Course Syllabi
Department of Electrical Engineering

EEL101 ELEMENTARY ELECTRICAL ENGINEERING (3-0-2-4)

Pre-requisite: NIL

Contents:

Electrical circuit, circuit elements resistance, inductance & capacitance, Kirchhoff's laws, voltage source & current source, superposition theorem, thevenin's theorem, norton's theorem, duality, star-delta transformation.

AC circuits, periodic function, average & r.m.s. values, steady state behavior with sinusoidal excitation, phase representation, reactance & impedance, power and power factor, series & parallel circuit, resonance and quality factor, principle of generation of single phase & three phase voltages, power in balanced three phase ac system.

Power systems: elementary idea about bulk power generation, long distance transmission and distribution, industrial and residential distribution, safety & legal standards.

Magnetic circuit, flux, mmf, reluctance, analogy with electric circuits. Simple calculations for composite magnetic circuits.

Measurement of electrical current, voltage and energy in ac & dc systems.

Transformer: introduction, basic principles, construction, phasor diagram for transformer under no load condition, transformer on load, balance of mmf on both sides, phasor diagram, equivalent circuit, open circuit & short circuit test.

Electric Machines:

a) DC shunt and series motor – construction, principle of working and applications, need of starters, torque and speed control.
b) Induction motors – construction, principle of working of single phase and 3-phase motors, torque-slip characteristics.

Practical: Practicals as per course contents.

Text Books:

1. Hughes, E., Electrical and Electronics Technology, 10th ed., Pearson Education, 2013.
2. Kulshreshtha, D.C., Basic Electrical Engineering, Tata McGraw Hill, 2013.

Additional Books:

1. Toro, V.D., Electrical Engineering Fundamentals, 2nd ed., Prentice Hall of India, 2012.
2. Kothari D.P., Nagrath I.J, Theory and Problems of Basic Electrical Engineering, Prentice Hall India 2011.

EEL 202 BASIC ELECTRICAL CIRCUITS (3-0-2-4)

Pre-requisites: EEL101 ELEMENTARY ELECTRICAL ENGINEERING

Contents:

Classification of elements of an electrical circuit, Resistors, Inductors, Capacitors, Controlled sources, Diodes and ideal transformers. Basic circuit analysis methods nodal, Mesh and modified nodal-analysis. Transient analysis of RL, RC and RLC circuits.

Network theorems: Tellegen's theorem, Superposition theorem, Thevenin theorem, Norton theorem, Substitution theorem, Reciprocity theorem, Maximum power transfer theorem, Network analysis methods, Poly-phase circuits. Circuits transformers, Laplace transforms and their adaptation to networks. Two port networks, Two-port parameters, Interconnection of two ports and their effect on the parameters. Tellegen's generalized reciprocity theorem, Multiport and multiterminal networks, Their representations and interconnections.

Pole-zero concept, network synthesis: Hurwitz polynomial, Properties of Hurwitz polynomial, Positive real functions and their properties, Concepts of network synthesis, Realization of simple R-L, R-C and L-C functions in Cauer-I, Cauer-II, Foster-I and Foster-II forms.

Practical: Practicals as per course contents.

Text Books:

1. Hayt, W.H. and Kemmerley, J.E. and Durbin, S.N., Engineering Circuit Analysis, 7th ed., McGraw Hill, 2013.
2. Choudhury, D.R., Networks and Systems, 2nd ed., New Age Publication, 2014.

Additional Books:

1. Murthy, K.V.V.and Kamath M.S, Basic Circuit Analysis, 8th ed., Jaico Publishing House, 2010
2. Valkenburg, M. E. Van, Network Analysis, 3rd Ed. Prentice Hall India, 2011.

EEL203 ELECTRICAL MACHINE (3-0-2-4)

Pre-requisite: NIL

Contents:

DC Machines: Concept of induced emf, Armature winding and field winding, mmf of armature and field winding.

DC Motor: Basic principle and operation, classification, torque, power, losses and efficiency, characteristics.

DC Generator: emf equation, shunt and compound generator, characteristics & applications.

Three Phase Transformer: connection and phasor groups, effect of phase sequence, inrush current & harmonics, tertiary winding, open delta connection, Scott connection, applications.

Three Phase Induction Motor: principle and operation, types of motors, starting against load, star delta starter, soft starting, matching with load torque-speed characteristics, determination of equivalent circuit parameter, motor faults, single phasing & protection.

Single Phase Induction Motor: principle and two phase operation, types, equivalent circuit, characteristics, motors for special operation.

Three phase Alternator: constructional features of cylindrical and salient pole rotor machines, steady state operation of three phase synchronous generators, phasor diagram, regulation & efficiency, parallel operation, transient & sub transient reactances and their measurement, short circuit fault currents. Effects of variable excitation and mechanical power input on generator operation.

Three phase Synchronous Motor: methods of starting, performance and leading power factor operation due to effect of variable excitation and load on motor operation.

Practical: Practicals as per course contents.

Text Books:

1. Fitzgerald, A.E., Kingsley, C. and Umans, S.D., Electric Machinery,6th ed., Tata McGraw Hill, 2014
2. Bhattacharya, S.K., Electrical Machines, 3rd ed., McGraw Hill Education (India) Private Limited, 2013.

Additional Books:

1. Bhimbhra, P.S., Electrical Machinery, Khanna Publishers, Delhi, 2003.
2. Nagrath, I. J. and Kothari, D. P., Electric Machines, Tata McGraw Hill, 2006.
3. Toro, V.D., Electric Machines and Power Systems, Prentice Hall, 1985.

EEL 204 NETWORK THEORY (3-2-0-4)

Pre-requisite: NIL

Contents:

Graphs: paths, connectedness, circuits, cutsets, trees, matrix representation of directed graphs, incidence, cutset and circuit matrices, methods of analysis of linear networks, nodal, cutset, mesh and loop analysis.

Trigonometric and exponential Fourier series, discrete spectra and symmetry of waveform, steady state response of a network to non-sinusoidal periodic inputs, power factor, effective values, Fourier transform and continuous spectra, three phase unbalance circuit and power calculation. Frequency domain approaches to electrical networks.

Driving points and transfer functions poles and zeros of immittance function, their properties, sinusoidal response from pole-zero locations, convolution theorem and integral solutions.

Elements of Filter Theory: introduction, classification of filters, introduction of windows, butter worth filter challenge filter equation of ideal filter, image parameters and characteristics impedance, passive and active filter of various filter, low pass, high pass, constant K type, M derived filters and their design.

Transmission line parameters and performance, operation for maximum power transfer, characteristic impedance.

Text Books:

1. Hayt, W.H. and Kemmerley, J.E. and Durbin, S.N., Engineering Circuit Analysis, 7th ed., McGraw Hill, 2013.
2. Choudhury, D.R., Networks and Systems, 2nd ed., New Age Publication, 2014.

Additional Books:

1. Chua , L.O., Desoer, C.A. and Kuh, E.S., Linear and Nonlinear Circuits, McGraw Hill, 1991
2. Murthy, K.V.V. and Kamath M.S, Basic Circuit Analysis, 8th ed., Jaico Publishing House, 2010
3. Valkenburg, M. E.V., Network Analysis, 3rd ed., Prentice Hall of India, 2011.

EEL 205 MEASUREMENT & INSTRUMENTATION (3-0-2-4)

Pre-requisite: NIL

Contents:

Classification of measuring instruments, comparison of analog and digital instruments, advantages of digital instruments, classification of analog instruments, absolute and secondary instruments, indicating type, recording type and integrating type instruments, loading effect of instruments.

Measurement of resistance: classification, measurement of low resistance by Kelvins' double bridge, measurement of medium resistance by voltmeter-ammeter method, Wheatstone bridge. Measurement of high resistance by Ohmmeter, Megger and loss of charge method, general theory of AC bridges, study of Maxwell, Hay's, Owen's, De Sauty's, Wien and Schering bridges, detectors for AC bridges.
Principles and use of D.C. potentiometer for calibration purposes, principle and applications of A.C. potentiometer. ammeter, voltmeter, principles of moving coil, moving iron and dynamometer type instruments, extension of range using series and shunts, error due to extension of range, digital voltmeter : types of DVM, integrating type DVM.
Measurement of active and reactive power in polyphase circuits using dynamometer type instruments, measurement of energy in single and polyphase circuits using induction type instruments. Errors in power and energy measurements, class of accuracy, maximum demand indicator, trivector meter.
General theory of extension of range using CT and PT, errors in instrument transformers, applications of instrument transformers. Special instruments: power factor meter, frequency meter, synchroscope, rectifier type instrument, measurement of non-electrical quantities, digital frequency meter.
Practical: Practicals as per course contents.

Text Books:

1. Sawhney, A.K., A Course in Electrical and Electronics Measurements and Instrumentation, Dhanpat Rai and Sons, 2013
2. Cooper, W.D. and Helfrick, A.D.,Modern Electronic Instrumentation and Measurement Techniques, 3rd ed., PHI Learning Private Limited, 2012

Additional Book:

1. Golding, E. W. andWiddis, F. C., Electrical Measurements and Measuring Instruments, 5th ed.,Wheeler Publishing, New Delhi,, 1998.

EEL301 POWER SYSTEM (3-2-0-4)

Pre-requisites: EEL101 ELEMENTARY ELECTRICAL ENGINEERING, EEL202 BASIC ELECTRICAL CIRCUIT

Contents:

General structure of electrical power system. Basic concept of inductance and capacitance of transmission lines. Per unit system and single line diagram representation.
Models of short, Medium, Long transmission lines. A, B, C, D parameters. Introduction to load flow analysis, Y bus formation, Types of overhead line insulators, String efficiency.
Voltage regulation , efficiency of short, medium, long transmission lines, Conductor Configuration, Spacings and Clearances, Sag and Tension Calculations, Erection Conditions, Factors affecting Sag.
Stability of power system: Introduction, Dynamics of synchronous machine.
Swing equation, Swing equation for multi machine system. Power angle equation, Steady state stability studies.
Transient stability studies: Swing curve, Equal area criterion for transient stability, Application of equal area criterion for different disturbances. Solution of swing equation point by point methods of improving transient stability.
Introduction of HVDC transmission, Line insulators, Power cables, Sag and tension, Corona and its effects.

Text Books:

1. Grainger, J.J., Stevenson, W.D., Power System Analysis, 22th ed., McGraw Hill Education (India) Private Limited, New Delhi, 2014.
2. Nagrath, I. J. andKothari, D.P., Power System Engineering, 2nd ed., Tata McGraw Hill Publications, 2013.

Additional Books:

1. Elgerd, O.I., Electric Energy Systems Theory: An Introduction, 2nd ed., Tata Mc-Graw Hill Education , 2012.
2. Saadat, H., Power System Analysis, 3rd ed., PSA Publishing, 2010.

EEL 302 CONTROL SYSTEM (3-0-2-4)

Pre-requisite: NIL

Contents:

Introduction to need for automation and automatic control. Use of feedback, broad spectrum of system application.
Mathematical modeling, differential equations, transfer functions, block diagram, signal flow graphs, application to elementary system simplifications, effect of feedback on parameter variation, disturbance signal servomechanisms and regulators.
Control system components, electrical, electromechanical, and other components. Their functional analysis and input output representation.
Time response of first order and second order system, standard inputs, concept of gain and time constants. Steady state error, type of control system, approximate methods for higher order system.
Root location and its effect on time response, elementary idea of root locus, effect of adding pole and zero and proximity of imaginary axis.
Stability of control systems, conditions of stability characteristic equation, Routh-Hurwitz criterion, special cases for determining relative stability.
Frequency response method of analyzing linear system, Nyquist and Bode plots, stability and accuracy analysis from frequency responses, open loop and close loop frequency response. Nyquist criterion, effect of variation of gain and addition of pole and zero on response plot, stability margins in frequency response.
State variable method of analysis, characteristic of system, state, choice of state representation of vector matrix differential equation standard form, relation between transfer function and state variable.
Practical: Practicals as per course contents.

Text Books:

1. Ogata, K., Modern Control Engineering,5th ed., Prentice Hall of India, 2012.
2. Nagrath, I.J. and Gopal, M., Control System Engineering, 5th ed., New Age International, 2012.

Additional Books:

1. Dorf R. C. and Bishop R. H., Modern Control Systems, 12th ed., Pearson Education, 2013.
2. D'Azzo J. J., Houpis, C.H. and Sheldon, S.N., Linear Control System Analysis and Design with MATLAB, 6th ed., CRC Press, 2014.
3. Kuo, B.C. and Golnaraghi F., Automatic Control Systems, 8th ed., Wiley India, 2011.
4. Nise, N.S., Control Systems Engineering, 6th ed., Wiley, 2013.
5. Gopal, M., Control Systems: Principles and Design, 3rd ed., Tata McGraw Hill Education, 2010.

EEL303 POWER ELECTRONICS (3-0-2-4)

Pre-requisite: NIL

Contents:

Power semiconductors devices and switching circuits: SCR and its characteristics, SCR ratings ,series and parallel operations of SCRs, Triggering circuits, commutating circuits, protection of SCR. Gate circuit protection, over voltage and over current protection, snubber circuit design, converter circuit faults and their protection, Uni-Junction Transistor (UJT), Self Commutating Device: characteristics and working of MOSFET. Gate turn off thyristor and insulated gate bipolar transistor.
AC to DC Converters: working of single pulse and two pulse converters. Three pulse midpoint converter and 3 phase six pulse bridge converter. Effect of source inductance in converters. Effect of freewheeling diode. Speed control of DC motor using converter.
DC to DC Converters: Classification, principles of step down chopper and step up chopper, Buck, Boost, Buck-Boost converter and application to low power circuits.
DC to AC Converters: Single phase and three phase bridge inverters, output voltage control, harmonics in output voltage waveform, harmonics attenuation by filters. Harmonic reduction by pulse width modulation techniques, analysis for single pulse width modulation, working of current source inverters, applications of inverters.
AC to AC Converters: Operation & analysis of single phase integral cycle and phase controlled converters, configuration of three phase controllers, Cycloconverters: Single phase and three phase configurations and operating principle, AC voltage controller Introduction of matrix converter.
Practical: Practicals as per course contents.

Text Books:

1. Mohan, Ned, Undeland, T.M. and Robbins, W.P., Power Electronics, 3rd ed., Wiley India, 2014
2. Rashid, M.H., Power Electronics: Circuits Devices & Applications, 3rd ed., Pearson Education, 2012.

Additional Books:

1. Singh, M.D. and Khanchandani K.B., Power Electronics, 2nd ed., Tata McGraw Hill Education, 2012.
2. Bose, B.K., Modern Power Electronics and AC Drives, PHI Learning, New Delhi, 2012.
3. Lander, C.W., Power Electronics, 3rd ed., McGraw Hill, 1993.
4. Bimbhra, P.S., Power Electronics, Khanna Publishers, 2012.
5. Dubey, G.K., Fundamentals of Electrical Drives, 2nd ed., Narosa Publication, 2013.

EEL304 SWITCHED MODE POWER CONVERTERS (3-2-0-4)

Pre-requisite: NIL

Contents:

The ideal switch; basic switch cell; basic topology rules; possible basic converter topologies: buck, boost, buck-boost; steady-state analysis; dc transformer equivalent.
Switch characteristics of common switches: Power Diodes, SCRs, Power BJTs, GTOs, Power MOSFETs, IGBTs; conduction and switching loss; V-I plane representation of switches; switch realization from basic switch cell; drive requirements for switches; drive circuits; switching aid networks; designing with real switches: switch selection, loss calculation, basics of thermal design.

Effect of non-idealities on converter performance, efficiency, steady-state voltage gain; state space averaging; basics of small signal analysis; ac equivalent circuit.
Control of converters; voltage mode control; review of bode plots; design of converter controls.
Resonant Converters; Parallel loaded and series loaded resonant converters; transfer characteristics; design.
Inverters; basic two-level inverters: topology derivation and switching schemes; PWM methods: sine-triangle and space-phasor methods.
Multi-level inverters: basic topology derivation and introduction to PWM schemes for multi-level inverters.

Text Books:

1. Mohan, Ned, Undeland, T.M. and Robbins, W.P., Power Electronics, 3rd ed., Wiley India, 2014.
2. Vithayathil, J., Power Electronics: Principles and Applications, Tata Mc Graw Hill, 2013.

Additional Book:

1. Ericksson, R., and Maksimovic D., Fundamentals of Power Electronics, 2nd ed., Springer, 2013.

EEL305 SOFT COMPUTING TECHNIQUES (3-0-2-4)

Pre-requisite: NIL

Contents:

Introduction, brief history of artificial intelligence, comparison with deterministic methods, aims, objectives of artificial intelligence and current state of the art.
Expert systems: introduction to knowledge based systems structure and definitions knowledge acquisition inference engine, forward and backward chaining.
Fuzzy logic: introduction to concepts, fuzzy reasoning, defuzzification, adaptive fuzzy systems.
Artificial neural networks: basic concepts, back-propagation, multi-layer networks, introduction to various paradigms, learning in neural networks.
Evolutionary computing (Genetic algorithms): basic concepts, applications of AI to power systems like alarm processing, condition monitoring, protective relaying etc.
Genetic algorithms and variants, Differential evolution, Particle swarm optimization (PSO) and variants, Bacterial foraging optimization (BFO), Ant colony optimization - travelling salesman problem, cat swarm optimization.
Practical: Practicals as per course contents.

Text Books:

1. Zurada, J.M., Introduction to Artificial Neural Systems, Jaico Publication House, 2006.
2. Haykin, S.S., Neural Networks and Learning Machines, 3rd ed., PHI Learning, 2013.

Additional Books:

1. Deb, K., Multi-Objective Optimization Using Evolutionary Algorithms, John Wiley and Sons, 2009.
2. Hagan, M.T., Demuth, H.B. and Beale, M.H., Neural Network Design, Vikas Publishing House, New Delhi, 2004.

EEL306 POWER QUALITY ISSUES AND SOLUTIONS (3-0-0-3)

Pre-requisite: NIL

Contents:

Power System Components: single line diagram of power system.
Transmission Lines: configurations, types of conductors, resistance of line, skin effect, Kelvin's law, proximity effect.
Voltage Sags and Interruptions: sources of sags and interruptions, end user issues, Ferro resonant transformer, on-line UPS, hybrid UPS, motor generator set, SMES etc., motor starting sags, utility system fault clearing issues.
Transient over Voltage: sources of transient over voltages, principles of over voltage protection, devices for over voltage protection, utility capacitor switching transients, utility lightning protection, load-switching transient problems.
Harmonics: voltage and current harmonics distortions, harmonics of single-phase power supplies, effects of harmonics distortion, system response characteristics, locating sources of harmonics, peripherals for controlling harmonics, devices for filtering harmonics distortion, harmonics study procedure, symmetrical components, modeling harmonics sources, harmonic filter design, telecommunication interferences, computer tools for harmonic analysis.

Text Books:

1. Kennedy, B.W., Power Quality Primer,Mc-Graw Hill, 2000.
2. Dugan, R.C. and et.al.,Electrical Power Systems Quality, 3rd ed., Tata McGraw Hill, 2012.

Additional Book:

1. Kazibwe, W.E. and Sendaula, M.H., Electric Power Quality Control Techniques, Van Nostrand Reinhold, 1993.

EEL 307 ELECTRICAL AND INDUSTRIAL SAFETY (3-0-0-3)

Pre-requisites: EEL203 ELECTRICAL MACHINES, EEL301 POWER SYSTEM

Contents:

Review of electrical concept, Working principle of major electrical equipment, Typical supply situation, Standards and statutory requirements, Indian electricity acts and rules, Indian boiler acts and regulations statutory requirements from electrical inspectorate. International standards of electrical safety, First aid-cardiopulmonary resuscitation (CPR).
Electrical hazards, Effect of electrical shock of human being, Effect of lightening current on installation and buildings, Energy leakage, Clearance and insulation, Excess energy, Current, Surges, Electrical causes of fire and explosion,
Importance of earthing in installation. Safety of transmission lines, substations, Transformer, circuit breakers and power control drives. National electrical safety code. General safety rules, Principles, Maintenance, Inspections.

Text Books:

1. Krishnan, N.V., Safety Management in Industry, Jaico Publishing House, 1997.
2. Cooper W.F., Electrical Safety Engineering,3rd ed., Newnes, 2002.

Additional Books:

1. Cadick, J., et. al., Electrical Safety Handbook, 4thed, McGraw Hill, 2013.
2. Bureau of Indian Standards, National Electrical Code 2011, Bureau of Indian Standards, New Delhi, 2011.
3. Manchanda, S.C., Manchanda's the Indian Boilers Regulations, 1950 and the Indian Boilers Act, 1923 (Act No. V of 1923), 2nd ed., Delhi Law House, Delhi, 2009.

EEL 308 INDUSTRIAL INSTRUMENTATION (3-0-2-4)

Pre-requisite: NIL

Contents:

Measurement of force torque, velocity: Electric balance, different types of load cells, magnets, elastics load cell, strain gauge load cell, different methods of torque measurement, strain gauge, relative regular twist, speed measurement, revaluation counter, capacitive tacho-drag up type tacho D.C and A.C tacho generators, stroboscope.

Measurement of acceleration, vibration and density : Accelerometers, LVDT, piezo-electric, strain gauge and variable reluctance type accelerometers, mechanical type vibration instruments, seismic instrument as an accelerometer and vibrometer, calibration of vibration pickups, units of density, specific gravity and viscosity used in industries, Baume scale API scale, pressure head type densitometer, float type densitometer, ultrasonic densitometer Bridge type gas densitometer.

Pressure measurement: Units of pressure, manometers, different types, elastic type pressure gauges, Bourde type bellows, diaphragms, Electrical methods, elastic elements with LVDT and strain gauges, capacitive type pressure gauge, piezo resistive pressure sensor, resonator pressure sensor, measurement of vacuum, McLeod gauge, thermal conductivity gauges, Ionization gauge cold cathode and hot cathode types, testing and calibration of pressure gauges, dead weight tester.

