SYLLABUS FOR PHD ADMISSSION INTERVIEW

Department of Electronics and Communication Engineering, IIITD

Antennas and Propagation:

- Why do antennas radiate? Maxwell's equations, Vector Potential A for Electric Current Source, Vector Potential F for Magnetic Current Source, Solution to Inhomogeneous Helmholtz equation, Far field radiation

- Fundamental parameters of antennas: Radiation Pattern, Beamwidth, Directivity, Antenna Efficiency and gain, Bandwidth, Input impedance, Polarization, Antenna effective length and effective area, Frii's transmission equation and radar range equation

- Linear wire antennas: Infinitesimal dipole, Small dipole, Half wavelength dipole, Effect of conductors near ground plane, Monopole

- Loop Antennas: Small circular loop, Circular loop with constant current, Ferrite Loop

- Antenna Arrays: Two Element Array, N-element array, Super directivity, Planar array, Circular array

Linear Systems:

- Induced norms and matrix norms

- Ordinary differential equations

- Existence and uniqueness of solutions

- Linearisation

- State transition matrix

- Time invariant linear systems - Laplace transform, transfer functions, jordan form

- Stability of linear time invariant and time varying systems

- Controllability and observability, kalman decomposition

- State feedback and state observer design

Communication Networks:

Link layer protocols, ARQ, framing, CSMA CA/CD, routing protocols, TCP/UDP, Congestion control, Flow control, and Queueing models.

Digital VLSI Design:

CMOS transistors and logic gates, first-order current-voltage and capacitance-voltage models for transistors, transfer characteristics of CMOS inverter, performance estimation for circuits through logical effort, interconnects, combinational circuit design, circuit families, sequential circuit design including clocking and latching techniques, design of datapath subsystems (adders, shifters, multipliers etc.), design of memory subsystems.

Advanced Signal Processing:

- LTI systems: Characterization and analysis, Convolution

- Transforms: Continuous and Discrete time Fourier series and transform; (b) Laplace transform (c) z-transform, Analysis of discrete time systems in the z-domain

- Sampling and Reconstruction of Signals

- Discrete Fourier Transform (DFT): Frequency domain sampling, Linear filtering methods based on DFT, Frequency analysis of signals using DFT

- Design of Digital Filters: Digital filter realization through pole-zero placements: All pass filters, Notch filters, Bandpass, Lowpass and Highpass filters; FIR filters- Linear phase filter design by Windowing, IIR filters from analog filters - Impulse invariance, Bilinear transformation; Analog templates - Butterworth and Chebyshev filters.

Digital Communications:

- Digital modulation Schemes: PAM, Phase modulation, OQPSK, PI/4QPSK, QAM, CPM, CPFSK, Power spectrum of digitally modulated signals

- Detection of Signals in AWGN: Maximum Likelihood detection, Matched filtering, Impact of phase and timing uncertainties

- Error correction coding: Linear block codes, Cyclic codes, Convolutional codes, Performance analysis

- Intersymbol interference: Nyquist Criterion, Equalization techniques

Statistical Signal Processing:

- Detection Theory: Hypothesis testing (binary and M hypotheses) - Bayes detection, Neyman-Pearson based detection & LRT; Composite Hypothesis Testing -

Generalized Likelihood Ratio Test (GLRT), GLRT for deterministic & random signals; Detector Performance- ROC, Sensitivity/Specificity; Waveform Detection
- Parameter Estimation: Univariate and Multivariate random parameter estimation - MMSE, MAP estimation, Cramer-Rao Lower Bound, Best linear unbiased estimator; Non-random parameter estimation- ML criterion; Expectation Maximization

- Adaptive Filtering: Mean Square Error Criteria, Wiener Filtering, Properties of the Quadratic Error Surface, Steepest Descent Method, Least Mean Square (LMS) and its variants, Kalman Filtering

Introduction to Robotics:

- Motion planning

- Sensors

- Kinematics

- Estimation

- Controller design

RF Circuit Design:

- Importance of Radio Frequency Design, Frequency Spectrum, RF Behavior of Passive Components, Chip Components and Circuit Board Considerations, RF Circuit Manufacturing Process.

- Transmission Line Analysis, Example of Transmission Lines, Equivalent Circuit Representation, Theoretical Foundation, Circuit Parameters for a Parallel-Plate Transmission Line, Summary of Different Transmission Line Configurations, General Transmission Line Equations, Microstrip Transmission Lines, Terminated Lossless Transmission Line (Analytical Treatment, MATLAB Simulations), Special Termination Conditions (Analytical Treatment, MATLAB Simulations)

- The Smith Chart (From Reflection Coefficient to Load Impedance, Impedance Transformation, Admittance Transformation, Parallel Series Connection), Introduction to ADS (Simple Examples), ADS Design Guides (Smith Chart and its applications)

- Single- and Multi-port Networks (Interconnecting networks, Network properties and Applications, Scattering Parameters), Design and Analysis of multi-port network using ADS

- Passive RF Components (Coupler Design: analytical technique and ADS implementation; Power Combiner and Power Divider: analytical techniques and ADS implementation; Multi-band Component Design Techniques)

- Active RF Components (RF Field Effect Transistors, MOSFETs, HEMTs), Power Amplifier (Biasing and Matching Networks Design Techniques and ADS Implementation; Stability Considerations, Constant Gain, Constant VSWR Circles, Power Amplifier Topologies, Power Amplifier Operation Modes, Multi-band Matching Techniques for Power Amplifiers)

Analog CMOS Design:

- Single Stage MOS Amplifiers (Intro to CS, CD, CG Amplifiers, analysis of CS amplifier with resistive load, analysis of CS amplifier with diode connected load, analysis of CS amplifier with current source load)

- Analysis of Source Follower (CD amplifier), analysis of CG amplifier

- Analysis of CS amplifier with source degeneration, analysis of cascode and folded cascade, cascade as a current source

- Introduction to current mirror, simple CMOS current mirror, source-degenerated current mirror, small-signal analysis, large-signal analysis (PA), and common mode properties of current mirror

- Differential amplifier (single ended operation, differential mode operation, common mode response, common mode rejection)

- Differential amplifier (differential pair with active loads, cascade differential amplifier), Gilbert Cell

- Frequency Response (fundamental concepts, relationship between transfer function and frequency response, Bode's Rules, Association of Poles with Nodes, Miller Effect and Miller's Theorem and its dual, General Frequency Response, Frequency Response of CS Amplifier, Frequency Response of Differential Amplifier)

- Feedback, Feedback Topologies, Properties of Feedback Circuits, Stability in Feedback Systems

- Multi-stage Op Amps (one-stage and two-stage Op Amps, Comparison, Common-Mode Feedback, Input Range Limitations, Slew Rate)

- Multi-stage Op Amps (Power Supply Rejection, Multi-pole Systems, Phase Margin, Compensation in Two-stage Op Amps), Bandgap References

Embedded Systems:

- Communication Protocols in Embedded Systems

- Power saving techniques

- CPU Architectures
- Design spaces, challenges and modeling in Embedded Systems
- Peripherals in Embedded systems