module 3** | | **Hours 12** |
| Simulation and modelling of single phase and three-phase converters: rectifier, ac voltage controllers and inverters. Power electronic converters in power distribution systems, simulation and modelling of dc to dc converters | | |
| **Module 4** | | **Hours 9** |
| Interaction between power electronic converters and rotating machines | | |
| **Reference books** | 1. N. Mohan, T.M. UdelandandP. Robbins, "Power Electronics: Converters, Applications, and Design," J. Wiley, New York, 1994.<br>2. P.C. Krause, "Analysis of electric machinery", McGraw Hill, New York, 1986.<br>3. Louis G Birta and GilberArbez, “Modelling and Simulation(Exploring Dynamic System behavior)” Springer Verlag, 2007<br>4. M. B. Patil, V. Ramanarayanan, V. T. Ranganathan “Simulation of Power Electronic Circuits”, Narosa publications<br>5. Muhammad H. Rashid, Hasan M. Rashid “Spice for Power Electronics and Electric Power”, 2nd Edition, Taylor & Francis | |

| **Subject Code EE 524** | **Poly-phase Systems and component Transformation** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | An overview of poly-phase circuits combined fault analysis and system working in unbalanced load conditions. | |
| **Module 1** | | **Hours 10** |
| Balanced poly phase circuits: generation of poly phase voltages, phase sequence, three phase 3 wire and 4 wire systems, wye and delta connections, the n-phase star and mesh, power calculations in balanced systems, general n-wire balanced systems, harmonics in wye and delta systems. | | |
| **Module 2** | | **Hours 10** |
| Unbalanced poly phase circuits**:** unbalanced loads, wye-wye system with and without neutral connections, neutral shift, the wye-delta system, phase sequence effects, methods of checking voltage phase sequence, three wattmeter/two wattmeter methods of measuring three phase power, the use of (n,1) watt meters for measuring n-wire power, power factor in unbalanced three phase systems, extensions to non-sinusoidal behaviour. | | |
| **Module 3** | | **Hours 08** |
| Introduction to symmetrical components: A brief historical review, fundamental principles, symmetrical component systems, resolution of three vectors into symmetrical components, independence of sequences in symmetrical systems, sequence impedances. | | |
| **Module 4** | | **Hours 10** |
| Calculation of unbalanced faults: sequence networks, connection of networks to represent faults, outline of short circuit calculations, analysis of transformer connections, measurement of sequence voltages and currents,measurement of sequence power quantities, flow of power due to unbalance. | | |
| **Module 5** | | **Hours 07** |
| Multiphase systems: resolution of multiphase systems into symmetrical components, 2-phase and 4-phase systems, Irregular systems, analysis of poly phase circuits, Impedances of symmetrical poly phase systems, Harmonics. | | |
| **Reference books** | 1. C.F. Wagner, R.D. Evans, "Symmetrical Components", McGraw,Hill, 1933.<br>2. J.L. Blackburn, "Symmetrical Components for Power System Engineering", Marcel,Dekker ,1993.<br>3. Edith Clarke, "Circuit Analysis of AC Power Systems – Volumes I and II", John Wiley and Sons, 1950. | |

| **Subject Code EE 525** | **Power system Dynamics** | **Credits: 3 (3-0-0)** **Total hours: 45** |
|---|---|---|
| **Course Objectives** | To investigate and understand the stability of power system, with the main focus on stability theories and power system modelling. To study the steady and transient stability problems. To examine the power system modelling using simulation tools. | |
| **Module 1** | | **Hours 10** |
| Modelling: Dynamic modelling requirements, angle stability, equal area criterion, critical fault clearing time and angle, numerical integration techniques. | | |
| **Module 2** | | **Hours 10** |
| Synchronous machines: Park's transformation, flux linkage equations, formulation of normalized equations, state space current model, simplified models of the synchronous machine ,turbine, generator, steady state equations and phasor diagrams. | | |
| **Module 3** | | **Hours 10** |
| Dynamics of Synchronous machines: Mechanical relationships and electrical transient relationships, adjustment of machine models, Park's equation in the operational form. | | |
| **Module 4** | | **Hours 08** |
| Dynamics of Induction machines: Induction motor equivalent circuits and parameters, free acceleration characteristics, dynamic performance, effect of three phase short circuit and unbalanced faults. | | |
| **Module 5** | | **Hours 07** |
| Stability: Transient and dynamic stability, linear model of unregulated synchronous machine and its oscillation modes, distribution of power impacts, effects of excitation on stability, supplementary stabilization signals. | | |
| **Reference books** | 1. Elgerd, O.I., "Electric Energy Systems Theory", TMH, New Delhi, 2nd edition ,1991 .<br>2. Anderson, P.M. and Fouad, A.A., "Power System Control and Stability", Galgotia Publ., New Delhi, 2003.<br>3. Krause, P.C, "Analysis of Electric Machinery" McGraw,Hill International Editions, 2000.<br>4. K.R. Padiyar, "Power System Stability and Control", Interline, 1996.<br>5. PrabhaKundur, "Power System Stability and Control", TMH, 1994. | |

| **Subject Code EE 526** | **Advanced Power Electronics** | **Credits: 3 (3-0-0) Total hours: 45** |
|---|---|---|
| **Course Objectives** | Understand the concept of resonant switch converters, multilevel inverters, pulse width modulation techniques and inductor design. | |

| **Module 1** | **Hours 15** |
|---|---|
| DC-DC converters: Basic topologies of buck, boost, buck-boost converters, Cuk, flyback, forward, push-pull, half bridge, full bridge & isolated Cuk converters, input & output filter design, zero voltage and zero current switching, classification of resonant converters, basic resonant circuit concepts, types of resonant converters, converter transfer functions, applications. | |
| **Module 2** | **Hours 10** |
| Design concepts : Design of inductors, transformers, selection of core, core loss, copper loss, and skin effect proximity effect, design of capacitors, selection of capacitors for different applications, power semiconductor selection and its drive circuit design, controller design, stability considerations. | |
| **Module 3** | **Hours 12** |
| Inverters: Single phase half and full bridge inverters, voltage control of single phase inverters using various PWM techniques, three phase voltage source inverters, $180^0$ and $120^0$ mode of operation, selective harmonic elimination, sinusoidal and space vector modulation PWM techniques, . | |
| **Module 4** | **Hours 08** |
| Multilevel Inverters: Introduction, multilevel concept, diode clamped, flying capacitor, H-bridge, cascaded multilevel inverters, applications. | |

| **Reference books** | 1. Ned Mohan, et.al, "Power Electronics converters, Applications and Design", Wiley India, New Delhi, 3rd, Edition 2003<br>2. M.H. Rashid, Power Electronics - Circuits, Devices and Applications, PHI, 2002. |
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