Syllabus for Electrical Engineering (Degree)

1. MATHEMATICS

Surds, Logarithms and Quadratic Equations: Surds, Logarithms, Quadratic Equations.
Sequences and Series: Sequences, Arithmetic Progression, Geometric Progression.
Binomial Theorem and Computer Mathematics: Binomial Theorem, Computer Mathematics.
Trigonometric Functions: Angles, Circular Functions of Trigonometric Ratios, Inverse Trigonometric Functions.
Applications of Trigonometry: Properties of Triangles, Solutions of Triangles, Heights and Distances.
Coordinate Geometry and Straight Line: Cartesian Coordinate System.
Circles and Conic Sections: Circle, Conic Section.
Vector Algebra: Basic Concepts, Components of a Vector, Operations on Vectors, Product of Two Vectors.
Differential Calculus: Real Number System, Functions, Limits, Continuity, Derivative.
Applications of Derivatives: Application to Geometric, Derivative as a Rate Measure, Increasing and Decreasing Function, Maxima and Minima, Roller Theorems, Mean Value Theorem, Curve Sketching.
Indefinite Integrals: Antiderivatives, Basic Definitions, Methods of Integration, Integration of Rational Functions, Integration of Irrational Functions.
Definite Integrals: Definite Integrals, Fundamental Theorem of Calculus, Properties of Definite Integrals, Applications.
Complex Numbers: Complex Numbers, Geometrical Representation of Complex Numbers, Exponential and Circular Functions of Complex Numbers.
Matrices and Determinants: Matrices, Matrix Multiplication, Determinants, Adjoint and Inverse of a Matrix, Solutions of Linear Equations with the help of Inverse of a Matrix.
Statistics: Statistical Data and Variables and Units of Observations, Construction of Frequency Tables (or Frequency Distributions) from Raw Data, Graphical Presentation of Frequency Distributions, Measures of Location and Dispersion.

2. PHYSICS:

Properties of Matter: Surface Tension, Fluid Statics, Fluids in Motion, Elasticity.
Thermal Energy: What is Heat? Mechanical Equivalent of Heat, Modes of Heat Transfer, Kinetic Theory of Gases.
Sound: Waves, Sound and its Characteristics, Speed of Sound: Newton's Formula.
Light: Laws of Reflection and Laws of Refraction, Image Formation by Reflecting Surfaces, Image Formation of Refracting Surfaces, Optical Instruments, Photometry.
Electricity and its Effects: Electric Charge and Electric Force, Simple Electrical Circuits, Electrical Instruments, Heating Effects of Current, Chemical Effects of Currents, Sources of EMF: Battery.
Magnetism: Magnetic Field, Electric Origin of Magnetism: Biot-Savert's Law, Effects of Magnetic Field on Electric Current, Motion of a Charged Particles in magnetic Field, Magnetic Materials.

3. CHEMISTRY

Periodic Table and Period Properties: Development of Periodic Table, Periodic Table and Electronic Configuration of Elements, Periodic Properties.
Non-Metal: Atmosphere, Hydrogen, Oxygen, Nitrogen and Ammonia, Chlorine, Acids.
Metals: Occurrence and Properties of Metals, Iron and Steel, Copper, Aluminium, Alloys.
Water Technology: Sources of Water, Structure of Water, Solvent Action of Water, Hardness of Water, Sludge and Scale Formation of Boilers, Boiler Corrosion and its prevention, pH Value and Water Treatment.
Fuels: Classification of Fuels, Calorific value of Fuels, Characteristics of a Good Fuel, Comparison between Solid, Liquid, and Gaseous Fuels, Determination of Calorific Value, Solid Fuels, Liquid Fuels, Gaseous Fuels.
Lubricants: Lubricants, Lubrication, Selection of Lubricants, Classification of Lubricants, Lubricating Emulsion, Gases as Lubricants, Propertied of Lubricants.
Polymers: Importance of Polymers, Types of Polymers, Properties of Polymers, Moulding of Plastic, Rubber.
Glass and Ceramics: Manufacture of Glass, Glass Transition, Varieties of Glasses, Ceramics, Refractories, Bleaching Powder, Commercial Bleaching Powder.

ELEMENTS OF ELECTRICAL ENGINEERING

DC CIRCUITS: Review of Linear, Lumped, Finite, Passive, Bi-lateral Circuit Elements, Voltage sources, Current sources, Source transformation, Mesh Current and Node Voltage analysis of DC Circuits, Network Reduction Technique: Star-Delta and Delta-Star transformation.
MAGNETIC CIRCUITS: MMF, Magnetic flux, Reluctance, Flux density, Analogy with electric circuits, Analysis of magnetic circuits, Self and Mutual Inductances, Expression of self and mutual induced emfs.

SINGLE PHASE AC CIRCUITS: Representation of sinusoidal voltages and currents, rms value and average value, j-operator, Phasors, Voltages and Currents relationship and instantaneous and average power in a pure resistor, pure inductor and pure capacitor, Impedance, Admittance, Analysis of circuits, Complex power, active and reactive powers, Power Triangle, Power factor, Power factor Improvement.
THREE PHASE AC CIRCUITS: Symmetrical sinusoidal supply systems, voltage, current and power relationship in 3-phase balanced star and delta connected loads, Analysis of three phase balanced star and delta connected loads, Measurements of power in a single and three phase balanced loads, Two wattmeter method of measurement of power.

TRANSFORMERS: Construction, working principle, Emf equation, Transformer on no-load, Phasor diagrams on no-load and full-load, Auto-transformer: working principle.

THREE PHASE INDUCTION MOTOR: Revolving field, principle of operation, slip, rotor induced e.m.f, rotor frequency, rotor reactance, expression of torque developed from rotor input and torque-slip characteristic.

POWER SYSTEM: Scheme of Power System from generation, transmission & distribution, internal wiring of buildings, earthing

ENGINEERING MATHEMATICS III

OBJECTIVE: The objective of this paper is to give some concept about topics like Fourier analysis, Partial Differential equations (PDE), Vector calculus and Numerical Methods. All these topics are very helpful for engineering studies. The concept of gradient, divergence, curl and PDE are required for study of Fluid Mechanics. Fourier series is used to approximate the periodic functions, Fourier transform is used to solve differential equations. In higher studies, to get analytical solution for mathematical problem like integration, system of linear equations (with large number of variables) are not always possible or not so easy. So numerical methods are helpful to solve.
Pre-requisites: Basic concept of vectors, coordinate geometry, calculus, multiple integral, ordinary differential equations, linear algebra.

Fourier analysis

Periodic functions, Trigonometric Series, Fourier series, Fourier series of odd and even functions, functions with arbitrary period, half range expansion, Fourier integrals, Fourier transforms, Fourier sine and cosine transforms, Convolution theorem(statement only).
Application of Fourier series to forced vibration problems, Application of Fourier integral and Fourier transform to solve heat equation.

Partial differential equations

Definition, degree, order of a PDE. Formation of PDE. Linear and nonlinear PDE. Solution of first order linear PDE, Lagrange's method. Solution of first order Nonlinear PDE, Charpit's method. Solution of higher order PDE by direct integration. Solution of higher order linear PDE with constant coefficients, homogeneous and nonhomogeneous.
Derivations of one dimensional wave equation (vibrating string) and its solutions by using method of separation of variables. Simple problems. D ' Alembart's solution of' wave equation. Derivation of one dimensional heat equation and its solution by using method of separation of variables. Solution of 2D-Laplace's equation.

Vector calculus

Vector-calculus-gradient, divergence and curl, their physical meaning and identities. Line, surface and volume integrals. Simple .problems- Green's theorem - statements of divergence and Stoke's theorems - Simple applications. Curvilinear Co-ordinates.

Numerical Analysis I

Interpolation and application : finite difference, central and divided differences, Newton - Gregory and Lagrange's interpolation formulae. Inverse interpolation. Numerical differentiation. Numerical integration: Trapezoidal rule, Simpson's one third and three eight rule Solution of systems of linear equation: Jacobi, Gauss-Seidal and relaxation methods. Solution of tridiagonal systems. Eigen values and eigen vectors of matrices and elementary properties, computation of largest eigen value by power method. numerical evaluation of Fourier coefficient, difference equations with constant coefficient and their solution.

CIRCUITS & NETWORKS

Network theorems: Linearity and superposition Theorem, Thevenin's Theorem, Maximum power transfer theorem, Norton's Theorem, Reciprocity Theorem, Millman's Theorem. (A.C. & D.C.)

Resonance-series and parallel, Half power frequencies, quality factor, Band width, Impedance,Admittance and current locus for series and parallel circuits, current at resonance from locus diagram

Time Domain Analysis Of First And Second Order Circuits: Introduction, source free RC and RL circuits, Response of the first order circuit for different type of excitation like step,impulse,sinusoidal and exponential, Time constant, Concept.

Source free RLC Series and Parallel circuit, Impulse and Step response of Series and Parallel RLC circuits, Setting time, rise time, Maximum overshoot.

Network Topology

Graph of a network, Concept of tree and cotree, incidence matrix, tie set and cutest, Formulation of equibilirium equation in matrix form, Principle of duality, Tellegen's Theorem.

Two port network:

z,y,t,h parameters, Condition of reciprocal and symmetry for the z,y,t,h parameters, Interrelationship between parameters, connection of two port network

Network Functions:

Driving point and Transfer function, Poles and Zeroes and its significance.

Synthesis:

Hurwitz polynomials, Concept of positive real functions and testing procedures for realness.

Synthesis of one port LC, RL, RC Networks by Foster and cauer methods. Zeroes of transmission, Realization of RC and LC ladder lattice Networks.

ELECTRICAL MACHINES – I

Magnetic circuits applied to electrical machines- self inductance, mutual inductance and leakage inductance.

Transformers: Review of Construction, ratings & specification of X'mer, Principle of operation of single phase transformer, phasor diagram (no-load and on-load). Development of equivalent circuit, O.C and S.C tests, Voltage regulation, losses and efficiency, All-day efficiency, three phase transformers and different connections: Vector Grouping: Star-star, Star-delta, Delta-star, Delta-Delta, Scott connection, Open delta connection, 3-phase to 6-phase conversion: Double star, double delta and diametrical connection, Polarity test, Sumpner's test. Parallel operation of single phase and three phase transformers, ON-and OFF-load tap changers, Autotransformers.

Energy conversion principles in rotating electrical machines.

DC Generators: Construction, principle of operation, Methods of excitation, armature reaction, commutation, characteristics of DC generators-OCC and external characteristics.

DC Motors: Principle of operation, characteristics of motors, different types of D.C. motor (shunt & series & compound).

Field and armature methods of speed control, principle of DC motor starting, 3 & 4 point starters.

Losses and Efficiency of DC machines, Swinburne's test, Hopkinson's test, Retardation test, Field's test.

MEASUREMENT AND INSTRUMENTATION

Units of measurement- the fundamental units of SI, derived units, conversion factors. Errors- definition; types of errors in measurement (with examples).

Basic electromechanical indicating instruments- the D'Arsonval Galvanometer, principle of operation and use as an ammeter and voltmeter. Basic idea about instruments with non-linear response- moving iron type,

electrodynamometer- as ammeter, voltmeter, wattmeter, multimeter and energy meter; rectifier-type instrument. Single-phase and three-phase energy meters. Digital voltmeters and multimeters.

Measurement of resistance- classification of resistance; wheatstone bridge (W.B.), limitations of W.B., Kelvin's double bridge. Concept of earth resistance and its measurement; Megger. AC Bridges- Maxwell's bridge, Maxwell-Wein bridge, Anderson's bridge, Schering bridge, Desauty bridge.

Potentiometer- introduction and types; theory, operation and applications of student's type, Brook's deflection type, co-ordinate and polar-type potentiometers.
Instrument transformers- current transformer (CT) and potential transformer (PT); construction and operation for metering and protection applications; Silsbee's method.

Transducers- introduction and classification. Strain gauges, force-summing members such as diaphragms, bourdon tubes and piezo- electric devices. Hall-Effect transducers. Temperature sensors- resistance-type temperature sensors esp. platinum resistance thermometer, thermistors and thermocouple- properties, materials used for construction, reference junction compensation of thermocouples. Current, voltage, and torque transducers.
Introduction to signal conditioning- OP-AMPs as signal conditioners; its application as a buffer amplifier, and in analog-to-digital converter's (ADCs) and digital-to-analog converters (DACs). Dual slope ADC, successive-approximation ADC, flash-type ADC. Digital frequency meters.
Cathode ray tube (CRT)- construction, working and general applications. Measurement of voltage, current, phase and frequency (using Lissajous patterns) on a CRO.
Wave analyzer- introduction and qualitative treatment of frequency selective wave analyzer and heterodyne wave analyzer; discussions on basic spectrum analyzer. Data acquisition system, including the concept of virtual instrumentation.

DIGITAL ELECTRONICS

NUMBER SYSTEM AND CODES

Review of Binary number systems, Number systems and codes: Binary to decimal conversion, decimal to binary conversion, octaL and hexadecimal numbers, ASCII code, Excess-3 code, gray code, arithmetic codes: Binary addition, hexadecimal arithmetic, binary subtraction, unsigned binary numbers, 2's complement arithmetic,

LOGIC CIRCUITS & LOGIC FAMILIES

OR, AND, NOT, NOR and NAND gates, truthtables, Boolean algebra, DE Morgan's theorems, Sum of products, product of sums (Minterm& max- terms), function minimisation using Karnaugh's map, Don't care conditions, variable entered mapping, minimisation using variable entered maps.
TTL circuits, Tri-state TTL devices, positive and Negative logic, CMOS circuits, Transfer characteristics, Fan out, Fan in, Propagation delay, noise margin, TTL and CMOS interfacing.

COMBINATORIAL CIRCUITS

Arithmetic building block, half adder, full adder, adder, subtractor, carry look ahead adder.
Data processing circuits: Multiplexes, demultiplexers, decoders 1 to 16 decoder, BCD-decimal decoder, seven segment decoder, encoder, parity generators, parity checkers, ROM, PAL.

SEQUENTIAL CIRCUITS

Flip flops: Memory element, LATCH, SR, Dand JK flip flops, excitation tables.
Shift registers: Serial in - Serial out, parallel in – parallel out shift registers, ring counter.
Counters: Asynchronous, synchronous, Mod-3, Mod-5, Preset table, shift counters, Mod-10 shift counters.
Semiconductor memories: Memory addressing, ROMS, PROMS, EPROMS, RAMS, DRAMS, memory cell.

ANALOG ELECTRONIC CIRCUITS

Review of Semiconductor physics.

P-N Junction - Open circuited P-N Junction, Bias conditions, The current components in a P-N Junction diode. The volt-ampere characteristics, Reverse saturation current, Breakdown. The effect of temperature on V-I characteristics, Diode resistance, Transition capacitance, Diffusion capacitance, Switching lines, Zener diodes, Semiconductor photo -diode, Light emitting diode, specifications. .
Diode circuits- Diode as a circuit element, load-line concept, diode model, clipping circuits, clipping at two independent levels, clamping circuits.
Transistor Characteristics- Bipolar Junction Transistor, Bias conditions, Transistor current components common base configuration, Transistor amplifying action, Transistor as a switch, common emitter

configuration, common collector configuration, Maximum voltage rating, Limits of operation, Transistor specifications.

Biasing and stabilization against variation in I_{CO},V_{BE} and β.

Fundamentals of Insulated Gate Bipolar Transistor (IGBT)

Small signal model (H-parameter model) -comparison and applications of the CE, CB, CC configuration (with CE hybrid model only). Cascade connections, Darlington configuration, current sources and current mirror circuits (using Transistor only).

Field Effect Transistors - Characteristics of FETs, Transfer characteristics, specification, Depletion type MOSFET, Enhancement type MOSFET, VMOS, CMOS, FET and MOSFET biasing,

Rectifier and Power supplies - voltage regulation, shunt voltage regulator, IC. Voltage regulators

Amplifiers -Classification of amplifiers, Distortion in amplifiers, Frequency response ofan amplifier, Polar-plots, gain bandwidth product.

Large Signal Amplifiers (Class A, Class B and Class AB) - Transformer coupled amplifier, Thermal runaway, Theoretical deficiency, Distortion analysis, complementary and quasi complementary push-pull amplifier.

ELECTRO TECHNOLOGY

DC machine: Construction, principle of operation, EMF & torque equation, types, characteristics, starting and speed control of DC motor.

Electric heating: Advantages of electric heating, classification of heating methods, transfer of heat, calculation of quantities of heat, core type induction furnace, resistance heating, designing of heating elements, dielectric heating.

Basic operation amplifier, block diagram of typical op amp, characteristics of an ideal op amp, input offset voltage & current, CMMR, slew rate, feed back in operational amplifier circuit, closed loop voltage gain, application as inverting and non-inverting amplifier, voltage follower, summing amplifier, difference amplifier, comparator.

Thyristor: Members of thyristor family, SCR, two transistor analogy of SCR, V – I characteristics of SCR, triggering methods, SCR ratings, turn on and turn off mechanisms, commutation of SCR, power control using SCR, average and RMS values of load voltage and current, application of SCR in motor speed control, light dimming control, heater control, inverters, Triac, operation, V-I characteristics, application.

Introduction to Control System, open loop and closed loop controls, transfer function, block diagram s of control system.

Mathematical Models of physical systems: differential equations of physical systems, transfer function analysis, mechanical, translational and rotational systems, electrical systems, hydraulic systems, pneumatic systems, thermal systems and electromagnetic systems.

Standard test signals, types and order of a system, time response of first and second order systems, time response specification.

Stability: Necessary conditions for stability, Routh-Hurwitz stability criterion, Routh's test – difficulties and remedies, relative stability.