Temperature measurement: Definitions and standards, primary and secondary fixed points, calibration of thermometers different types of filled in system thermometer, sources of errors in filled in systems and their compensation, Bimetallic thermometers, Electrical methods of temperature measurement signal conditioning of industrial RTDs and their characteristics, 3 lead and 4 lead RTDs.

Thermocouples and pyrometers: Thermocouples, law of thermocouple, fabrication of industrial thermocouples, signal conditioning of thermocouple output, thermal block references functions, commercial circuits for cold junction compensation, response of thermocouple, special techniques for measuring high temperature using thermocouples, Radiation methods of temperature measurement, radiation fundamentals, total radiation and selective radiation pyrometers, optical pyrometer, two colour radiation pyrometer.
Introduction to Sequence Control, PLCs and Relay Ladder Logic
Practical: Practicals as per course contents.

Text Books:

1. Doebelin, E.O. and Dhanesh, N.M, Measurement Systems,6th ed., Tata McGraw Hill Education Private Limited, 2012.
2. Krishnaswamy, K. and Vijayachitra, S., Industrial Instrumentation, 2nd ed.,New Age International Publication, 2013.

Additional Books:

1. Rangan, C.S., Sarma, G.R. and Mani, V.S.V., Instrumentation: Devices and Systems, 2nd ed., Tata McGraw Hill, 1997.

2. Cooper, W.D. and Helfrick, A.D., Modern Electronic Instrumentation and Measurement Techniques, 3rd ed., PHI Learning Private Limited, 2012.

EEL309 ELECTRIC DRIVES (3-0-2-4)

Pre-requisite: NIL

Contents:

Definitions, classification and speed torque characteristics of common industrial loads & drive motors and their characteristics under starting, running, braking and speed control.

Rating & service Capacity: selection of motor, power capacity for continuous and intermittent periodic duties, load equalization: flywheel effect, speed-time relations.

Programmable logic controllers: basic construction, operation block diagram arrangement, its elementary programming and applications in electric drives.

AC and DC contactors and relays: magnetic structure, operation, arc interruption contactor rating, H.V. contactors, control circuits for automatic starting and braking of DC motor and three phase induction motor, control panel design.

Traction Motors: motor used in AC/DC traction, their performance and desirable characteristics, requirements and suitability of motor for traction duty. Control of D.C. traction motor, series parallel control. Starting and braking of traction motor.

Practical: Practicals as per course contents.

Text Books:

1. Dubey, G.K., Fundamentals of Electrical Drives, 2nd ed., Narosa Publication, 2013.
2. Partab H., Modern Electrical Traction; Dhanpat Rai and Co. Pvt. Ltd, 2014.

Additional Books:

1. Subrahmanyam, V., Electric Drives: Concepts and Applications, 2nd ed., Tata McGraw Hill Education, New Delhi, 2011.
2. Soni, M.L., Gupta, P.V. and Bhatnagar, U.S., A Course in Electrical Power, Dhanpat Rai & Sons, New Delhi, 1987.

EEL 310 CONTROL SYSTEM DESIGN (3-2-0-4)

Pre-requisite: NIL

Contents:

Introduction to design: state-space models, performance measures like ISE, ITAE, quadratic indices, controllability and observability. Linear Quadratic Regulator (LQR), performance index, optimal control law, algebraic riccati equation, frequency-domain interpretation. Linear Quadratic Gaussian (LQG): statistical descriptions of noise, Kalman filter, stability margins. H design, uncertainty descriptions, robustness measures, formulation for control-synthesis, riccati equation, and model-order reduction. Case studies, inverted pendulum, missile guidance, process control. Software based design of industrial controllers.

Text Books:

1. Dorf, R.C., Modern Control System, 11th ed., Pearson Education, 2013.
2. Nise, N., Control System Engineering, 6th ed., John Wiley & Sons, 2013.

Additional Books:

1. Anderson, B.D.O. and Moore, J.B., Optimal Control: Linear Quadratic Methods, Dover Publications, 2007
2. Friedland, B., Control System Design: An Introduction to State-Space Methods, Dover Publications, 2012
3. Doyle, J.C., Francis, B.A. and Tannenbaum, A.R., Feedback Control Theory, Dover Publications, 2009

EEL 312 ELECTRICAL ENERGY SYSTEM (3-0-0-3)

Pre-requisite: NIL

Contents:

Introduction, Fossil fuel based systems, Impact of fossil fuel based systems, Non-conventional energy, seasonal variations and availability, Renewable energy, sources and features, Hybrid energy systems, distributed energy systems and dispersed generation (DG)

Solar thermal systems: Solar radiation spectrum, Radiation measurement, Technologies, Applications, Heating, Cooling, Drying, Distillation, Power generation.

Solar Photovoltaic systems: Operating principle, Photovoltaic cell concepts, Cell, module, array, Series and parallel connections, Maximum power point tracking, Applications, Battery charging, Pumping, Lighting, Peltier cooling.

Microhydel: Operating principle, Components of a microhydel power plant, Types and characteristics of turbines, Selection and modification, Load balancing.

Wind: Wind patterns and wind data, Site selection, Types of wind mills, Characteristics of wind generators, Load matching.

Hybrid Systems: Need for Hybrid Systems, Range and type of Hybrid systems, Case studies of Diesel-PV, Wind-PV, Microhydel-PV, electric and hybrid electric vehicles.

Tariffs and cost of energy under regulated and de-regulated environment, Energy audit and its methodologies.

Text Books:

1. Rai, G.D., Non-Conventional Energy Sources, 5th ed., New Age International, 2013.
2. Ramesh, R., Renewable Energy Technologies: Ocean Thermal Energy Conversion and other Sustainable Energy Options, Narosa, New Delhi,1997.

Additional Book:

1. Vanek, F.M., Albright, L.D. and Angenent, L.T., Energy Systems Engineering: Evaluation and Implementation, 2nd ed., Tata McGraw Hill, 2012.

EEL 313 ELECTRICAL DISTRIBUTION SYSTEM (3-0-0-3)

Pre-requisites: EEL301 POWER SYSTEM (3-2-0-8)

Contents:

General concepts: Introduction to distribution systems, Load modeling and characteristics. Coincidence factor, Contribution factor loss factor-relationship between the load factor and loss factor. Classification of loads (Residential, Commercial, Agricultural and industrial) and their characteristics.

Distribution feeders: Design consideration of distribution feeders: Radial and loop types of primary feeders, Voltage levels, Feeder loading; Basic design practice of the secondary distribution system. Substations: location of substation, Rating of distribution substation, Service area within primary feeders. Benefits derived through optimal location of substations.

Underground Cables :Introduction, Insulation, Sheath, Armour and Covering, Classification of Cables, Pressurized Cables, Effective Conductor Resistance, Conductor Inductive Reactance, Parameters of Single Core Cables, Grading of Cables, Capacitance of Three Core Belted Cable, Breakdown of Cables, Cable Installation, Current Rating of Cables, System Operating Problems with Underground Cables, HVDC Cables.

System Analysis: Voltage drop and power-loss calculations, Derivation for voltage drop and power loss in lines, Manual methods of solution for radial networks, Three phase balanced primary lines.

Protection: Objectives of distribution system protection, Types of common faults and procedure for fault calculations. Protective devices: Principle of operation off uses, Circuit re-closures, Line sectionalizes, and Circuit breakers.

Coordination: Coordination of protective devices: General coordination procedure. Compensation for power factor improvement, Capacitive compensation for power-factor control. Different types of power capacitors, Shunt and series capacitors, Effect of shunt capacitors (fixed and switched), Power factor correction, Capacitor allocation-economic justification, Procedure to determine the best capacitor location.

Voltage control: Equipment for voltage control, Effect of series capacitors, Effect of AVB/AVR, Line drop compensation.

Text Books:

1. Gonen, T., Electric Power Distribution System Engineering, 3rd ed.,CRC Press 2014.
2. Pabla, A.S., Electric Power Distribution, 6th ed., Tata McGraw Hill, 2012.

Additional Books:

1. Sivanagaraju, S. and Sankar, V., Electrical Power Distribution and Automation, Dhanpat Rai & Co, 2006.
2. Kamaraju, V., Electrical Power Distribution Systems, Tata McGraw Hill Education, New Delhi, 2011.

EEL314 HIGH VOLTAGE ENGINEERING (3-0-0-3)

Pre-requisite: NIL

Contents:

Levels of high voltage, votage levels, electrical insulation and dielectrics, importance of electric field intensity in the dielectrics, types of electric fields and degree of uniformity of fields, utilization of dielectric properties and stress control.

Properties of atmospheric air, SF6 and vacuum, relate dionization process, properties in vacuum, related ionization process, development of electron Avalanche, breakdown mechanisms, Townsend's mechanism, breakdown mechanisms, streamer mechanism, breakdown in uniform fields (Paschen's law), breakdown of gaseous dielectrics in weakly non-uniform and the limiting value of Î, development of PB in extremely non-uniform fields, breakdown characteristics in air with stable PB (corona).

Classification and properties of liquid dielectrics, classification and properties of solid dielectrics, classification and properties of liquid dielectrics, classification and properties of solid dielectrics, insulation resistance, conductivity and losses in dielectrics, partial breakdown phenomenon in dielectrics, partial breakdown phenomenon on the surfaces of solid and liquid dielectrics and degradation due to PB.

Definition and measurements of intrinsic and practical breakdown strengths of liquid dielectrics, measurement of intrinsic breakdown in solid dielectrics, thermal and other breakdown mechanisms in extremely non-uniform fields, comparison of the development of breakdown in extremely and weakly non-uniform fields and the requirement of time for breakdown in solid dielectrics.

methods of generation of power frequency high test voltage, transformers in cascade, resonance transformers, g generation of high DC voltage, voltage multiplier circuits and ripple minimization, sources of overvoltages and standard lightning and switching wave shapes, impulse voltage generator, analysis of single stage circuit, multistage impulse generator and their triggering methods.
Peak high voltage measurement techniques, sphere gap, construction, effects of earthed objects and atmospheric conditions, electrostatic voltmeters, principle and construction.
Potential dividers, their types and applications.
Measurable properties of dielectrics, measurement of dielectric properties with Schering bridge and Mega ohm meter, partial breakdown (PB), measurement techniques in dielectrics/ equipment. Over voltages and basic insulation level design systems.

