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:

Additional Books:

EEL 202 BASIC ELECTRICAL CIRCUITS (3-0-2-4)
Pre-requisites: EEL101 ELEMENTARY ELECTRICAL ENGINEERING

Contents:


Practical: Practicals as per course contents.

Text Books:

Additional Books:

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, imbalance 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.
Three Phase Synchronous Motor: principle and two phase operation, types, equivalent circuit, characteristics, motors for special operation.

Practical: Practicals as per course contents.

Text Books:

Additional Books:

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.

Practical: Driving points and transfer functions poles and zeros of imittance 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:

Additional Books:

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 Kelvin’s 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

**Additional Book:**


**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.
- 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.
- 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 insulation, Power cables, Sag and tension, Corona and its effects.

**Text Books:**


**Additional Books:**


**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. Time function 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:**


**Additional Books:**


**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 AC 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:**


**Additional Books:**


**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-idealties 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-phaser methods. Multi-level inverters: basic topology derivation and introduction to PWM schemes for multi-level inverters.

**Text Books:**

**Additional Book:**

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**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:**

**Additional Books:**

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**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:**

**Additional Book:**

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**EEL 307 ELECTRICAL AND INDUSTRIAL SAFETY**

(3-0-0-3)

**Pre-requisites:** EEL203 ELECTRICAL MACHINES, EEL301 POWER SYSTEM

**Contents:**

**Text Books:**

**Additional Books:**

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**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, elastic load cell, strain gauge load cell, different methods of torque measurement, strain gauge, relative angular 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:**

**Additional Books:**
EEL309 ELECTRIC DRIVES (3-0-2-4)

Pre-requisite: NIL

Contents:
Definitions, classification and speed 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 & 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 DC traction motor, series parallel control. Starting and braking of traction motors.
Practical: Practicals as per course contents.

Text Books:

Additional Books:

EEL 310 CONTROL SYSTEM DESIGN (3-2-0-4)
Pre-requisite: NIL

Contents:

Text Books:

Additional Books:

EEL 312 ELECTRICAL ENERGY SYSTEM (3-0-3-0)
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)
Microhydel: Operating principle, Components of a microhydel power plant, Types and characteristics of turbines, Selection and modification, Load balancing.
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:

Additional Book:

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 Cable, 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.
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.

Text Books:

Additional Books:

EEL 314 HIGH VOLTAGE ENGINEERING (3-0-0-3)
Pre-requisite: NIL

Contents:
Levels of high voltage, voltage 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 dieonization 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 I, 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 weakly and non-uniform fields and the requirement of time for breakdown in solid dielectrics.

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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:

Additional Books:

**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:**

**Additional Books:**

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

Pre-requisite: NIL

**Contents:**

- 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.

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:**

**Additional Books:**

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

Pre-requisite: NIL

**Contents:**

- 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 L.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:**

**Additional Books:**

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

**Contents:**


**Text Books:**

**Additional Books:**
EEL404 COMPUTER CONTROL AND AUTOMATION OF POWER SYSTEMS (3-0-0-3)
Pre-requisite: NIL
Contents:

Text Books:

Additional Books:

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:

Additional Book:

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.

Text Books:

Additional Books:

EEL 407 POWER PLANT ENGINEERING (3-0-0-3)
Pre-requisite: NIL
Contents:
- Concepts 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.

Text Books:

Additional Books:

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:

Additional Books:

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.


Text Books:

Additional Books:

EEL 411 POWER SYSTEM ECONOMICS & MANAGEMENT (3-0-0-3)
Pre-requisite: NIL

Contents:

Text Books:

Additional Books:

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, Multi-variable etc.


Text Book:

Additional Books:

EEL413 COMPUTER AIDED POWER SYSTEM ANALYSIS (3-0-0-3)
Pre-requisite: EEL202 BASIC ELECTRICAL CIRCUITS, EEL301 POWER SYSTEM

Contents:

Load flow studies, its importance. Classification of buses, Load flow techniques, Iterative solutions and computer flow charts using gauss-seidel and newton-raphson methods, Decom coupled 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:

Additional Books:
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:

Additional Books:

EEL415 POWER QUALITY MITIGATION TECHNIQUES (3-0-0-3)
Pre-requisites: EEL301 POWER SYSTEM, EEL306 POWER QUALITY ISSUES AND SOLUTIONS
Contents:
- 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:

Additional Books:

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.

Text Book:

Additional Books:

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.

Text Book:

Additional Books:
1. Rashid M.H. “Power Electronics, circuit, Devices and applications”, Prentice Hall of India.

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:

Additional Books:
Contents:

Text Book:

Additional Books:

EEL420 POWER SYSTEM DYNAMICS & STABILITY (3-0-3)
Pre-requisite: EEL301 POWER SYSTEM
Contents:

Text Book:

Additional Books:

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

Additional Books:

EEL422 SYSTEM ENGINEERING (3-0-3)
Pre-requisite: EEL302 CONTROL SYSTEM
Contents:

Text Book:

Reference Books:

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

Additional Books:

**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 the future, 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/short 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, Maximum power point tracking (MPPT) algorithms, Torque/speed characteristics, Sensorless operation, Power controllers and their controllers, Methods of Rotor position sensing: Sensorless operation of synchronous machines, Phasor diagram – Torque/speed characteristics – Power controllers - Converter Volt-ampere requirements.

**Practical:** Practical as per course contents.

**Text Book:**

**Additional Books:**

**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:**

**Additional Books:**

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

Pre-requisite: NIL

Contents:

**Text Book:**

**Additional Books:**
3. Artificial Intelligence techniques in power system By Kevin Warwick, T.J.E. Miller, 1993.

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

Pre-requisite: NIL

Contents:

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NITUK Course Book-2016
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:

Additional Books:

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: Objective 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:

Additional Books:

EEL430 INDUSTRIAL AUTOMATION AND CONTROL (3-0-0-3)
Pre-requisite: EEL302 CONTROL SYSTEM

Contents:

Text Book:

Additional Books:

EEL431 ADVANCED ELECTRICAL MACHINES
(3-0-0-3)
Pre-requisite: EEL203 ELECTRICAL MACHINES

Contents:


Text Book:

Reference Books:

EEL432 SMART GRID TECHNOLOGY (3-0-0-3)
Pre-requisite: 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, Advanced metering systems, Smart grid communications, Fault detection and Self-healing systems, Application and challenges; Security and privacy: Cyber security challenges in smart grid, Defense mechanism, Privacy challenges.

Text Book:

Additional Books:

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.


Text Book:

Additional Books: