Syllabus for Ph.D. Written Test

EE1 (Communication and Signal Processing):

Basic Electrical and Electronic Circuits
Basic Network Theory

Signals and Systems**:**
- Continuous-time and discrete-time signals and systems
- LTI systems and representations
- Sampling and reconstruction
- Transform domain analysis (Fourier, Laplace, and Z-transforms),
- Basics of filter design

Signal Processing:
- Representation of signals on orthogonal basis
- Discrete systems: attributes, Z-Transform
- Analysis of LSI systems, Frequency analysis, Inverse Systems,
- Discrete Fourier Transform (DFT)
- Fast Fourier Transform algorithm
- Implementation of Discrete Time Systems: Design of FIR Digital filters, Design of IIR Digital filters

Probability and Random Processes:
- Random variables, Expectation Theory, Generating functions,
- Cumulative distribution functions (CDFs), Probability density functions (PDFs), conditional CDFs and PDFs, conditional expectation, functions of one and two random variables
- Probability inequalities (e.g., Markov, Chebyshev, Chernoff, Schwartz)
- Random vectors, Joint CDFs and PDFs, Joint moments, Joint characteristic functions
- Laws of large numbers, Central limit theorem
- Gaussian processes, Power spectral density
- Basics of detection and estimation.

Analog and Digital Communications:
- Modulation techniques, Signal representation, Quantization,
- Power and bandwidth considerations
- Noise in communication systems
- Entropy and mutual information, Data compression techniques
- Probability of error in digital communications

Communication Networks:
- ARQ strategies
- MAC protocols
- Routing algorithms

Electromagnetic Waves and Antennas:
- Maxwell's equations
- TEM modes in a linear homogenous isotropic medium

- TEM waves incident on a boundary, Snell's laws, wave propagation inside a conductor
- Transmission lines, impedance matching, Smith chart
- Rectangular and cylindrical waveguides
- Electromagnetic radiation, antenna gain, radiation resistance, radiation pattern
- Study of some standard antennas – dipole, array, aperture, horn and optical

EE2 (Control and Computing):

Topics from basic mathematics: Maxima/ minima, polynomials and their roots, sequences, series, and convergence, probability, permutations, combinations, prime numbers, Chinese remainder theorem, multivariable calculus, 2D/3D coordinate geometry, complex numbers.

Linear algebra: Rank of a matrix, solutions to Ax=b, vector space, basis, eigenvalues, eigenvectors,
determinant, characteristic polynomial.

Mathematical modelling: Linear ordinary differential equations, difference equations.

Topics from Electrical Engineering: Electrical and electronic circuits, basic network theory, network
theorems, KCL/KVL, dynamics of RLC circuits.

EE3 (Power Electronics and Power Systems):

(i) Basic Electrical and Electronic Circuit Analysis, Signals and Systems and Electric and Magnetic Fields.

(ii) Basic Concepts of Feedback Control Systems (Transfer Function and State Space Analysis, Step Response, Transient and Steady State analysis).

(iii) Principle of operation and speed control of Electric machines: dc, induction, synchronous and special machines.

(iv) Power electronics: Principle of operation of line commutated ac to dc converters, unity power factor voltage source ac to dc converters, dc to dc converters like buck, boost, buck-boost and Cuk converters, isolated dc to dc converters like flyback, forward and push pull converters, dc to ac inverters. Various pulse width modulation techniques like SPWM, Space vector pulse width modulation technique etc.

(v) Power generation, ac and dc transmission, and distribution concepts. Models and performance of transmission lines and cables. Series and shunt compensation. Power System Analysis and Computation (Load-flow, admittance matrices, per-unit representation). Voltage and Frequency control, Power factor correction. Fault Analysis and Protection. System stability. Power Electronic applications in Power systems.

EE5 (Electronic Systems):

Topics from basic mathematics: Maxima/ minima, polynomials and their roots, sequences, series, and convergence, probability, permutations, combinations, prime numbers, linear algebra

Basic Electrical and Electronic Circuits

Basic Network Theory
Basic Analog and Digital Cicuits

Signals and Systems:
- Continuous-time and discrete-time signals and systems - LTI systems and representations
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Signal Processing:
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- Discrete systems: attributes, Z-Transform
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EE6 (Integrated Circuits & Systems):

• Basic Electrical and Electronic Circuits and Network Theory
• Basic Mathematics: Linear Algebra, Fourier transforms, Complex Analysis, Vector Algebra and
Differential Equations
• Linear and Non-linear Circuits (discrete and integrated)
• Basic CMOS Analog and Digital Circuits

• Suggested references:
  - o Basic Electronic Devices and Circuits by Mahesh B. Patil
  - o Microelectronic Circuits by Sedra and Smith

EE7 (Solid State Device):

Devices division will have questions based on the following topics.

(a) Topics:
- Basic mathematics – linear algebra, Fourier transforms, complex analysis, vector algebra, differential equations
- Basic electronics and circuits

- Quantum mechanics (particle in a box, tunnelling, harmonic oscillator, wave-particle duality)
- Crystal structure, electrons in solids, energy band theory
- P-n junction diode, charge carriers in semiconductors
- Drift-diffusion theory
- MOS capacitors, field-effect transistors, bipolar junction transistors
- LEDs and solar cells

(b) Suggested references:

- Semiconductor devices fundamentals by R. Pierret
- Solid state electronic devices by Streetman and Banerjee
- Introduction to Quantum Mechanics by David J. Griffiths