Syllabus for Ph.D. Entrance Examination: Electrical Engineering

Section 1: Electric Circuit Theory and Network Analysis & Synthesis

Network reduction: voltage and current division, source transformation – star delta conversion. Thevenin and Norton Theorems – Superposition Theorem – Maximum power transfer theorem – Reciprocity Theorem –Millman's theorem.

A.C. circuits – Average and RMS value – Phasor Diagram – Power, Power Factor and Energy. - Analysis of three phase 3-wire and 4-wire circuits with star and delta connected loads, balanced & unbalanced – phasor diagram of voltages and currents – power measurement in three phase circuits.

Series and parallel resonance – their frequency response – Quality factor and Bandwidth – Self and mutual inductance – Coefficient of coupling –Tuned circuits – Single tuned circuits.

Network solution methods: nodal, mesh analysis and different network theorems for ac circuits. Magnetically coupled circuits. Network topology. Time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform. Frequency domain analysis of RLC circuits. 2-port network parameters: driving point and transfer functions. Passive filter as a two-port network. Fundamental of network synthesis. Fourier series and transform. Synthesis of R-L-C function. Digital filter design techniques.

Section 2: Signals and Systems

Signals and Systems Representation of continuous and discrete time signals, shifting and scaling properties, linear time invariant and causal systems, Fourier series representation of continuous and discrete time periodic signals, sampling theorem, Applications of Fourier Transform for continuous and discrete time signals, Laplace Transform and Z transform. R.M.S. value, average value calculation for any general periodic waveform

Section 3: Electrical Machines

Electrical Machines Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three-phase transformers: connections, vector groups, parallel operation; Auto-transformer, Electromechanical energy conversion principles; DC machines: separately excited, series and shunt, motoring and generating mode of operation and their characteristics, speed control of dc motors; Three-phase induction machines: principle of operation, types, performance, torque-speed characteristics, no-load and blocked-rotor tests, equivalent circuit, starting and speed control; Operating principle of single-phase induction motors; Synchronous machines: cylindrical and salient pole machines, performance and characteristics, regulation and parallel operation of generators, starting of synchronous motors; Types of losses and efficiency calculations of electric machines

Section 4: Power Systems

Introduction to Power System generation, transmission and distribution. Element of AC distribution, Single fed, double fed and ring main distributor. Transmission line parameters and their evaluations, types of overhead conductors with calculations of inductance and capacitance. Models of short, medium and

long transmission lines, skin, proximity and Ferranti effect. Classification of cables, Cable conductor's, insulating materials, insulation resistance, grading of cables;

Per unit Representation of power Systems: Fault Analysis (Balanced Faults): Faults, types of faults, symmetrical 3-phase balanced faults, calculation of fault currents, current limiting reactors. Fault Analysis, (unsymmetrical faults) Symmetrical components, sequence impedances, sequence networks, unsymmetrical faults-single line to ground, line to line, double line to ground faults on unloaded alternators and on power systems. Insulation Co-ordination. Surge performance of Transmission lines: Traveling waves on transmission lines, open end line, short-circuited line, line

Terminated through a resistance, line connected to a cable. Interference of Power Lines with communication Circuit.

Load Flows: Nature and importance of the problem, Network model formulation, algorithm for the formulation of Y-bus matrix, formulation of Y-bus by singular transformation, primitive network, Bus incidence matrix, load flow problem, load flow equations, bus classification, gauss – seidel & Newton-Raphson method for solving load flow problem, Power System Stability: The stability problem, steady state, dynamic and transient stability, rotor dynamics and swing equation, power angle curve, equal-Area criterion of stability, Numerical solution of swing equation, Factors affecting transient stability, Automatic Generation Control: Real power balance and its effect on system frequency, load frequency control of single area system-speed governing system. Control of voltage and Reactive Power: Methods of voltage control-injection of reactive power, tap changing transformers, booster transformers, phase-shift transformers. Economic Operation of Power System. Power System protection, over current, overvoltage, Differential protection, Distance relays.

Section 5: Control Systems

Control Systems Mathematical modeling and representation of systems, Feedback principle, transfer function, Block diagrams and Signal flow graphs, Transient and Steady-state analysis of linear time invariant systems, Stability analysis using Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; state space model, Solution of state equations of LTI systems.

Section 6: Electrical Measurements and Instrumentation

Electro-mechanical indicating instruments, Classification, effects utilized in measuring instruments, errors and their types, various methods of damping, galvanometers (D' Arsenal and Ballistic) Ammeters and Voltmeters (PMMC, Induction, electrostatic and Dynamometer type), errors in voltmeters and ammeters, extension of instrument range, ammeter shunts, voltmeter multipliers, Measurement of Power, Energy and Power Factor Measurement of reactive power

(Single phase and 3-phase), Energy measurement using induction type classification, Wheatstone bridge, Meggar, Measurement of inductance, Capacitance and Frequency using a. c bridges, Potentiometers; D.C. instrumentation: Introduction of virtual instrumentation. Measurement of Electrical and non-electrical quantitates using virtual instruments control System. Renewable Energy: Solar, wind and Hybrid.

Section 7: Analog and Digital Electronics

Analog and Digital Electronics Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: biasing, equivalent circuit and frequency response; oscillators and feedback amplifiers; operational amplifiers: characteristics and applications; single stage active filters, Active Filters: Sallen Key, Butterwoth, VCOs and timers, combinatorial and sequential logic circuits, multiplexers, demultiplexers, Schmitt triggers, sample and hold circuits, A/D and D/A converters.

Section 8: Power Electronics

Power Electronics Static V-I characteristics and firing/gating circuits for Thyristor, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost Converters; Single and three-phase configuration of uncontrolled rectifiers; Voltage and Current commutated Thyristor based converters; Bidirectional ac to dc voltage source converters; Magnitude and Phase of line current harmonics for uncontrolled and thyristor based converters; Power factor and Distortion Factor of ac to dc converters; Single phase and three-phase voltage and current source inverters, sinusoidal pulse width modulation. Multilevel Inverters, Advanced Modulation Techniques, Resonant & Soft-switching Converters, Isolated DC-DC converters, and Control of Converters, Gate Driver and Protection circuits, Power System Applications, Industrial Applications, AC & DC drives.