Text Book:

1. Naidu, M. S. and Kamaraju, V., High Voltage Engineering, 4th edition, Tata McGraw-Hill, New Delhi, 2008.

Additional Books:

1. Kuffel J., Kuffel E., and Zaengl W. S., High Voltage Engineering fundamentals, 2nd edition, Newness (Oxford, Boston), 2000.
2. Abdel-salam M., Anis H. and, Abdel-salamani, High Voltage Engineering: Theory and Practice, 2nd edition, CRC Press, 2001.
3. Ray S., An introduction to High Voltage Engineering, Prentice Hall, New Delhi, India, 2004

EEL315 ELECTRICAL UTILIZATION & TRACTION (3-0-0-3)

Pre-requisite: NIL

Contents:

Electric Traction: features of an ideal traction system, systems of electric traction, mechanism of train movement, speed-time curve, traction supply system, transmission line to substation, feeding and distributing system on an ac traction, system of current collection,traction motors, tractive effort and horse power, speed control schemes, electric braking.
Electric heating: classification, heating element, losses in oven and efficiency, resistance furnace, radiant heating, induction heating, high frequency eddy current heating, dielectric heating, arc furnace, heating of buildings.
Electric welding: methods and equipment, electrolysis and electroplating applications.
Illumination: radiant energy,terms and definitions, laws of illumination, polar curves, photometry, MSCP, integrating sphere, luminous efficacy, electrical lamps, design of interior and exterior lighting systems, illumination levels for various purposes, light fittings, factory lighting, flood lighting, street lighting, energy conservation in lighting.
Air conditioning and refrigeration: control of temperature, protection of motors, simple heat load and motor calculations. Air-conditioning, function of complete air conditioning system, type of compressor motor. Cool storage, estimation of tonnage capacity and motor power. Technology of electric and hybrid electric vehicles.

Text Books:

1. Openshaw, T.E., Utilisation of Electric Energy, Orient Longman, 2007.
2. G. C. Garg, "Utilization of Electric Power and Electric Traction" Khanna Publishers, 2004.

Additional Books:

1. Arrillaga, J., Liu, Y.H. and Watson, N.R., Flexible Power Transmission: The HVDC Options, Wiley, 2007.
2. Gupta, J.B., Utilization of Electric Power and Electric Traction, S.K. Kataria and Sons, 2013.
3. S.L. Uppal & S. Rao, "Electrical Power Systems" Khanna Publishers, 2009.

EEL 401 SWITCHGEAR AND PROTECTION (3-0-2-4)

Pre-requisite: NIL

Contents:

Faults in Power Supply System: Symmetrical component transformation. Three phase power in unbalanced circuit in terms of symmetrical component. Sequence impedance of generator. Transformer transmission line & passive loads. Phase shift in Y/delta three phase transformer (Yd1, Yd11 connection). Symmetrical fault analysis without & with prefault load currents. Selection of circuit breakers ratings, current limiting reactors.
Unsymmetrical fault analysis L-G, L-L-G-, L-L, open conductors fault using symmetrical components.
General philosophy of protective relaying: protective zones. Primary protection, back up protection, remote and local back up, selectivity. Medium voltage line protection: overcurrent relaying directional over current relays.
High voltage line protection: Distance relays, carrier distance schemes. Unit carrier schemes.
Equipment protection: principles of differential relaying, protection of generator, transformers and busbars by differential relaying and other relays. Protection of induction motor's against overload, short-circuits, thermal release, miniature circuit breaker.
Introduction to numerical relays: Comparison of static and electro-mechanical relays, two input amplitude and phase comparators and their duality. Generation of various distance relay characteristics using above comparators.
Switchgear: circuit breakers, arc interruption theory, recovery and restriking voltages, RRRV, breaking of inductive and capacitive current, C.B. ratio, different media of arc interruption, SF6 and vacuum breakers.
Practical: Practicals as per course contents.

Text Books:

1. Ram, B. and Vishwakarma, D.N. Power System Protection & Switchgear,2nd ed., Tata McGraw Hill, 2013.
2. Paithankar, Y.G. and Bhide, S.R., Fundamentals of Power System Protection, 2nd ed., PHI Learning, 2013

Additional Books:

1. Elmore, W.A, Protective Relaying Theory and Applications, 2nd ed., MarcelDekker, New York, 2004.
2. Mason, C.R., Art and Science of Protective Relaying, Wiley, New York, 1968.
3. Warrington, A.R.V., Protective Relays: Their Theory and Practice (Vol. I & Vol. II), 3rd ed., Chapman and Hall, London, 1978.

EEL402 SPECIAL ELECTRICAL MACHINES DESIGN (2-0-2-3)

Pre-requisite: NIL

Contents:

Review of material used in construction of electrical machines. Classification of insulating materials depending upon permissible temperature rise, properties of transformer oil, standard specifications, C.M.R. and short time rating of machines. Heating and cooling characteristics.
Transformer design: Specific loading, equation for voltage per turn for power and distribution transformer output equation.
Principle of electric and magnetic circuits, design, method of cooling and cooling circuit design. Estimation of performance characteristics from the design data.
Inductor motor: main dimensions, output equation, loading constants, estimation of axial lengths, air gap diameter, winding design.
Air gap length, slot dimension for stator and rotor I.M., cage rotor and wound rotor design, calculation of no load current and other performance on characteristics for design data.
Synchronous machines: air gap length, methods of obtaining sinusoidal output voltage, field coil design for salient pole machine and for turbo generator rotor. Ventilation of synchronous generator, cooling air circuits, closed ventilation/quantity of cooling medium hydrogen and water as cooling media.
Practical: Practicals as per course contents.

Text Books:

1. Sawhney, A.K, Electrical Machine Design, Dhanpat Rai and Sons, Delhi, 2013.
2. Singh, B., Electrical Machine Design, Vikas Publishing House Private Limited, New Delhi, 1982

Additional Books:

1. Say, M.G., Performance and Design of AC Machines, 3rd ed., CBS Publishers and Distributors, 2008.
2. Pyrhonen, J., Jokinen, T. and Hrabovcova, V., Design of Rotating Electrical Machines, 2nd ed., Wiley, 2014.

EEL 403 OPTIMAL CONTROL THEORY (3-2-0-4)

Contents:

Basic mathematical concepts, conditions for optimality, static and dynamic optimization. Parameter optimization. Calculus of variations : problems of Lagrange. Mayer and Bolza. Euler-Language equation and transversality conditions, Lagrange's multipiliers. Pontryagin's maximum principle: theory, application to minimum time, energy and control effort problems, and terminal control problem. Dynamic programming : Belaman's principle of optimality, multistage decision processes. Application to optimal control. Linear regulator problem : matrix Riccati equation and its solution, tracking problem. Brief introduction to H-2 and H-infinity optimal control problem.

Text Books:

1. Kirk, D. E., Optimal Control Theory: An Introduction, Dover Publications 2004.
2. Kwakernaak, H. and Sivan, R., Linear Optimal Control Systems, Wiley-Interscience, 1972

Additional Books:

1. Anderson, B.D.O. and Moore, J.B., Optimal Control: Linear Quadratic Methods, Dover Publications, 2007.
2. Sage, A.P. and White, C.C., Optimum Systems Control, 2nd ed., PrenticeHall, 1977.
3. Tabak, D. and Kuo, B.C., Optimal Control by Mathematical Programming,Prentice Hall, 1971.

4. Athans, M. and Falb, P.L., Optimal Control: An Introduction to the Theory and its Applications, Dover Publications, 2007

EEL404 COMPUTER CONTROL AND AUTOMATION OF POWER SYSTEMS (3-0-0-3)

Pre-requisite: NIL

Contents:

Energy Management Systems (EMS): Energy Management Centers and Their Functions, Architectures, recent Developments. Characteristics of Power Generating Units and Economic Dispatch. Unit Commitment (Spinning Reserve, Thermal, Hydro and Fuel Constraints); Solution techniques of Unit Commitment. Generation Scheduling with Limited Energy. Energy Production Cost – Cost Models, Budgeting and Planning, Practical Considerations. Interchange Evaluation for Regional Operations, Types of Interchanges. Exchange Costing Techniques.

Supervisory Control and Data Acquisition (SCADA): Introduction to Supervisory Control and Data Acquisition. SCADA Functional requirements and Components. General features, Functions and Applications, Benefits. Configurations of SCADA, RTU (Remote Terminal Units) Connections. Power Systems SCADA and SCADA in Power System Automation. SCADA Communication requirements. SCADA Communication protocols: Past Present and Future. Structure of a SCADA Communications Protocol.

Text Books:

1. Wood, A. J., Wollenberg, B.F. and Sheble, G.B., Power Generation Operation and Control,3rd ed.,Wiley-Interscience, 2014.
2. Green J.N, Wilson, R,Control and Automation of Electric Power Distribution Systems,CRC Press, 2013

Additional Books:

1. Handschin E. and Petroianu, A., Energy Management Systems: Operationand Control of Electric Energy Transmission Systems, Springer Verlag, 1991.
2. Handschin, E., Real-Time Control of Electric Power Systems, Elsevier, 1972.
3. McDonald, J.D., Electric Power Substations Engineering, 3rd ed., CRC Press, 2012.

EEL 405 FACTS (3-0-0-3)

Pre-requisite: NIL

Contents:

Introduction of semiconductor devices, Need of FACTS, Steady state and dynamic problems in AC systems, Power flow, types of conductors in transmission line.

Flexible AC transmission systems (FACTS) : Basic realities & roles, types of facts controller, principles of series and shunt compensation. Thermal ratings.

Description of static VAR compensators (SVC), Thyristor controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC). IEEE standards. DVR: circuit operation and control.

modelling and analysis of FACTS controllers. Control strategies to improve system stability. Harmonics, harmonics creating loads, modeling, harmonic power flow, mitigation of harmonics, filters, passive filters.

location of FACTS devices, real life examples, BEP.

Text Books:

1. Hingorani, N. G. and Gyugi, L., Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press, Delhi, 2001.
2. Padiyar, K.R., FACTS Controllers in Power Transmission and Distribution, New Age International Publisher, 2013.

Additional Book:

1. Ghosh, A. and Ledwich, G., Power Quality Enhancement Using CustomPower Devices, Springer Verlag, 2012.

EEL 406 DISCRETE DATA AND DIGITAL CONTROL (3-2-0-4)

Pre-requisite: EEL302 CONTROL SYSTEM

Contents:

Sampling and data reconstruction processes: sampled, Data control systems, Ideal sampler, Sampling theorem, Sample and hold operations, Frequency domain considerations.

Z-transforms: Properties inverse, Applications to solution of difference equations, Convolution sums.

Stability of discrete systems: Location of poles, Jury's stability criterion, Stability analysis through bilinear transforms.

General procedures for obtaining pulse Transfer functions, Pulse Transfer function of open loop and closed loop systems, Dead beat controller, closed loop digital control systems with time delay systems.

Design of digital control systems: PID controllers and frequency domain compensation design.

State variable methods and the discrete linear regulator problem. Deadbeat observer, The Separation Principle, Reduced order observer, Root locus technique.

Text Books:

1. Ogata, K., Discrete Time Control System, 2nd ed., Prentice Hall of India, 2011.
2. Gopal, M., Digital Control Engineering and State Variable Methods: Conventional and Intelligent Control Systems, 4th ed., Tata McGrawHill,2012.

Additional Books:

1. Isermann, R., Digital Control Systems, 2nd ed., Springer, 1997.
2. Landau, Y.D. and Zito, G., Digital Control Systems: Design, Identification and Implementation, Springer, 2006

EEL407 POWER PLANT ENGINEERING (3-0-0-3)

Pre-requisite: NIL

Contents:

Conventional Sources of electrical energy : Steam, hydro, nuclear, diesel and gas, their scope and potentialities for energy conversion.

Generation : Different factors connected with a generating station, load curve, load duration curve, energy load curve, base load and peak load plants.

Thermal stations : Selection of site, size and no. of units, general layout, major parts, auxiliaries, generation costs of steam stations.

Hydro stations : Selection of site, mass curve, flow duration curve, hydrograph, classification of hydro plants, types of hydro turbines, pumped storage plants.

Nuclear stations : Main parts, location, principle of nuclear energy, types of nuclear reactors, reactor control, nuclear waste disposal.

Power station control and interconnection: Excitation systems, excitation control, automatic voltage regulator action, advantage of interconnection.

Economic operation of power system: introduction, distribution of load between units within the plant. Optimum generation scheduling considering transmission losses

Alternate energy sources: Solar, wind, geo-thermal, ocean-thermal, tidal wave, MHD and biomass.

Text Books:

1. Deshpande, M.V., Elements of Electrical Power Station Design, 5th ed.,PHI, 2013.
2. Gupta, B.R.,Generation of Electrical Energy,S. Chand, New Delhi, 2013.

Additional Books:

1. Nag, P.K., Power Plant Engineering, 3rd ed., Tata Mc-Graw Hill Education, 2013.
2. Raja, A.K., Srivastava, A.P. and Dwivedi, M., Power Plant Engineering,New Age International Private Limited, New Delhi, 2006.

EEL 409 PROCESS CONTROL & INSTRUMENTATION (3-0-2-4)

Pre-requisite: NIL

Contents:

An introduction to automatic process control, basic concepts and techniques, selection of controlled variables & manipulated variables, controller selection and tuning procedures, dynamic behavior of process model, special feedback techniques, direct synthesis and adaptive control, decoupling and feed-forward methods, various multiple loop feedback control strategies widely used in industries, such as cascade, ratio, split-range, selective, feed-forward compensation, sensors, transmitters, transducers and actuators, final control elements, selection of a controller's action and direction, basics of industrial automation systems: PLCs and Distributed Control Systems (DCS), their features and applications.

Types of processes: Dead time signal and multi-capacity, self and non-self-regulating , interaction and non-interaction, linear and non-linear, process gain , process reaction curve, process time constant and constant step analysis method for finding time constant, dead time, dynamic element in control loop, PID control of processes, tuning of PID controllers, basic idea of MPC.

Practical: Practicals as per course contents.

Text Books:

1. Shinskey, F.G., Process Control Systems: Application, Design and Tuning, 4th ed., McGraw Hill, 1996.
2. Chaudhuri, U.R. and Chaudhuri, U.R., Fundamentals of Automatic Process Control, CRC Press/Taylor and Francis, 2013.

Additional Books:

1. Rao, A.R., Process Control Engineering, Gordon and Breach Science Publishers, 1993.
2. Bequette, B.W., Process Control: Modeling, Design and Simulation, Prentice Hall, 2010.

EEL 410 HVDC (3-0-0-3)

Pre-requisite: NIL

Contents:

Evolution of HVDC Transmission, Comparison of HVAC and HVDC systems, Type of HVDC Transmission systems, Components of HVDC transmission

systems, Analysis of simple rectifier circuits, Required features of rectification circuits for HVDC transmission, Analysis of HVDC converter, Different modes of converter operation, Output voltage waveforms and DC voltage in rectification, Output voltage waveforms and DC in inverter operation, Thyristor voltages, Equivalent electrical circuit, HVDC system control features,Control Modes, Control Schemes, Control comparisons.
Converter mal-operations, Commutation failure,Starting and shutting down the converter bridge, Converter protection.
Smoothing reactor and DC Lines, Reactive power requirements, Harmonic analysis, Filter design.
Component Models for the Analysis of AC DC Systems, Power flow analysis of AC-DC systems, Transient stability analysis,Dynamic stability analysis.
Multi-terminal HVDC system, Advances in HVDC transmission, HVDC system application in wind power generation.

Text Books:

1. Padiyar, K.R., HVDC Power Transmission Systems, 2nd ed., New Age International, 2013.
2. Kimbark, E.W., Direct Current Transmission, Wiley-Interscience, New York, 1971.

Additional Books:

1. Singh, S.N., Electric Power Generation, Transmission and Distribution,2nd ed., PHI Learning, New Delhi, 2010.
2. Arrillaga, J., High Voltage Direct Current Transmission, 2nd ed., Institution of Engineering and Technology, London, 2008.

EEL 411 POWER SYSTEM ECONOMICS & MANAGEMENT (3-0-0-3)

Pre-requisite: NIL

Contents:

Economic Operation of Power Systems: Optimal operation of Generators in Thermal Power Stations, Heat rate Curve, Cost Curve, Incremental fuel and Production costs, input-output characteristics, Optimum Generation allocation with line losses neglected.
Optimum generation allocation including the effect of transmission line losses – Loss Coefficients, General transmission line loss formula.
Hydrothermal Scheduling: Optimal scheduling of Hydrothermal System: Hydroelectric Power plant models, Scheduling problems-short term Hydrothermal scheduling problem.
Modeling of Turbine, Generator and Automatic Controllers: Modelling of Turbine: First order Turbine, model, Block Diagram representation of Steam Turbines and Approximate Linear Models.
Modelling of Generator (Steady State and Transient Models): Description of Simplified Network Model of a Synchronous Machine (Classical Model), Description of Swing Equation (No Derivation) and State-Space II-Order Mathematical Model of Synchronous Machine.
Modelling of Governor: Mathematical Modelling of Speed Governing System – Derivation of Small signal transfer function. Modelling of Excitation System: Fundamental Characteristics of an Excitation system, Ttransfer function, Block Diagram Representation of IEEE Type-1 Model
Single Area Load Frequency Control:
Necessity of keeping frequency constant. Definitions of Control area, Single area control, Block diagram representation of an isolated power system, steady state analysis, Dynamic response, Uncontrolled case.
Two-area load frequency control:
Load frequency control of 2-area system – uncontrolled case and controlled case, tie-line bias control.
Load Frequency Controllers:
Proportional plus Integral control of single area and its block diagram representation, steady state response – Load Frequency Control and Economic, Dispatch control.
Reactive Power Control: Overview of Reactive Power control, Reactive Power compensation in transmission systems, advantages and disadvantages of different types of compensating equipment for transmission systems, load compensation, Specifications of load compensator, Uncompensated and compensated transmission lines, shunt and Series Compensation.

Text Books:

1. Kundur P., Power System Stability and Control, EPRI Series, McGraw-Hill, 1998.
2. Wood A. J. and Wollenberg B. F., Power Generation, Operation and Control, second edition, Willey Publication, 2008.

Additional Books:

1. Nagrath I. J. and Kothari D. P., "Power System Engineering", 2nd edition, Tata Mc-Graw Hill Publishing Company,2008.
2. Saadat H., Power System Analysis, 1st International Edition, Tata McGraw-Hill Publishing Company Limited, 2008.

EEL412 ADVANCED CONTROL THEORY (3-0-0-3)

Pre-requisite: EEL202 BASIC ELECTRICAL CIRCUITS, EEL302 CONTROL SYSTEM

Contents:

State variable analysis & design: Concept of state and state variables, Diagonalisation, Eigen values and eigenvector, Determination of state transition matrix, Solution of state equations-properties of the state transition matrix, Computation of state transition matrix, Computation by techniques based on the cayley-hamilton theorem, Sylvester's expansion theorem. Concepts of controllability and observability, Effect of pole-zero cancellation in transfer function. Pole placement by state feedback, State observer systems. Introduction to design of control systems, Design of phase lag and phase lead controllers in time domain as well as frequency domain.
Nonlinear systems: Behavior of nonlinear systems, Investigation of nonlinear systems. Study of common physical nonlinearities-saturation, Friction, Backlash, Relay, Multivariable etc.
The phase plane method- basic concepts; Singular points: Nodal point, Saddle point, Focus point, Centre or vortex point; Stability of non-linear systems: Limit cycles; Construction of phase trajectories: Construction by analytical method, Construction by graphical methods.
The Describing function method: Basic concepts, Derivation of describing functions- dead zone and saturation, Relay with dead-zone, Hysteresis, Backlash.
Stability analysis by describing function method: Relay with dead zone, Relay with hysteresis, and Stability analysis by gain-phase plots. Jump resonance.
Liapunov's stability analysis: Introduction, Liapunov's stability criterion, Basic stability theorems, Liapunov functions, Instability. Direct method of liapunov for the linear systems, Methods of constructing liapunov functions for nonlinear systems.

Text Book:

1. Control Systems (Principles & Design) by M.Gopal, Tata Mc.Graw Hill Publishing Company Ltd, 3rd Edition (2008).

Additional Books:

1. Systems and Control by Stanislaw H.Zak, Oxford University Press (2003).
2. Non Linear Systems, by Hassan K. Khallil, Prentice Hall, Inc. (Pearson Education), Publications, 3rd edition (2002).
3. Ogata K., Modem Control Engineering, 5th Edition, PHI (2010).
4. Doyle, J.C., Francis, B.A. and Tannenbaum, A.R., Feedback Control Theory, Dover Publications (2009).

EEL413 COMPUTER AIDED POWER SYSTEM ANALYSIS (3-0-0-3)

Pre-requisite: EEL202 BASIC ELECTRICAL CIRCUITS, EEL301 POWER SYSTEM

Contents:

Review of matrix operations, Graph theory, and Various circuit incidence matrices, Primitive network and matrix, Formation of various network matrices by singular transformation interrelations.
Building algorithm for bus impedance matrix, Modification of bus impedance matrix for change of reference bus for network changes, Formation of bus admittance matrix and modification, Gauss elimination, Node elimination (Kron reduction), LU factorization, Schemes of ordering, Sparsity, Calculation of z bus elements for y bus.
Representation of three phase network elements, Treatment under balanced and unbalanced excitation, Transformation matrices, Unbalanced elements.
Network short circuit studies using Z bus, Short circuit calculations for various types of faults.
Load flow studies, its importance. Classification of buses, Load flow techniques, Iterative solutions and computer flow charts using gauss-seidel and newton-raphson methods, Decoupled and fast decoupled load flow solution, Representation of regulating and off nominal ration transformers, Tie-line control, Comparison of methods.
Introduction to AC-DC load flow problems: Formation and solutions.
Optimal power flow: Solution methods of OPF, Steepest gradient method, OPF using newton's method, Successive quadratic programming, Successive linear programming, Interior point methods and variants, Security and environmental constraint OPF.
Power system security, Contingency analysis using z bus sensitivity factors.
Introduction to state estimation, maximum likelihood weighted least square error estimation, State estimate of an AC network.

Text Book:

1. G.W. Stagg & A.H EI-Abaid, "Computer methods in Power system analysis", McGraw Hill, New York, 1968.

Additional Books:

1. M A Pai, Dheeman Chatterjee, "Computer Techniques in Power System Analysis", 3rd Edition, McGraw Hill Education, 2014.
2. Arrillaga, C.P Arnold &Harker, "Computer Modeling of Electrical Power Systems", 2nd Edition, John Wiley & Sons 2001.
3. John J.Grainger and W.D.Stevenson, "Power System Analysis", McGraw Hill, New York, 1994.
4. A.J. Wood & W.F. Wollenberg, "Power Generation, Operation, and Control", 2nd Edn, John Wiley & Sons, New York, 1996.

5. O.I. Elgerd, “Electric Energy Systems Theory: An Introduction”, McGraw Hill, New York, 1982.

EEL414 WIND ENERGY (3-0-0-3)

Pre-requisite: EEL312 ELECTRICAL ENERGY SYSTEM, EEL303 POWER ELECTRONICS

Contents:

Wind turbine, Wind turbine architecture, Wind generators compared with conventional power plant, Grid code regulation for integration of wind generation.

Synchronous generator modelling, Steady state operation, Excitation control, Prime mover control.

Induction machine construction, Steady state characteristics, Fixed speed induction generator (FSIG) for wind generation, FSIG model as a voltage behind a transient reactance. Dynamic performance of FSIG wind turbines.

Doubly fed induction generator (DFIG) construction, Steady state characteristics, Control strategies for a DFIG, Dynamic performance assessment, Fully rated converter based (FRC) wind turbines, Synchronous generator based (FRC-SG), Induction generator based(FRC-IG).

Influence of rotor dynamics on wind turbine operation: Blade bending dynamics, Derivation of three mass models, two mass models.

Power system stabilizers for a synchronous generator, DFIG, FRC wind farms. Integration of wind farms into the power systems. Wind turbine control for system contingencies: Frequency regulation, Fault ride through (FRT) capability.

Text Book:

1. Olimpo Anaya-Lara, Nick Jenkins, J. Ekanayake, P. Cartwright, Mike Hughes, “Wind Energy Generation: Modelling and Control”, Wiley Publication, 2009.

Additional Books:

1. S. Heier, “Grid Integration of wind energy conversion systems”, 3rd Edition, Wiley, New York (USA), 2014.
2. Johnson Gary L. “Wind Energy System”, Prentice Hall Inc. Englewood Cliffs N. J. (USA), 1985.
3. L. L. Freris, “Wind Energy Conversion System”, Prentice Hall (U.K.), 1990.

EEL415 POWER QUALITY MITIGATION TECHNIQUES (3-0-0-3)

Pre-requisites: EEL301 POWER SYSTEM, EEL306 POWER QUALITY ISSUES AND SOLUTIONS

Contents:

Power quality standards and monitoring: Introduction, State of the art on power quality standards and monitoring, Power quality terminologies, Power quality definitions, Power quality standards, Power quality monitoring.

Passive shunt and series compensation, Active shunt compensation: DSTATCOMs,

Active series compensation, Unified power quality compensators, Loads that cause power quality problems: Introduction, State of art on nonlinear loads, Classification of nonlinear loads, Principle operation and control of nonlinear loads, Analysis and design of nonlinear loads, Modeling simulation and performance of nonlinear loads, Passive power filters, Shunt active power filters, Series active power filters, Hybrid power filters.

Text Book:

1. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad , Power Quality Mitigation Techniques, Wiley, 2015

Additional Books:

1. Arindam Gosh, Gerard Ledwich, Power Quality Enhancement using custom Power devices, Kluwer Academic Publishers, 2002
2. A. Moreno- Munoz (Ed.), Power Quality Mitigation Technologies in a Distributed Systems, Springer, 2007

EEL416 ADVANCED AC ELECTRIC DRIVES (3-0-0-3)

Pre-requisites: EEL303 POWER ELECTRONICS, EEL302 CONTROL SYSTEM

Contents:

Power electronics converter for ac drive control, Voltage source inverter, Current source inverter. Multilevel converter, Different PWM techniques for two level and multi-level converter. Space vector modulation techniques, Selective harmonic elimination techniques.

Inverter fed AC drives : Constant v/f controlled induction motors, Slip power controlled induction motor drives, Vector controlled induction motor drives : Direct vector control, Indirect vector control, Sensor less vector control, Tuning of the vector controller, Parameter sensitivity of the indirect vector controlled induction motor drives, Flux weakening operation , Adaptive control techniques.

Permanent magnet synchronous motor drive: Synchronous machine permanent magnet, Vector control of PM synchronous motor and different control strategies; Flux weakening operation; Speed controller design; Sensorless control, Parameter sensitivity.

Principle of soft switching in inverters and converters.

Text Book:

1. Krishnan R., “Electric Motor Drives – Modeling, Analysis and Control”, Prentice Hall of India Private Limited. 2007.

Additional Books:

1. Holmes D.G., Lipo T.A., “Pulse Width Modulator For Power Converters – Principles and Practice”, IEEE Press, John Wiley & Sons, Inc. 2003.
2. Murphy J. M. D. and Turnbull F. G., “Power Electronics Control of AC Motors”, Peragmon Press. 1990.
3. Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors. 2001.
4. Bose B. K., “Modern Power Electronics and AC Drives”, Pearson Education. 2008.
5. Dubey G. K., "Power Semiconductor Controlled Drives", Prentice-Hall International Editions. 1989.

EEL417 POWER ELECTRONIC CIRCUIT DESIGN AND ANALYSIS (3-0-0-3)

Pre-requisite: EEL303 POWER ELECTRONICS

Contents:

Switched mode converters: Non-isolated and isolated topologies (flyback, forward, Cuk, SEPIC, Zeta, Half bridge, Push-pull and Bridge converter), Continuous and discontinuous modes of operations, Steady state & dynamic analysis, Modeling and control, EMI issues.

Classification of resonant converters, Basic resonant circuit concepts, Load resonant converters, Resonant switch converters, Zero voltage switching.

Multilevel converters: H- Bridge, Diode clamped, Cascaded and modular, Multilevel converter, Principles, Control and applications.

Other advanced converters: Multi pulse converters, High power factor converter, Matrix converter.

Reactive elements in power electronic systems, Design of inductor, Design of transformer, Capacitors for power electronic applications.

Heat sink calculations.

Text Book:

1. N. Mohan, T. Undeland, and W. Robbins, “Power Electronics Converters, Applications, and Design,” Third edition, 2003, John Wiley and Sons Inc.

Additional Books:

1. Rashid M.H. “Power Electronics, circuit, Devices and applications”, Prentice Hall of India.
2. Ericksson, R., and Maksimovic D., Fundamentals of Power Electronics, 2nd ed., Springer, 2013.

EEL418 DIGITAL PROTECTION OF POWER SYSTEM (3-0-2-4)

Pre-requisites: EEL301 POWER SYSTEM, EEL401 SWITCHGEAR & PROTECTION

Contents:

Review on power system protection schemes: Over current relay, Differential, and Distance.

Introduction to Numerical Relay- Numerical protection schemes of power system equipments, Different methods to compute the phasor, Phasor based protection, Detection of fault

Distance relaying: Algorithms for different types of fault, Classification of fault, Problems with distance relay in the presence of series compensation and three terminal line, Performance of distance relay during power swing and load encroachment, Time domain algorithms, Travelling wave based protection, Fault location algorithms.

Directional relay: Phasor based algorithms, sequence component based algorithms, Problems with directional relay with the presence of series compensation.

Differential protection: Phasor based differential protection of transmission line, Transformer, Bus bar, Performance during CT saturation.

Adaptive relaying:- Over current, Distance, Differential relaying.

WAMS: - Wide area measurement System, Phasor measurement unit based system protection schemes.

Switchgear – ACBs, SF6 CB, VCBs and short circuit testing. Problems in relaying due to CTs and transient in CCVTs.

Practical: Practicals as per course contents.

Text Book:

1. A.G.phadke, S.H. Horowitz, Power system relaying, 3rd ed, willeyPublisers, 2010,

Additional Books:

1. A. G. Phadke, J. S.Thorp, Computer Relaying for Power Sytem, John willey and Sons, 2009
2. P. M.Anderson, Power System protection, Mac Graw Hill 1999
3. G. Zeigler, Numerical Distance Protection, Willey Publisher, 1999

EEL419 PROCESS DYNAMICS AND NONLINEAR CONTROL (3-0-0-3)

Pre-requisites: EEL302 CONTROL SYSTEM, EEL412 ADVANCED CONTROL THEORY

Contents:

Introduction to process control. Dynamic modelling of engineering systems. Review of laplace transforms. First order, second order systems. Systems with time delays. Interacting & non-interacting processes. Process identification. Feedback control. Block diagram. Feedback controllers: PID control etc. Typical time-domain responses of feedback control systems, Stability analysis of closed-loop control systems. Routh stability criterion. Root locus technique

Review of dynamic behavior of linear systems and their control system design, Linear processes with difficult dynamics. Nonlinear process dynamics; Phase-plane analysis; Multiple steady state and bifurcation behavior, Direct synthesis and Internal model control design, Controller design via frequency response analysis, Cascade, Feed forward and ratio control; Introduction to multivariable systems.

Linear versus nonlinear systems. Describing function analysis of nonlinear systems. Reliability of describing method analysis. Compensation and design of nonlinear system using describing function method, Existence of limit cycles. Linearization: Exact linearization, Input-state linearization, Input-output linearization. Concept of stability, Stability in the sense of lyapunov and absolute stability. Zero-input and BIBO stability. Second (or direct) method of lyapunov stability theory for continuous and discrete time systems. Aizermans and kalmans conjecture. Construction of lyapunov function-methods of Aizerman; Kalman conjectures, variable gradient method. Lure problem. Popovs stability criterion, generalized circle criterion, Simple variable structure systems. Sliding mode control, feedback linearization. Concept of uncertainties and robustness: Structured uncertainties, Unstructured uncertainties, Sensitivity, Complementary sensitivity and their significance for performance and robustness study, Robust stability of structure, Kharitonov polynomial.

Text Book:

1. Seborg,D.E. Edgar,T.F., Mellichamp,D.A. 'Process Dynamics and Control', 2nd Edition , John Wiley & Sons, 2004.

Additional Books:

1. Process Control Principles and Applications by Surekha Bhanot, Oxford Publication (2008).
2. Control Systems Engineering, by I.J. Nagrath and M.Gopal., 5th Edition (2007 / 2009), New Age International (P) Ltd. Publishers.
3. Process control: theory and applications by J.-P. Corriou Springer-Verlag, London, (2004).
4. Non Linear Systems, by Hassan K. Khallil, 3rd edition (2002), Prentice Hall, Inc. (Pearson Education), Publications.

EEL420 POWER SYSTEM DYNAMICS & STABILITY (3-0-0-3)

Pre-requisite: EEL301 POWER SYSTEM

Contents:

Definitions and classification of power system stability synchronous machine modeling for stability studies: Basic equations of a synchronous machine, The dq0 transformation, Per unit representation, Equivalent circuits for direct and quadrature axes, Steady state analysis, Transient performance, Magnetic saturation, Equations of motion, Swing equation, Simplified model with ammortisseurs neglected, Constant flux linkage model.

Excitation and prime mover controllers: Elements of excitation systems, Types of excitation system, dc, ac and static excitation systems, System representation by block diagram and state equations, Prime mover control system.

Small signal stability of power systems: Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix, Small signal stability of a single machine infinite bus system, Effects of excitation system, Power system stabilizers, System state matrix with ammortisseurs, Small signal stability of multi machine systems. Use of PSS to improve small signal stability.