Proportional, PI and PID controllers.

ENGINEERING- MATHEMATICS

Objective: The objective of teaching this paper is to apply the Fourier transform in solving integration, one-dimensional heat equation and in digital signal and image processing. The objective of teaching probability is to provide some basic idea on Probability and its applications in the field of Science and Engineering. It has lot of applications in Digital Communications & Modeling of physical problems.

Numerical analysis has numerous applications in all fields of science and engineering, and essentially any type of work that requires calculations to give very precise solutions.

Complex numbers are applied to study control theory, signal analysis, electromagnetism and electrical engineering etc.

The Z transform is used in many applications of mathematics and in signal processing.

Pre-requisites: Some prior knowledge of integral calculus, differential equation, matrices are required

Probability Theory

Finite sample space, conditional probability and independency, Baye's theorem, one dimensional random variable, mean, variance and expectation, Chebyschev's inequality.

Two and higher dimensional random variables, covariance, correlation coefficients, least squares principle of curve fitting.

Distributions : Binomial, Poission, Uniform, Normal, Gamma, Chi square and exponential, simple problems.

Numerical Analysis II

Numerical solution of algebraic and transcendental equations using Newton Rapson's method, Solution of nonlinear equation by Newton Rapson's method, Numerical solution of initial value problems in ordinary differential equations by Taylor series method, R- K Method.

Complex Variables

Introduction -complex numbers, functions, continuity, differentiability, analyticity -Cauchy Riemann equations and properties of ana1ytic functions. Line integrals in complex plane and basic properties of Cauchy's integral theorem and Cauchy's integral formula -derivatives of analytic functions.Taylor, Maclaurin and Laurent's series, residue theorem, evaluation of standard real integrals using contour integrals.

Application of Fourier and Z Transform

Parseval's identity of Fourier transforms, Solution of boundary value problems using Fourier transforms, Z transforms, Solution of difference equation using Z transforms.

SIGNALS & SYSTEMS

Introduction: Definitions of signal and systems, Classification of signals, Basic operations on signals, Elementary signals, Energy and Power signals , Interconnection of system and Properties of systems.

Lapace Transform: Introduction, Properties, Inverse of Laplace transform, Application in solving circuits problems and Differential equation.

Time-domain Representations for Linear Time Invariant (LTI) Systems: Convolution, Impulse response representation, Convolution Sum and Convolution Integral. Properties of impulse response representation, Differential and difference equation Representations and Block diagram representations.

Fourier Representation for Signals: Introduction, Discrete time and Continuous time Fourier series (derivation of series excluded) and their Properties. Discrete and continuous Fourier series (derivations of transforms are excluded) and their properties.

Applications of Fourier representations: Introduction, Frequency response of LTI systems, Fourier series representation of periodic signals and Fourier Transform representation of discrete time signals.

Z-Transforms: Introduction, Z – transform, Properties of ROC, Properties of Z – transforms, Inversion of Z – transforms. Modified Z- transform, Transform analysis of LTI Systems, unilateral Z Transform and its application to solve difference equations.

Analog Filter Design: Classification of filters, Design of Butterworth, Chebyshev, Elliptical LPF, inverse Chebyshev filter, Bessel function, Comparison of analog filters and Frequency transformation.

ELECTRICAL MACHINES-II

Three Phase Induction Motors: Review of construction and principle of operation of three phase induction motor, Development of equivalent circuit. Torque equation, Torque-slip characteristics, No load and blocked rotor tests, Starters, Double cage and Deep bar motors. Cogging and crawling. Operation of Induction motor as induction generator. Single Phase Induction Motors - Principle of operation and Starting methods.

Special Machines - Permanent magnet motors, Brushless d.c. motor, Switched reluctance motor, and Stepper motors.

Synchronous Generators: Constructional features, EMF equation, Winding factors, Armature reaction. Leakage reactance, Synchronous impedance, Equivalent circuit. Phasor diagram, Voltage regulation by EMF, MMF, ZPF and ASA methods, Two reaction field theory and Phasor diagram for salient pole machines and slip test. Expressions for power developed and Power input.

Synchronization: Synchronizing power and torque, Parallel operation of two alternators and load sharing, Effects of constant input and variable excitation, Constant excitation and variable input, Alternators on infinite bus, V-curves.

Synchronous motors: Construction, Principle of operation, V-curves, Hunting. Starting methods and Synchronous condenser.

ELECTROMAGNETIC THEORY

The Co-ordinate Systems and revision of vector calculus- Electrostatics: Electric Flux and Flux Density; Gauss's law -Energy and Potential. - Capacitors and Capacitances- Method of Images. Steady Electric Currents: -The Equation of Continuity. Joules law- Magnetostatics: The Biot-Savart law. Amperes' Force Law - Magnetic Vector Potential.- Ampere's Circuital law.

Faraday's Law of Induction; Self and Mutual inductance. Maxwell's Equations from Ampere's and Gauss's Laws. Maxwell's Equations in Differential and Integral forms; Equation of Continuity. Concept of Displacement Current. Electromagnetic Boundary Conditions -Poynting's Theorem, Time – Harmonic EM Fields. Maxwell stress tensors.

Plane wave Propagation: Helmholtz wave Equation-Plane wave solution.-Plane wave propagation in lossless and lossy dielectric medium and conducting medium. Polarization of EM wave - Linear, Circular and Elliptical polarization. Boundary Conditions

Transmission Lines. LCR ladder model for transmission lines. The transmission line equation. - Solution for lossless lines. Wave velocity and wave impedence. Reflection and Transmission coeffcients at junctions. VSWR. Introduction to electromagnetic interference and compatibility.

GENERATION, TRANSMISSION & DISTRIBUTION OF ELECTRICAL POWER

Types of generation: Conventional and Non-conventional, Thermal Power Plant, Hydro Power Plant, Gas Power Plant, Nuclear Power Plant, Costing and comparision, Co-generation and Various sources of Non-Conventional Energy Sources.

AC Transmission: Typical AC transmission and distribution scheme, Standard Voltages- Advantages and limitation of AC high voltage transmission, Feeders, Distributors end service mains- Effect of working voltage on feeders and distributors, IE rules regarding permitted voltage variation, Selection of ACSR conductor size by voltage drop method, Kelvin's law, Merits and Demerits.

Line Parameters: Calculation of inductance and capacitance of single phase line and three phase lines with symmetrical and unsymmetrical spacing, Transposition, GMD, GMR and their applications in the inductance and capacitance calculations.

Line Performance: Short and medium lines, Nominal T & PI models, Rigorous solution for long lines, ABCD constants, Equivalent T and PI circuits and Regulated system of transmission by reactive power control.

Corona: Phenomenon, Critical voltages, Factors affecting corona and Corona loss.

Underground Cable: Insulating Materials used - PVC, Paper, XLPE comparison, Constructional features of cables PVC, Paper insulated, XLPE, Electrostatic stress, Capacitance and insulation resistance of single core cables and Capacitance of 3- core cables.

Mechanical Characteristics of Overhead (OH) lines: Sag calculations in conductor's level supports and supports at different levels, Effect of wind and ice, Tension and sag at erection and Stringing chart.

Insulators: Types, Constructional features, Potential distribution in a string of suspension insulators, Methods of equalizing the potential, String efficiency and Testing of insulators.

ANALOG SYSTEMS DESIGN

Feedback Amplifiers: Classification, Concepts, Feedback amplifier topologies. Properties of negative feedback amplifier, Classifications, (Voltage series, Voltage shunt, Current series, Current shunt), Properties of negative feedback amplifiers, Effect of feedback on R_i, R_o and bandwidth. Advantages of negative feedback.

Oscillators: R-C, Phase-Shift, Wein bridge using operational amplifier, Crystal oscillators.

Operation Amplifier: Architecture, Two-stage architecture, Gain stage with active load, Small signal model the differential stage, D.C. level shifting, Current mirror, Offset voltage and current, CMRR frequency response, Compensation, Bandwidth consideration, Offset voltage and current and Slew rate limitations.

OPAMP Applications: Inverting, Non-inverting amplifier, Voltage follower, Integrator, Differentiator, Summing amplifier, Differential amplifier, Phase shifter, Voltage to Current converter, Active filters- Low pass, High pass, Band pass, Band reject and All pass filters. (Butterworth)

Non-Linear Applications of OPAMPS- Comparator, Schmitt Trigger, Stable multivibrator, Monostable multivibrator, Triangular wave generator, Precision rectifier, Peak detector, Zero crossing detector, Square wave generator, Ramp generator, V/f and f/V

Other Linear IC: 555 Timer, Architecture, Applications, (Astable multivibrator, Monostable multivibrator, Schmitt trigger ramp generator), Phase locked loops and Voltage controlled oscillators.

POWER ELECTRONICS

Silicon Controlled Rectifiers (SCR): Basic structure, Equivalent circuit, Operation. V-I characteristics, turn-on, turn-off mechanisms, gate characteristics, gate drive requirements, firing circuits, di/dt, dv/dt and overload protection, committing circuits: Resonant commutation, complementary commutation, auxiliary commutation, calculation of committing components, series- parallel connection of SCRs, causes for unequal distribution of voltages and currents, string efficiency, static and dynamic equalization circuits.

Other Power Semiconductor Devices: Triac, Power MOSFET, IGBT – Basic structure, Equivalent circuit, operation, terminal characteristics, safe operating area (SOA), device rating. Base/Gate drive requirements, typical drive circuit with short circuit protection, turn on and turn off snubbers and their design.

Single phase converters: Half wave, bridge converters, operation with RL and back emf loads, performance with free wheeling diode, full wave controlled bridge rectifier with controlled free wheeling, effect of source inductance.

Three Phase converters : Trigging sequence, semi controlled and fully controlled three-phase converters.

Dual converters: Single phase and three dual converters, mode of operation –circulating and non circulating. Circulating current.

AC regulators: Single-phase AC voltage regulators.

DC-DC Converters: Basic principle of time ratio control, constant and variable frequency, Step down and step up chopper, classification of choppers. Multiphase choppers.

DC-AC Converters: Single phase and three phase bridge inverters, square wave operation, 120 and 180 degree modes, potential diagrams. Qualitative treatment of line commutated inverters.

PWM Inverters: Voltage control, Unipolar and Bipolar voltage switching, Harmonic reduction.

PWM Technique: Current regulated (Hysteresis) Modulation, Selective harmonic elimination, sine triangular modulation, linear modulation. over modulation, Harmonics in the output voltage, stair case PWM, space vector modulator.

LINEAR CONTROL SYSTEMS

Introduction to Control systems, Classification, comparison of open-loop and closed-loop systems, Representation of control systems by block diagrams, Mathematical models of electrical, mechanical and electromechanical systems, Transfer function and it realization using OP-AMP and block diagram representations of dc generator, dc and ac servomotors, servomechanisms. Block diagram reduction, signal flow graphs, Masons gain formula, limitations of mathematical models.

Time Response: Step response of first - and second - order systems, under damped system response, over damped, critically damped system - time domain specifications, Concept of order of system, type of systems. Steady state errors, Error ratio, Static error Constants, Generalized error series. dynamic error coefficients, steady state errors due to Impulse, step, ramp and parabolic inputs. Frequency response of a system, frequency domain specifications. Different types of controller, Proportional control, proportional-plus- integral control, proportional-plus-derivative control. proportional-plus- integral-plus-derivative control, their realization. Tuning the controllers - ziegler and Nicholas methods.

Stability- Concept and definition, BIBO stability, location of the roots of the characteristic equation in the S-plane, Routh-Hurwitz stability criterion, Bode Magnitude and phase plots, Concept of gain margin and phase margin. Root locus method, Magnitude and angle criteria, Root locus construction rules for positive K, interpretation of nature of system response from root locus plots. Polar plots, Nyquist criterion for stability, Nyquist diagrams.

Control system design, design specifications, series compensation, phase- lag and phase-lead compensation - frequency response approaches, lag-lead compensation.

