Syllabus for Ph.D entrance Exam (Autumn 2015-16)

Note: There will be 100 multiple choice questions

Section A


Electromagnetics: Elements of vector calculus: divergence and curl; Gauss’s and stoke’s theorems, Maxwell’s equations: differential and integral forms. Wave equation, pointing vector. Plane waves: propagation through various media; reflection and refraction; phase and group velocity; skin depth. Transmission lines: characteristic impedance; impedance transformation; Smith chart; Impedance matching; S-parameters, pulse excitation. Waveguides: modes in rectangular waveguides; boundary conditions; cut-off frequencies; dispersion relations. Basics of propagation in dielectric waveguide and optical fibers. Basics of Antennas: Dipole antennas; radiation pattern; antenna gain.
Section B

**Fundamental Concept of Antenna:** Physical concept of radiation, Antenna parameters, Friis transmission equation, Radiation integrals and auxiliary potential functions.

**Radiation from Wires and Loops:** Infinitesimal dipole, Finite-length dipole and its properties, small circular loop.

**Aperture and Reflector Antennas:** Huygens’ principle, Radiation from rectangular and circular apertures, Horn antennas.

**Broadband Antennas:** Log-periodic and Yagi antennas, Frequency independent antennas.

**Microstrip Antennas:** Basic characteristics, Feeding methods, Methods of analysis, Design of rectangular and circular patch antennas.

**Antenna Arrays:** Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, Extension to planar arrays, Synthesis of antenna arrays using Schelkunoff polynomial method.

**Electromagnetic Scattering:** Maxwell's equation, interface conditions, constitutive equations, Wave Equations and Their Solutions, Volume Scattering by Dielectric Targets, Volume Equivalence Principle, Integral Equations, Surface Scattering by Perfectly Electric Conducting Targets.

**Radar Basics:** Radar equation, receiver noise, probability of detection and signal-to-noise ratio, receiver bandwidth, target cross-section and cross-section fluctuations, statistical description of RCS, antenna coverage and gain, system coverage and gain, system losses.

Amplitude model: Range equation and its distributed target forms; Clutter: Signal-to-clutter ratio, temporal and spatial correlation of clutter; Compound models for RCS: Noise model and signal to noise ratio; Frequency models: Doppler shift, simplified approach to Doppler shift, stop-and-hop assumption; Spatial model: Variation with angle and range, projections; Multi-path spectral models.

**Radio Frequency Integrated Circuits (RFICs) & Systems:** RF Network Analysis: Z, Y, ABCD and S-parameters and their properties, measurement of S-parameters of passive and active devices Transmission Lines for RFICs: Planar transmission lines e.g. strip lines, microstrip lines, coplanar waveguides, slot lines and their transmission properties. Discontinuities RFICs: Open, Short, Gap, Step, T junction and their equivalent circuits for RF Integrated circuits

Lumped Elements in RFICs: Thin film resistors, Spiral inductors, metal-insulator-metal capacitors, inter digital capacitors and transformers, LC resonators
Passive RFICs: Design of on chip/off chip filters, power splitters/combiners and couplers
RF System Fundamentals: Homodyne and heterodyne transceiver architectures, noise and non-linearity in RF system, link budget
Non Linear and Active RFICs: RF integrated circuits using nonlinear passive semiconductor devices (e.g. PIN diode based circuits, Schottkey diode based circuits), RF integrated circuits using nonlinear active devices such as low noise amplifiers, power amplifiers, active mixers and oscillators.

**Solid State Electronics:** Schrodinger equation and its solutions to simple cases, Energy band in solids, Fermi level, Carrier concentration under thermal equilibrium, and their temperature dependence, Extrinsic and Intrinsic Semiconductors, Carrier Transport in semiconductors, Drift, Diffusion, Excess carriers, Continuity equation, Poission's equation. p-n junction, Equilibrium Conditions, Forward and Reverse Biased Junctions, Zener Breakdown, Avalanche Breakdown, Schottky contacts, Ohmic contacts, BJTs

**VLSI Design Rules:** CMOS Process technology, Layout design Rules, CMOS process enhancements, Technology related CAD issues, Manufacturing issues

**VLSI Technology:** Crystal growth & Wafer preparation, Epitaxy, Diffusion, Lithography, Oxidation, Ion-implantation, Etching etc, Isolation Techniques, circuit fabrication.

**MOS Device Physics:** Long Channel MOSFETs, Drain Current Model, IV Characteristics, Subthreshold Characteristics, Substrate Bias Dependence of Threshold Voltage, MOSFET Channel Mobility, MOSFET Capacitances, Short Channel Effects, Velocity saturation, Channel Length Modulation, MOSFET Breakdown, Constant Field Scaling, Generalized scaling, Threshold Voltage Requirement, Discrete Dopant Effects on Threshold Voltage, Definitions of MOSFET Channel Length. Basic MOSFET as a 3T & 4T device (Device physics and its applications), MOS Models

**Digital Integrated Circuits:** Static CMOS Inverter, Robustness, Switching Threshold, Noise Margins, Dynamic Behaviour, Propagation Delay, Power, Energy, and Energy-Delay Product. Designing Combinational Logic Gates in CMOS (sizing of transitors), Complementary CMOS, Ratioed Logic, Pass-Transistor logic, Inverter level models of dynamic, static and short circuit power, transient effects of long interconnects, CMOS sequential circuit elements, CMOS memories

**Analog Integrated Circuits:** Single stage amplifiers, Current mirrors, Differential amplifiers, frequency response of common source amplifier. Feedback and stability (analog circuits section)
VLSI Signal Processing

PROBABILITY AND RANDOM VARIABLES: Axioms of probability, random variables, distribution and density functions, Expected values, moments and characteristic functions, bivariate distributions and functions of two random variables, conditional distributions, joint and conditional densities, joint moments and characteristic function.
Binary hypothesis testing: Bayes, Neyman-Pearson, maximum likelihood, MAP and minimum probability of error criterion, Estimation in communication, Bayes, ML and MAP estimation.

DIGITAL COMMUNICATION: Sampling theorem, quantization, quantization noise and signal to noise ratio analysis in PCM, DPCM and DM, Baseband transmission, intersymbol interference, Nyquist criterion for zero ISI, wave shaping and correlative coding, Linear equalization, decision feedback equalization, maximum likelihood sequence estimation, Digital modulation techniques-BPSK, FSK, QPSK, MSK, matched filter receiver and probability of error analysis in BPSK, FSK and QPSK.

DIGITAL SIGNAL PROCESSING: Review of discrete time signals and systems, system properties, discrete LTI system, impulse response, convolution, system representation by difference equation, natural and forced responses, Review of Fourier transform, DTFT, DTFS and Z-transform, DFT and circular convolution, Basic concepts of IIR and FIR filters.