Transient stability: Equal area criterion, Numerical integration methods, Simulation of power system dynamic response, Direct methods of transient stability analysis – description of transient energy function approach, Limitations of the direct methods. Methods of improving transient stability.

Voltage stability: Basic concepts related to voltage stability, Voltage collapse, Voltage stability analysis – static and dynamic analysis, The continuation power flow analysis, Bifurcation methods prevention of voltage collapse.

Text Book:

1. P. Kundur, 'Power System Stability and Control', 1st ed., McGraw Hill Education, 2006.

Additional Books:

1. K.R. Padiyar, 'Power System Dynamics', 2nd ed., BS Publications, 2002.
2. P.M Anderson and A.A Fouad 'Power System Control and Stability', 2nd ed., Wiley India Pvt. Ltd., 2008.
3. P. W. Sauer and M. A. Pai, "Power system dynamics and stability", Prentice-Hall, 1997.

EEL421 EHV AC TRANSMISSION (3-0-0-3)

Pre-requisite: EEL301 POWER SYSTEM

Contents:

Role of EHV AC Transmission, Standard transmission voltages, Average value of line parameters, Power handling capacity.

Line parameters, Properties of bundled conductors, Resistance, Inductance and capacitance of bundled conductor lines, Temperature rise of conductors and current carrying capacity. Voltage gradients on conductors: Charge potential relations for multi-conductor lines, Surface voltage gradient on conductors, Distribution of voltage gradient on sub conductors of bundle.

Corona Effects: Corona loss, Attenuation of traveling waves, Audible noise, Limits for audible noise, AN measurement and meters, Day night equivalent noise level, Limits for radio interference fields, RI excitation function, Measurements of RI, RIV, Excitation function.

Switching Over voltages: Origin of over voltages and their types, Over voltages due to interruption of low inductive current and interruption of capacitive currents, Reduction of switching surges on EHV systems.

Power frequency over voltages: Problems at power frequency, No-load voltage conditions and charging current, Voltage control using synchronous condensers, Sub synchronous resonance in series-capacitor compensated lines, State reactive compensating schemes.

Operational aspects of Power flow: Line loadability, Effects of over load, reactive power limitations and over voltage problem.

Text Book:

1. Begamudre, "EHV AC Transmission engineering", Wiley Easter Ltd. 2nd Ed.

Additional Books:

1. EPRI, Palo Alto, "Transmission line reference book 345 KV".
2. Rao S., "EHV AC & HVDC Transmission Systems" - Khanna Pub.
3. Edison Electric Institute, "EHV transmission reference book", GE Co.
4. Rudenberg, "Transient performance of electric power systems" McGraw Hill.

EEL422 SYSTEM ENGINEERING (3-0-0-3)

Pre-requisite: EEL302 CONTROL SYSTEM

Contents:

Introduction to Optimization, Generalized Principles of System Modeling, Engineering Applications of Optimization, Statement of problem, Classification of optimization problem techniques.

Linear programming, introduction, Requirements for a LP Problem, Graphical solution of 2-variable LP problems, Some exceptional cases, General mathematical formulation for LPP, Canonical and standard forms of LP problem, Simplex method, special cases in simplex method, Big-M method, Concept of duality, Dual simplex method and sensitivity analysis.

Transportation problem, Definition and mathematical representation of transportation model, Formulation and solution of transportation models (basic feasible solution by north-west corner method, Inspection method, Vogell's approximation method).

Network models, Scope and definition of network models, Minimal spanning tree algorithm, Shortest-route problem, Maximal flow model.

Goal programming, Formulation of goal programming, Introduction to goal programming algorithms, The weights method, The preemptive method.

Text Book:

1. "Operations Research-An Introduction' by H.Taha, Prentice Hall of India Pvt. Ltd., 8th Edition (2011).

Reference Books:

1. "Engineering Optimization-Theory & Practice" by S.S. Rao, New Age International (P) Ltd., 4th Edition (2009)
2. "Linear Programming", by G. Hadley, Addison-Wesley Pub. Co, Published by Narosa Publishing House Pvt. Ltd., New Delhi (2012)
3. "Operations Research – An Introduction" by P.K.Gupta & D.S.Hira, S.Chand & Company Ltd, New Delhi (2008)

EEL423 MODELING AND ANALYSIS OF ELECTRICAL MACHINES (3-0-0-3)

Pre-requisite: EEL203 ELECTRICAL MACHINES

Contents:

Energy state functions, Modeling of electromechanical systems Matrix method and use of generalized circuit theory of machines. Different methods of transformation, Phase variable instantaneous symmetrical component techniques, Development of basic performance equation and analysis of different rotating machines such as D.C., Synchronous and induction machines, Dynamics and transients in electric machines. Switching transients and surges, Transient and short circuit studies on alternators run-up switching and other transients in induction machines relevant computer techniques for machine analysis. Modelling of special electrical machines.

Text Book:

1. P.C. Krause, "Analysis of Electric Machinery and Drive Systems, 3rd Edition," IEEE Press 2013, ISBN: 978-1-118-02429-4

Additional Books:

1. P. C. Krause, O. Wasynczuk, and S. D. Sudhoff, Analysis of electric machinery and drive systems, 2nd ed., New York: Wiley-IEEE, 2002.
2. Chee-MunOng, "Dynamic Simulation of Electric Machinery: Using MATLAB/SIMULINK," Prentice Hall 1997, ISBN: 0137237855

3. Lyshevski, Sergey Edward, "Electromechanical systems, electric machines and applied mechatronics, CRC Press, 2000.
4. D. W. Novotny and T. A. Lipo, 1996, Vector Control and Dynamics of AC Drives, Clarendon Press, New York.
5. B. K. Bose, 2002, Modern Power Electronics and AC Drives, Prentice Hall, New Jersey.
6. R. Krishnan, 2001, Electric Motor Drives Modeling, Analysis and Control, Prentice Hall, New Jersey.

EEL424 GRID CONNECTED SOLAR SYSTEM (3-0-0-3)

Pre-requisite: EEL312 ELECTRICAL ENERGY SYSTEM, EEL303 POWER ELECTRONICS

Contents:

Introduction to photovoltaic (PV) systems: Historical development of PV systems. Overview of PV usage in the world, Solar energy potential for PV, irradiance, solar radiation and spectrum of sun, geometric and atmospheric effects on sunlight, Photovoltaic effect, conversion of solar energy into electrical energy, behavior of solar cells, Solar cells, basic structure and characteristics: Single-crystalline, multicrystalline, thin film silicon solar cells, emerging new technologies, Electrical characteristics of the solar cell, equivalent circuit, modeling of solar cells including the effects of temperature, irradiation and series/shunt resistances on the open-circuit voltage and short-circuit current, Solar cell arrays, PV modules, PV generators, shadow effects and bypass diodes, hot spot problem in a PV module and safe operating area.

Terrestrial PV module modeling: Interfacing PV modules to loads, direct connection of loads to PV modules, connection of PV modules to a battery and load together, Energy storage alternatives for PV systems. Storage batteries, lead-acid, nickel-cadmium, nickel-metal-hydride and lithium type batteries. Small storage systems employing ultracapacitors, charging and discharging properties and modeling of batteries,

Power conditioning and maximum power point tracking (MPPT) algorithms MPPT algorithms based on based on buck- and boost-converter topologies, Maximum power point tracking (MPPT) algorithms,

Inverter control topologies for stand-alone and grid-connected operation. Analysis of inverter at fundamental frequency and at switching frequency. Feasible operating region of inverter at different power factor values for grid-connected systems, Stand-alone PV systems. Consumer applications, residential systems, PV water pumping, PV powered lighting, rural electrification, etc., Grid-connected (utility interactive) PV systems. Active power filtering with real power injection, Modeling and simulation of stand-alone and grid-connected PV systems.

Text Book:

1. R. Messenger, J. Ventre, Photovoltaic Systems Engineering, 2nd ed., CRC Press, 2004.

Additional Books:

1. A. Goetzberger, V. U. Hoffmann, Photovoltaic Solar Energy Generation, Springer-Verlag, 2005.
2. L. Castaner, S. Silvestre, Modeling Photovoltaic Systems Using PSpice, John Wiley & Sons, 2002.
3. R. J. Komp, Practical photovoltaics: electricity from solar cells, 3rd ed., Aatec Publications, 2001.
4. M. R. Patel, Wind and Solar Power Systems, CRC Press, 1999.
5. R. H. Bube, Photovoltaic Materials, Imperial College Press, 1998.
6. T. Markvart, Solar Electricity, John Wiley & Sons, 1994.

EEL425 COMPUTER AIDED DESIGN OF ELECTRICAL MACHINE (2-0-2-3)

Pre-requisite: EEL203 ELECTRICAL MACHINES

Contents:

Synchronous Reluctance Motors:

Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance and Hybrid Motors – SYNREL Motors – Voltage and Torque Equations - Phasor diagram - Characteristics.

Stepping Motors:

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi stack configurations – Torque equations – Modes of excitations – Characteristics – Drive circuits – Microprocessor control of stepping motors – Closed loop control.

Switched Reluctance Motors:

Constructional features – Rotary and Linear SRMs - Principle of operation – Torque production Steady state performance prediction- Analytical method - Power Converters and their controllers Methods of Rotor position sensing – Sensorless operation – Closed loop control of SRM - Characteristics.

Permanent Magnet Brushless D.C. Motors:

Permanent Magnet materials – Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation – Power controllers – Motor characteristics and control.

Permanent Magnet Synchronous Machines:

Principle of operation – Ideal PMSM – EMF and Torque equations – Armature reaction MMF –Synchronous Reactance – Sinewave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements.

Practical: Practicals as per course contents.

Text Book:

1. K.Venkataratnam, 'Special Electrical Machines', Universities Press (India) Private Limited, 2008.

Additional Books:

1. T.J.E. Miller, 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, Oxford, 1989.
2. R.Krishnan, 'Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application', CRC Press, New York, 2001.
3. P.P. Aearnley, 'Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus London, 1982.
4. T. Kenjo and S. Nagamori, 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London, 1988.
5. T. Kenjo, 'Stepping Motors and Their Microprocessor Controls', Clarendon Press London, 1984.

EEL426 COMPUTATIONAL TECHNIQUES IN ENGINEERING (3-0-0-3)

Pre-requisite: EEL301 POWER SYSTEM, EEL303 POWER ELECTRONICS

Contents:

Least Squares problem, Canonical forms obtained via orthogonal transformations. Numerical methods and conditioning, State estimation and kalman filter, Generalized least squares (GLS) and instrumental variable (IV) method; Persistently exciting input signal; Likelihood functions and maximum likelihood estimation (MLE); Singular value decomposition (SVD); Introduction to system identification: identification based on differential equations, Laplace transforms, Frequency responses, Difference equations. Signals and system concepts, Stationarity, Auto-correlation, Cross-correlation, Power spectra. Random and deterministic signal. Markov's Inequality, Variance and moments of a random variable, Chebyshev's Inequality, A randomized algorithm for computing the median. System modeling and simulation. Controller design: PID, Sliding mode controller

Text Book:

1. Jain, Iyengar and Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 2008.

Additional Books:

1. Probability, Random Variables and Stochastic Processes 4th Edition by Athanasios Papoulis S. UnnikrishnaPillai TMH publication (2002).
2. Miller and Freund, Probability and Statistics for Engineers, Pearson, 2005.
3. Henry Stark and John W. Woods Probability and Random Processes with Application to Signal Processing, 4/E, Pearson Publication (2011).