Introduction to control machines – Synchro and Tachometers.

MICROPROCESSOR AND MICROCONTROLLER

Introduction to Microprocessor architecture, Memory Mapping.

8085 CPU Architecture, Signal descriptions, 8085 system,8085 Instruction Set, addressing modes, Programming using 8085 Instruction set, Instruction cycle, Machine cycles, Timing diagrams.

Interfacing Devices- Tristate devices, Buffers. Latches, 74 LS 138, 74 LS 245, 74 LS 148, 74 LS 373.

Hardware Interfacing-interfacing memory, Interfacing I/O: Memory mapped and I/O
Mapped

8085 Interrupts system.

Interfacing ADC AD558 and Interfacing DAC using status check with 8085.

Peripherals:

Programmable PPI 8255

Programmable Interval Timer- 8253.

Introduction to DMA with relevance to 8085 CPU& DMA Controller- 8257.

USART -8251.

Interfacing these peripheral to 8085 CPU and their applications.

Introduction to Micro controller architecture:

8051/8052/8031micro controllers Architecture,

Memory addressing,

Addressing modes, Instruction Set,

I/OPort programming, Timer/Counter Programming, Interrupt programming

DIGITAL SYSTEM DESIGN

Review *of* Sequential Machine Fundamental: Concept of memory, general model of sequential machine and classifications, clocked flip flop, SR, D, T arid JK flip- flops,

Excitation tables, Practical clocking aspects, timing and triggering considerations.
Analysis and Design of synchronous sequential finite state machines: ASM charts, synchronous analysis process, Design approaches, state reduction, design *of* next state-decoder and output decoder, design *of* counters and registers, code sequence detectors. sequential code generators,
Introduction to system controller design: System controller state specification (MDS diagram), timing and frequency considerations, synchronizing systems, state assignments, implementation using ROM, PAL, PLA.
Linked state machines.
Analysis and Design *of* Asynchronous sequential Finite state Machines: Need for Asynchronous circuits, Analysis, Cycles and Races, Hazards, Map entered variable approaches to asynchronous design.
Introduction to VLSI: Benefits *of* integration, criteria for evaluating implementation styles, introduction to computer-aided- design.
Introduction to Modern Digital System Implementation options- Mask Programmable gate array, cell based integrated circuits.
Field programmable logic device: complex PLDs, field programmable gate *arrays.*
Interfacing Units: Sampling, as aliening, antialiasing filters, sample and hold circuits, DACs, resistive ladder networks, (Weighted R, R-2R Net works), characteristics *of* DACs.
Methods *of* A/D conversions: simultaneous conversion, counter method, continuous A/D dual slope A/D successive approximation technique, characteristics *of* ADCs. Data acquisition systems.

PRINCIPLES OF COMMUNICATION

1. Introduction to Communication Systems:
Elements of a general communication system, frequency translation and its need, internal and external noise.
2. Analog Modulation:
Amplitude Modulation, generation and detection of AM., DSB-SC and SSB-SC, VSB, FDM.
3. Angle Modulation:
Phase and frequency modulation, generation and detection of FM Signal NBFM and - WBFM, Pre-emphasis and De-emphasis circuits.
4. Pulse Modulations:
Sampling of analog signal, Sampling theorem, PAM, PPM, Channel band width, TDM Pulse code modulation. Delta and adaptive Delta Modulation. Companding Channel Capacity.
5. Digital Modulation:
Binary communication, On-Off Keying, Frequcncy Shift Kcying(FSK), Phase shift keying(PSK), Detection of binary signals, Multi symbol signaling, Quadrature Amplitude Modulation(QAM),
6. Data Communication:
Analog and Digital Data, Transmission Media. Asynchronous and Synchronous Transmission, Error detection techniques, Interfacing, Local Networks: Local Network technology, Bus/Tree topology, Ring topology, Medium Access Control Protocols: Bus/ tree topology-token Bus, Ring topology- token ring, IEEE 802 Ring LAN standard, FDDI Ring.
7. The OSI Model
The Model Layered Architecture; Function of the layers – Physical Layer, Data Link Layer, Network Layer, Transport Layer, Session Layer, Presentation Layer, Application Layer, Summary of Layer Functions.
TCP/IP Protocol Suite

POWER SYSTEM ANALYSIS

Representation of power systems: One line diagram, impedance & reactance diagrams.
Per unit notation selection & change of base for per unit quantities.Thevenin's model for
power system, equivalent circuit in permit of three winding transformers, fixed tap changing transformers with off- nominal turns ratio. Network reduction using matrix algebra.
Formation of Y bus Z bus matrices, Z bus algorithm, measurement of elements of Y and Z matrices, significance.Symmetric three phase Short circuit calculations using Z bus.
Symmetrical 3 phase faults: Short circuit currents and reactance of Synchronous machines. Short circuit current calculations of unloaded & loaded Generators and power systems.Selection of circuit breakers, current-limiting reactors.Sequence components of line and phase voltages and currents of star-delta transformer banks. Sequence impedance's and networks of power system elements. Analysis of unsymmetrical faults in generator and power system under no load.Load flow studies: Formulation of Load flow equations, types of buses. Load flow solution techniques (using bus only) Gauss-Seidel, Newton Raphson (in polar coordinates only), Acceleration factors.Decoupled, fast decoupled method.

POWER SYSTEM STABILITY, OPERATION AND CONTROL

Introduction: Operating states, Preventive and emergency control, Megawatt-frequency and megavar-voltage interaction.

Load Frequency Control: Introduction, Speed governing system and modeling, Turbine modeling, Generator-load modeling, Steady-state and dynamic response of ALFC loop, The secondary ALFC loop, Integral control.

Multi Control Area System: Introduction, Pool operation, Two area systems, Modeling of tie line, Static and dynamic response of two area system, Tie-line bias control, Tie-line control, Digital electrohydraulic (DEH) control system, Implementation of DEH system.

Reactive Power Control: Introduction, Methods of voltage control, Power capacitors and its application to distribution and transmission system, Static var system.

