

**PhD Entrance Exam Syllabus**  
**Advanced Devices, Circuits & Systems**

**Section 1: Engineering Mathematics**

Linear algebra, basic calculus, differential equations, and probability/statistics

**Section 2: 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 and frequency domain analysis of linear circuits: RL, RC and RLC circuits, solution of network equations using Laplace 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.

**Section 3: 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 recombination of carriers, Poisson and continuity equations.

P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell.

**Section 4: 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 5: Digital Logic and Processors**

Combinational Circuits: Number Representations and 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.

Verilog Hardware Description Language: Types of modelling: Gate-level, Data-flow, Behavioural modelling; Structural - hierarchical and modular modelling; Verilog implementation of combinational circuits/modules, sequential-logic circuits and RTL structures.

Data Converters: Sample and hold circuits, ADCs and DACs.

Semiconductor Memories: ROM, SRAM, DRAM.

Processor Architecture: Machine instructions and addressing modes; Building blocks of processor: Data memory, Instruction Memory, Register File, Address decoding, Arithmetic-logic Unit (ALU), timing pulse generator, Program Counter (PC), Stack Memory and stack pointers, I/O registers, control unit, data-path structures; Instruction pipelining, pipeline hazards. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

Assembly Language Programming; Multicore systems;

Microcontroller Interfacing: AVR internal architecture and features like GPIOs, timers/counters, interrupts, communication protocols (SPI, I2C, UART), A/D, D/A, Real Time Clock, PWM, and other peripherals; Embedded C programming;

## **Section 6: Communications**

Random Processes: Auto correlation and power spectral density, properties of white noise, filtering of random signals through LTI systems.

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 correction, Hamming codes, CRC.

## **Section 7: Electromagnetics**

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

## **Section 8: Power Systems**

Circuit Analysis: Nodal and Mesh analysis, Superposition theorem, Norton's theorems, Thevenin's theorem, RL, RC, and RLC transient analysis.

Electrical Machines: Transformers, Induction machines, Synchronous machines, and DC machines

Power electronics: DC-DC converters, DC-AC converters, AC-DC converters, and power-switching device characteristics.

Control System: Open loop and closed loop systems, block diagram reduction techniques, Time response analysis, frequency response analysis, Stability analysis, Root locus, and Bode plot.

### **Section 9: Optical and Electronic Materials**

Electronic Materials, Structure–property relationships in materials, Crystalline vs amorphous materials, Polymers, metals, ceramics and composites used in electronics, Semiconductor materials, Organic semiconductors and conductive polymers, Mechanical properties of electronic materials (elasticity, viscoelasticity, fracture), Basic principles of resistive, capacitive and piezoelectric sensors.

Optoelectronic Devices: (Solar cells, LED)

Nanomaterials/ Nanotechnology Quantum confinement effect, Surface-to-volume ratio, Types of Nanomaterials, Nano Materials Synthesis Methods.