EEL427 INTELLIGENCE TECHNIQUES APPLICATION TO POWER SYSTEM (3-0-0-3)

Pre-requisite: NIL

Contents:

Introduction to artificial intelligence. Use of expert systems in power system, Monitoring operation and control. Expert systems in fault diagnosis. Applications of Neural network based power system estimators and controllers. Fuzzy logic based controllers. Alarm analysis and decision making processes. Applications of imaging and pattern recognition for system identification and control. Database management and computer graphics aided decision making processes. Artificial intelligence method of crisis control and restoration processes. Application of GA, PSO and NSGA in power system problem solution.

Text Book:

1. Power system Optimisation by D P Kothari , J S Dhillon, 2004.

Additional Books:

1. Computational Methods for Large Sparse Power Systems Analysis: An Object Oriented Approach, S A Soman, S A Khaparde and Shubha Pandit, 2001.
2. Computational Methods for electric power system, By M L Crow CRC Press, 2009.
3. Artificial Intelligence techniques in power system By Kevin Warwick , Arthur Ekwue ,Raj Aggarwal, 1997.

EEL428 DISTRIBUTION SYSTEM MODELING AND ANALYSIS (3-0-0-3)

Pre-requisite: NIL

Contents:

Introduction to distribution system, Nature of loads: Individual customer load, Distribution transformer loading, Feeder load, Voltage drop calculations using allocated loads. Approximate methods of analysis: K factors, Uniformly distributed loads, Lumping loads in geometric configurations, Series impedance of overhead lines, Series impedance of underground lines, Shunt admittance of overhead and underground lines. Distribution system line models, Voltage regulation, Three phase transformer model, Load model.

Distribution system load flow for balanced and unbalanced system radial and weekly meshed systems, Short circuit analysis of distribution systems, Basic of distribution system reliability, Voltage regulation in distribution systems, Distribution system protection issues, Distributed generation integration issues in distribution system.

Text Book:

1. Kersting W. H., Distribution system modeling and analysis, CRC press, New York, 2002.

Additional Books:

1. Brown R. E., Electric power distribution reliability, CRC press, New York, 2009.
2. Nothcote-Green J. and Willson R., Control and automation of electric power distribution systems, CRC press, New York, 2007.
3. Chowdhury A. A. and Koval D. O., Power distribution system reliability practical methods and applications, Wiley IEEE press, 2009.

EEL429 POWER SYSTEM PLANNING (3-0-0-3)

Pre-requisite: EEL301 POWER SYSTEM

Contents:

Basic Planning Issues: Introduction, Power system elements and structure, Static and dynamic planning, Transmission and distribution planning; Long-term and short-term planning, Basic issues in transmission planning; Optimization Techniques: Introduction; Problem definition and modelling, Mathematical and heuristic solution algorithms; Economic Principles: Introduction, Definition of various terms, Cash flow concept: Time value of money and economic terms, Economic analysis: Present worth method, Annual cost method, Rate of return method, Example; Load Forecasting: Introduction, Load characteristics and driving parameters, Spatial load forecasting, Long-term forecasting methods: Trend analysis, Econometric modelling, end-use analysis, Combined analysis, Examples - load forecasting of small and large scale utility; Single and multi-bus generation expansion planning: Problem description and mathematical formulation, Objective functions and constraints, Solution approaches; Substation Expansion Planning: Problem definition and formulation, Mathematical view: Objection function and constraints, Required data; Solution methodologies, Case studies; Network Expansion Planning: Problem definition and formulation: Objective function and constraints, Solution methodologies: Enumeration and heuristic methods, Case study; Reactive Power Planning: Introduction, Voltage profile and stability, Performance control parameters, Static and dynamic reactive power sources, Static reactive resource allocation and sizing, Dynamic reactive resource allocation and sizing, Solution methods, Case study; Planning with System Uncertainties: Introduction, Deregulation, Uncertainties in regulated and deregulated environment, Practical planning issues in deregulated environment, Dealing with uncertainties in planning: Expected cost criterion, Min-max regret criterion, Laplace criterion, and VNM criterion.

Text Book:

1. H. Seifi and M. S. Sepasian, "Electric Power System Planning: Issues, Algorithms and Solutions", 2011, Springer.

Additional Books:

1. R. L. Sullivan, "Power System Planning", 1987, McGraw Hill.
2. J. Schlabbach and K-H. Rofalsk, "Power System Engineering: Planning, Design, and Operation of Power Systems and Equipment", 2008, Wiley.

EEL430 INDUSTRIAL AUTOMATION AND CONTROL (3-0-0-3)

Pre-requisite: EEL302 CONTROL SYSTEM

Contents:

Process Control: Introduction: Process Definition, Feedback Control, PID Control, Multivariable Control.

PID controller tuning: Introduction, Zeigler-nichols tuning method (based on ultimate gain and period, and process reaction curve), Digital PID controllers.

Special control structures: Cascade control, Feed forward control, Feed forward-feedback control configuration, Ratio control, Selective control, Adaptive control, Adaptive control configuration.

Actuators: Introduction, Pneumatic actuation, Hydraulic actuation, Electric actuation, Motor actuators and Control valves.

Industrial automation: Programmable logic controllers: Introduction, Principles of operation, Architecture, Programming (Programming languages, Ladder diagram, Boolean mnemonics)

Distributed control: Distributed vs. Centralized, Advantages, Functional requirements, System architecture, Distributed control systems (DCS), Communication options in DCS.

Real-time programming: Multi-tasking, Task management, Inter-task communication, Real-time operating system.

Text Book:

1. Krishna Kant, "Computer-Based Industrial Control", PHI, 2009.

Additional Books:

1. Surekha Bhanot, Process Control: Principles and Applications, Oxford university Press, 2010
2. M. Gopal, "Digital Control and State Variable Methods" Tata McGraw Hill, 2003.
3. Smith Carlos and Corripio, "Principles and Practice of Automatic Process Control", John Wiley & Sons, 2006.
4. Jon Stenerson, "Industrial Automation and Process Control", Prentice Hall, 2003.
5. C. Johnson, "Process Control Instrumentation Technology", PHI, New Delhi (2005).

EEL431 ADVANCED ELECTRIC MACHINES (3-0-0-3)

Pre-requisite: EEL203 ELECTRICAL MACHINES

Contents:

Single phase induction motors and special machines: Constructional details of single phase induction motor – Double revolving field theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors - Shaded pole induction motor - Linear reluctance motor - Repulsion motor - Hysteresis motor - AC series motor; Synchronous reluctance motors: Constructional features – Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram - Characteristics – Vernier motor; Stepping motors: Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Theory of torque predictions – Linear and non-linear analysis – Characteristics – Drive circuits.

Switched reluctance motors: Constructional features – Principle of operation – Torque prediction – Power controllers – Non-linear analysis – Microprocessor based control - Characteristics – Computer control; Permanent magnet brushless d.c. Motors: Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Power controllers – Motor characteristics and control; Permanent magnet synchronous motors: Principle of operation – EMF and torque equations – Reactance – Phasor diagram – Power controllers - Converter - Volt-ampere requirements – Torque speed characteristics - Microprocessor based control.

Text Book:

1. T.J.E. Miller, "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.

Reference Books:

1. P.P. Aearnley, "Stepping Motors – A Guide to Motor Theory and Practice", Peter Perengrinus, London, 1982.
2. D.P. Kothari and I.J. Nagrath, 'Electric Machines', Tata McGraw Hill Publishing Company Ltd, 2002.
3. P.S. Bhimbhra, 'Electrical Machinery', Khanna Publishers, 2003.
4. T. Kenjo, "Stepping Motors and Their Microprocessor Controls", Clarendon Press London, 1984.
5. T. Kenjo and S. Nagamori, "Permanent Magnet and Brushless DC Motors", Clarendon Press, London, 1988.
6. A.E. Fitzgerald, Charles Kingsley, Stephen.D.Umans, 'Electric Machinery', Tata McGraw Hill publishing Company Ltd, 2003.

EEL432 SMART GRID TECHNOLOGY (3-0-0-3)

Pre-requisites: EEL301 POWER SYSTEM, EEL303 POWER ELECTRONICS

Contents:

Review of basic elements of electrical power systems, Desirable traits of a modern grid, Principal characteristics of the smart grid, Key technology areas; Smart grid communication: Two way digital communication paradigm, network architectures, IP-based systems, Power line communications, Advanced metering infrastructure; Renewable generation: Renewable resources: Wind and solar, Microgrid architecture, Tackling intermittency, Distributed storage and reserves; Wide area measurement: Sensor networks, Phasor measurement units, Communications infrastructure, Fault detection and Self-healing systems, Application and challenges; Security and privacy: Cyber security challenges in smart grid, Defense mechanism, Privacy challenges.

Text Book:

1. J. Momoh 'Smart Grid: Fundamentals of Design and Analysis' Wiley-IEEE Press, 2012.

Additional Books:

1. P. F. Schewe 'The Grid: A Journey through the Heart of our Electrified World' Joseph Henry Press, 2006.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama 'Smart Grid: Technology and Applications' Wiley press, 2012.
3. Ali Keyhani, 'Design of smart power grid Renewable Energy Systems' 2nd Edition Wiley-IEEE Press, 2011.

EEL433 SWITCHED MODE POWER CONVERTERS AND ITS APPLICATION (3-2-0-4)

Pre-requisite: EEL303 POWER ELECTRONICS

Contents:

The ideal switch; basic switch cell; basic topology rules; possible basic converter topologies: buck, boost, buck-boost; steady-state analysis; dc transformer equivalent.

Switch characteristics of common switches: Power Diodes, SCRs, Power BJTs, GTOs, Power MOSFETs, IGBTs; conduction and switching loss; V-I plane representation of switches; switch realization from basic switch cell; drive requirements for switches; drive circuits; switching aid networks; designing with real switches: switch selection, loss calculation, basics of thermal design.
Effect of non-idealities on converter performance, efficiency, steady-state voltage gain; state space averaging; basics of small signal analysis; ac equivalent circuit.
Control of converters; voltage mode control; review of bode plots; design of converter controls.
Resonant Converters; Parallel loaded and series loaded resonant converters; transfer characteristics; design.
Inverters; basic two-level inverters: topology derivation and switching schemes; PWM methods: sine-triangle and space-phasor methods.
Multi-level inverters: basic topology derivation and introduction to PWM schemes for multi-level inverters. Applications of converters: Computer power supply, LED lighting, Flood light, Telecommunication, Welding machine.

Text Book:

1. N. Mohan, T. Undeland, and W. Robbins, "Power Electronics Converters, Applications, and Design," Third edition, John Wiley and Sons Inc, 2003.

Additional Books:

1. Joseph Vithayathil; Power Electronics- Principles & Applications; Tata Mc-Graw Hill, 1995.
2. Ericksson, R., and Maksimovic D., Fundamentals of Power Electronics, 2nd ed., Springer, 2013