## DEPARTMENT OF ELECTRICAL AND COMPUTER SCIENCE ENGINEERING

## Discipline: Electrical Engineering

## Syllabus for written test for PhD Admissions

**Part-I [50% weight]**

### Research Methodology

Concepts and methods of engineering research, use of ICT and soft tools in research, research ethics, formulating the research problem, literature review, research design, collection-processing-analysis of data, reasoning, documentation-presentation-dissemination of research, intellectual property rights and scholarly publishing.

**Part-II [50% weight]**
**ANY ONE of the following seven sections to be attempted as per the choice of the candidate**

### Section A – Electronics

- **Electronic Devices:** Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors; Carrier Transport: diffusion current, drift current, mobility and resistivity, generation and recombinationof carriers, Poisson and continuity equations; P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell
- **Analog Circuits:** Diode circuits: clipping, clamping and rectifiers; BJT and MOSFET amplifiers: biasing, ac coupling, small signal analysis, frequency response. Current mirrors and differential amplifiers; Op-amp circuits: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers and oscillators.

### Section B – Communication Systems

- Amplitude modulation and demodulation, angle modulation and demodulation, Random variables and random process, autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems. PCM, DPCM, digital modulation schemes (ASK, PSK, FSK), matched filter receiver. Fundamentals of error probability in digital communication systems.

### Section C – Drones and Communications

- **Drones:** Basics of Drones, Assembly, Calibrations and Different types of sensors, Regulations.
- **Analog communications:** amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, super heterodyne receivers.
- **Information theory:** entropy, mutual information and channel capacity theorem.
- **Digital communications:** PCM, DPCM, digital modulation schemes (ASK, PSK, FSK, QAM), bandwidth, inter-symbol interference, MAP, ML detection, matched filter receiver, SNR and BER. Fundamentals of error.

### Section D – Signals, Systems and Processing

- Signal Classification, continuous & discrete time signals, basic operations on signals, classification of systems, linear time invariant (LTI) systems, properties of LTI systems, impulse response, convolution, causality, stability, Fourier Analysis, Fourier Series for periodic signals, Properties of Fourier Series, Gibbs Phenomenon, Fourier transform, properties of Fourier transform, Laplace transform, properties of Laplace transform.
- z-transform, properties of z-transform, Discrete time Fourier transform (DTFT), properties of DTFT, Discrete Fourier transform DFT, FFT, sampling, sampling theorem, Design of FIR and IIR filters: Bilinear Transformation and windowing methods of filter design.

### Section E – Power Systems, Electrical Machines & Power Electronics

- **Power Systems:** Generation, voltage and frequency control, transmission systems, performance of overhead transmission lines and underground cables, transmission line compensation, distribution systems, per-unit quantities, load dispatch, power factor correction, symmetrical components, fault analysis, protection.
- **Electrical Machines:** Operation and performance of single-phase and three-phase transformers; principle of electromechanical energy conversion; operation, characteristics, and speed control of dc machines; operation, performance, characteristics, and speed control of three-phase induction machines; Operating principle of single-phase induction motors; Operation, performance and characteristics of synchronous machines.
- **Power Electronics:** power semiconductor devices operation and characteristics; operation-control-applications of dc-dc, ac-dc, and dc-ac converters.

## Section F – Control Systems

- **Engineering Mathematics:**
  - **Linear Algebra**: Vector space, basis, linear dependence and independence, matrix algebra, eigenvaluesand eigenvectors, rank, solution of linear equations- existence and uniqueness.
  - **Calculus:** Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.
  - **Differential Equations**: First order equations (linear and nonlinear), higher order linear differential equations, Cauchy's and Euler's equations, methods of solution using variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.
  - **Vector Analysis**: Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stokes' theorems.
  - **Complex Analysis**: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, sequences, series, convergence tests, Taylor and Laurent series, residue theorem.
  - **Probability and Statistics**: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normaldistribution, joint and conditional probability

- **Control Systems:** Basic control system components; Feedback principle; Transfer function; Block diagram representation; Signal flow graph; Transient and steady-state analysis of LTI systems; Frequency response; Routh-Hurwitz and Nyquist stability criteria; Bode and root-locus plots; Lag, lead and lag lead compensation; State variable model and solution of state equation of LTI systems.

## Section G – Signals and Image Processing

- **Engineering Mathematics:**
  - **Linear Algebra**: Vector space, basis, linear dependence and independence, matrix algebra, eigenvaluesand eigenvectors, rank, solution of linear equations- existence and uniqueness.
  - **Calculus:** Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.
  - **Differential Equations**: First order equations (linear and nonlinear), higher order linear differential equations, Cauchy's and Euler's equations, methods of solution using variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.
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  - **Complex Analysis**: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, sequences, series, convergence tests, Taylor and Laurent series, residue theorem.
  - **Probability and Statistics**: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normaldistribution, joint and conditional probability

- **Networks, Signals and Systems:**
  - **Circuit analysis**: Node and mesh analysis, superposition, Thevenin's theorem, Norton's theorem, reciprocity. Sinusoidal steady state analysis: phasors, complex power, maximum power transfer. Time andfrequency domain analysis of linear circuits: RL, RC and RLC circuits, solution of network equations usingLaplace transform.
  - Linear 2-port network parameters, wye-delta transformation.
  - **Continuous-time Signals**: Fourier series and Fourier transform, sampling theorem and applications.
  - **Discrete-time Signals**: DTFT, DFT, z-transform, discrete-time processing of continuous-time signals. LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeroes, frequency response, group delay, phase delay

- **Electronic Devices:**
  - Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors.
  - **Carrier Transport**: diffusion current, drift current, mobility and resistivity, generation and recombinationof carriers, Poisson and continuity equations.
  - P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell

- **Analog Circuits:**
  - **Diode circuits**: clipping, clamping and rectifiers.
  - **BJT and MOSFET amplifiers**: biasing, ac coupling, small signal analysis, frequency response. Current mirrors and differential amplifiers.
  - **Op-amp circuits**: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers and oscillators
- **Digital Circuits:**
  - **Number representations**: binary, integer and floating-point- numbers. Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders.
  - **Sequential circuits**: latches and flip-flops, counters, shift-registers, finite state machines, propagation delay, setup and hold time, critical path delay.
  - **Data converters**: sample and hold circuits, ADCs and DACs.
  - **Semiconductor memories**: ROM, SRAM, DRAM.
  - **Computer organization**: Machine instructions and addressing modes, ALU, data-path and control unit, instruction pipelining