Excitation System: Introduction, Elements of an excitation system, Types of excitation system, Digital excitation system.

Power System Security: Introduction, Factors affecting power system security, Introduction to contingency analysis.

Power System Restructuring: introduction, Regulation vs. Deregulation, Competitive Market for Generation, The Advantages of Competitive Generation, Electric Supply Industry Structure Under Deregulation in India. Restructuring Models.

Power System Stability: Introduction to Power system Stability **c**lassification, Small signal and Transient stability, Rotor angle & Voltage Stability. Stability problem, swing equation and its numerical solution, Determination of initial state in a multi-machine system, Base case Y BUS and modified Y BUS, Computational algorithm, Improvement of stability.

ADVANCED CONTROL THEORY

Sampled Data Control Systems, Sampling process, ideal sampler, Sample hold circuit, Shannon's sampling theorem, zero order hold. The Z transform, mapping between s and z domains, definition and evaluation of z-transforms, the inverse z-transform, theorems and properties of z-transforms, the pulse transfer function, pulse transfer function of ZOH, System stability, z-plane stability, Jury's test, Bilinear transformation.

State space analysis, Concept of State, State Vector, State models, State models of electrical, Realization of state models from transfer functions, controllable canonical from and observable canonical form, cascade realization, parallel realization Hamilton theorem, properties for state transition matrix discrete time state equation, state diagrams, realization of pulse transfer functions.

Nonlinear Systems, Introduction, Commom Physical Non linearities, Limit Cycle, The Phase Plane Method: Basic Concept, Singular Points, Stability of Nonlinear Systems, The Describing function Method: Basic Concept , Derivation of Describing Functions, Stability Analysis by Describing.

EHV AC & DC TRANSMISSION

Aspects of EHV AC and DC transmission. General Background and State of art of EHV AC Transmission Technology Bundled conductors, Maxwell's Coefficients, Inductance and capacitance matrices Surface Voltage gradient on bundled conductors, Mangoldt's formula, Gradient factors. Corona Effects : Power Loss, Audible noise, BI & TVI. Ground level electrostatic field of EHV Lines. Switching over-voltages in EHV Systems. Introduction to FACTS.

Introduction to HVDC transmission: Comparison with EHV AC power transmission, HVDC system configuration and components. Principles of AC/DC conversion: Converter connections, Wave forms, Relevant Equations, Reactive Power requirements.

Harmonics and Filters : Waveforms of a-c bus currents in Star/Star, Star/delta & 12-phase converters and their Fourier-series representations, Non-characteristic harmonics, Harmful Effects of Harmonics, DC side harmonics, Filters and detuning, Cost considerations of filters.

HVDC system control : CC and CEA controls, Static characteristics of converters, Combined characteristics of rectifier and inverter, Power reversal, Asynchronous & synchronous HVDC links, Frequency Control of A.C. system, Stabilisation & damping of A.C. networks, CP Control.

HVDC systems elements: Converter transformers, D.C. smoothing reactors, Thyristor valves etc., Earth electrodes & earth return

RENEWABLE ENERGY SYSTEMS

Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts. Global environmental concern, Kyoto Protocol, Concept of Clean Development Mechanism (CDM) and Prototype Carbon Funds (PCF). Factors favoring and against renewable energy sources, IRP

Solar Energy: Solar thermal Systems and power generation: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, - solar cells , cell technologies, PV power generation, characteristics of PV systems, equivalent circuit, array design , building integrated PV system, its components , sizing and economics. Peak power operation, Solar tracking system, Standalone and grid interactive systems.

Wind Energy: Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Turbine rating Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation, On shore and off shore wind energy.

Hydro energy: Feasibility of small, mini and micro hydel plants scheme layout economics. Tidal and wave energy, Geothermal and Ocean-thermal energy conversion (OTEC) systems – schemes, feasibility and viability.

Energy storage and hybrid system configurations: Energy storage: Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators, battery management, flow batteries. Fly wheel- energy relations, components, benefits over battery. Fuel Cell energy storage systems. Ultra-Capacitors.

Grid Integration: Grid integration with the system: Interface requirements, Stable operation, Transient-safety, Operating limits of voltage, frequency, stability margin, energy storage, and load scheduling.

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

ELECTRICAL DRIVES

ELECTRIC DRIVES RATINGS:

Advantages of Electric drives, Factors affecting the choice of electric drives, Methods of closed loop control of drives, Selection of motor power rating, Thermal model of motor for heating and cooling, classes of motor duty, determination of motor rating, equivalent current, torque and power methods, short time duty, intermittent duty.

DC MOTOR DRIVES:

Performance characteristics of dc series, shunt and compound motors, Braking - Regenerative, dynamic and plugging.

Transient analysis of separately excited motor with armature voltage control, Starting, dynamic braking and energy loss.

SPEED CONTROL OF D.C. DRIVES: Armature voltage control, Flux control, Armature resistance control, Methods of speed control of single phase and three phase converter fed separately excited dc motor(Block diagram approach only), Speed control of chopper fed dc motor (Block diagram approach only), Four quadrant dc drive. Performance and control of static converters.

AC MOTOR DRIVES:

Induction motor drive: Performance characteristics of squirrel cage and slip ring induction motors, Braking - Regenerative, Dynamic and Plugging.

Transient analysis - Starting and Plugging, Calculation of energy loss. Speed control - Stator voltage control, Slip power recovery, E/f, V/f and flux weakening methods.

Synchronous motor drive: Starting and speed control of synchronous motor, reluctance motor, permanent magnet motor.

SWITCHGEAR AND PROTECTION

Functions of protective relaying, Fundamental characteristics of relays, Standard definition of relay terminologies, Relay classifications, operating principles of single and double actuating quantity type electromechanical relays. Directional relay, reverse power relay. Differential protection schemes for Bus bars, Transformer and Alternator. and transformers. Buchholtz relay for Transformer protection.

Alternator protection: Negative phase sequence relay, Loss of field protection, Reverse power protection.

Line protection: Various types of Distance relays, performance of distance relays, Distance protection schemes, Carrier current relaying.

