Written Test Format and Syllabus

Electronics and Communication Engineering, School of Electrical Sciences

Ph.D. Admission Test Format

The written test consists of two parts.

1. **Part A:** 10 questions on Basic Electronics and Signals and Systems.
2. **Part B**: In Part B, there are three sections based on specialization. Each candidate can choose one specialization and answer the questions. Each section contains 15 questions.

Part B Specializations

1. Communication Engineering
    - Analog and Digital Communication
    - Probability and Random Processes
    - Electromagnetic Theory
2. Signal Processing
    - Digital Signal Processing
    - Probability and Random Processes
    - Linear Algebra
3. VLSI Design and Microelectronics
    - Electronic Devices and Circuits
    - Digital Logic Design
    - VLSI Design

Ph.D. Admission Test Syllabus

Basic Electronic 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. Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates, arithmetic circuits, code converters, multiplexers, decoders. Sequential circuits: latches and flip-flops, counters, shift-registers, finite state machines.

Signals and Systems: 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.

Analog and Digital Communication: Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, superheterodyne

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 correction, Hamming codes, CRC.

Probability and Random Processes: Probability and Statistics: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normal distribution, joint and conditional probability. Random processes: autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems.

Electromagnetic Theory: Maxwell's equations: differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector. Plane waves and properties: reflection and refraction, polarization, phase and group velocity, propagation through various media, skin depth. Transmission lines: equations, characteristic impedance, impedance matching, impedance transformation, S-parameters, Smith chart. Rectangular and circular waveguides, light propagation in optical fibers, dipole and monopole antennas, linear antenna arrays.

Digital Signal Processing: Introduction to DSP, Signals and Systems Characterization, FIR and IIR : Recursive and Non Recursive, Z -Transform, Discrete Time Signals and Systems in Frequency Domain, Sampling, Quantization, Discrete Fourier Transform, Fast Fourier Transform, Short-time Fourier Transform, Digital Filter Structure, Analog Filter Design, Digital Filter Design.

Linear Algebra: Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and eigenvectors, rank, solution of linear equations- existence and uniqueness. Norm and its properties, inner product and its properties, Cauchy Schwarz inequality, eigen value decomposition, positive semidefinite matrices.

Electronic Devices and Circuits: Energy bands in semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors; Carrier transport: diffusion current, drift current, mobility and resistivity, Poisson, and continuity equations. P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photodiode, solar cell; Diode circuits; BJT and MOSFET circuits and amplifiers; current mirrors and differential amplifiers; op-amp circuits; feedback and oscillators.

Digital Logic Design: Binary arithmetic; Combinational circuits: Boolean algebra, minimization of functions; arithmetic circuits, code converters, multiplexers, decoders; Sequential circuits: latches and flip-flops, counters, shift-registers, finite state machines and timing; Data converters and semiconductor memories.

VLSI Design: Fabrication Technology: Basic steps of fabrication of CMOS; MOS transistor characteristics, MOS switch and inverter, Bi-CMOS inverter, latch-up in CMOS inverter, super-buffers, propagation delay models, switching delay in logic circuits; Logic Design: switch logic, gate restoring logic, various logic families and logic gates, PLA; Dynamic and sequential circuits: bi-stable circuit elements, CMOS SR latch, clocked latch and flip-flops; Semiconductor Memories: SRAM, DRAM, non-volatile memories.