Induction Motor Protection: Abnormal operating conditions, Contactors and circuit breakers for motors, Under voltage protection, phase and Earth fault protection, Overload protection, Single phasing preventer.

Solid state relays: Phase and amplitude comparators, Duality between phase and amplitude comparators, general equation for comparators, realization of directional, ohm, reactance, impedance and mho characteristics using general characteristic equation. Qualitative concepts of switched and non-switched scheme of static distance relays.

Computer aided relaying: Introduction to microcomputer based relays, Digital Protection general functional diagram of micro computer based relays. Advantages over conventional relaying techniques.

Types of System Transients: Surge phenomena, type and magnitude of switching and lightning over voltages.

Methods of over voltage protection –rod gap,valve,ZnO type-construction, working merits and applications, voltage and current ratings, residual voltage, selection of lightning arrestors. Insulation Coordination, BIL. Volt time characteristic Protection of transmission lines against over voltages.

Fuses and switches: Rewirable fuses HRC features , construction, fuse elements , phenomena of cut off , selection of fuses , comparison of fuses and circuit breakers, grading ,overt current and short circuit protection.

Neutral grounding- capacitor coupling, disadvantages of ungrounded systems, effectively grounded, resistive and reactive grounding. Neutral grounding practices-

Circuit breakers- principle of working, arc phenomenon, methods of arc extinction, recovery and restriking voltage.

Circuit breaker ratings- breaking capacity , making capacity, various times associated with circuit breakers,

Construction, principle of working, merits and application oil circuit backers/air circuit breakers/ MCCBs/MCBs.

Physical chemical and dielectric properties of SF6, principle, construction of different types including puffer type, working, merits and application of SF6 breakers. SF6 field switchgear and gas insulated substations.

Physical and dielectric properties of vacuum, arc extinction in vacuum, construction, shape of electrodes, sealing merits and application of vacuum circuit breakers.

DC circuit breaker, principle and construction, working and application. Selection of CBS, Applications, Setting.

DIGITAL SIGNAL PROCESSING

The concept of frequency in continuous time and discrete time signals. The sampling theorem. The Sampling theorem. Analysis of Digital Signals and systems versus Discrete- Time signals and systems. Time domain characteristics of LTI Discrete-Time Systems. Finite-Dimensional LTI Discrete-Time System. Correlation of Discrete-Time Signal, Linear Convolution.

The Discrete-Time Fourier transform, the Discrete Fourier transform, relation between DTFT and DFT and their properties, Inverses, Circular Convolution, Linear Convolution using DFT, the Z-Transform, properties, Inverse frequency response of finite-Dimensional Discrete-time systems, the transfer function, types of transfer function, simple digital filters.

Sampling of continuous-time signals, Analog low pass filter Design, Design of Analog High pass, Band pass and Band stop filters. Basic FIR and IIR Digital filter structure. Bilinear transformation method of IIR filter Design of low pass IIR Digital filters. Design of High pass, Band stop, and Band pass IIR Digital filters. Spectral transformation of IIR filters. FIR filter Design using windowed Fourier series and with least-mean square error. FFT Algorithm, Dual-tone Multi frequency Signal Detection., Introduction to Multirate and wavelets.

MODERN POWER CONVERTERS

Introduction to switched mode power converters

Generalized comparison between switched mode and linear DC regulator; Operation and steady state performance of Buck, Boost, Buck-Boost and Cuk Converters in continuous-conduction mode, discontinuous-mode and boundary between continuous and discontinuous mode of operation; Output voltage ripple calculation; Effect of parasitic elements.

DC-DC converters with Isolation

Fly back converters and its topologies; Forward converters - Switching transition; Push-pull converter-Switching transition, limitation of the push-pull circuit; Half-bridge and Full bridge DC-DC converters – their switching transitions.

Resonant Converters

Introduction and classification; Load resonant - series and parallel loaded converters in continuous and discontinuous mode of operation; Hybrid resonant DC-DC converters; zero current switch (ZCS); zero voltage switch(ZVS); ZCS- clamped voltage converters(ZCS-CV).

Single - Phase AC-DC Converters

Half wave- bridge converters; its operation with RL and back-EMF loads; performance with free-wheeling diode; Full-wave controlled-bridge rectifier with controlled free wheeling, effect of source inductance.

Three - Phase AC-DC Converters

Trigging sequence, self starting, operation, transformer connections and ratings; DC magnetization, Dual converters.

DC-AC Converters

Voltage source and current source inverter; single-phase and three-phase bridge inverters; square wave operation, 120 and 180 degree modes; potential diagrams.

PWM Inverters

Voltage control, Unipolar and Bipolar voltage switching, Harmonic reduction.

PWM Technique

Current regulated (Hysteresis) Modulation; Selective harmonic elimination; sine triangular modulation; linear modulation; over modulation; harmonics in the output voltage, stair case PWM, space vector modulator.

Cycloconverters and AC regulators (Three-phase and single-phase).

Power conditioners and uninterruptible Power supplies

Types of UPS- Redundant and Non-Redundant UPS.

ELECTRICAL MACHINE DESIGN

Principal Laws and Methods in Electrical Machine Design - Electromagnetic Principles, Application of the Principle of Virtual Work in the Determination of Force and Torque, Maxwell's Stress Tensor; Radial and Tangential Stress. Windings of Electrical Machines- Basic Principles, Salient-Pole Windings, Slot Windings, End Windings, Phase Windings Design of Magnetic Circuits- Air Gap, Core Length, Magnetic Materials of a Rotating Machine, Permanent Magnets, Flux Leakage, Resistances, DC Resistance, Influence of Skin Effect on Resistance.

Main Dimensions of a Rotating Machine- Mechanical, Electrical and Magnetic Loadability, Air Gap. Design Process and Properties of Rotating Electrical Machines- Asynchronous Motor, Synchronous Machine. Insulation of Electrical Machines - Dimensioning of an Insulation. Heat Transfer- Losses, Heat Removal, Thermal Equivalent Circuit.

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