Electronics Engineering Department, SVNIT, Surat

PhD Comprehensive Examination Syllabus

- **Section I (30 Marks), (Common for all students)**

A. PEC 901: Fundamentals of Electronics Engineering

- **Section II (120 Marks), (Section Specific)**

(Student will choose **ANY ONE** from the groups B, C, D and E.)

(Each Topic in the group carries 30 Marks weightage.)

B. PEC 902: Communication Systems

Topic	Contents
B1	Digital Communication
B2	Wireless Communication
B3	RF and Microwaves
B4	Optical Communication

C. PEC 903: VLSI Design

Topic	Contents
C1	Solid State Physics
C2	Digital Integrated Circuits
C3	Digital VLSI Design
C4	Analog VLSI Design

D. PEC 904: Electronics System Design

Topic	Contents
D1	Linear Integrated Circuits
D2	Embedded Systems
D3	Digital System Design
D4	Digital Signal Processing

E. PEC 905: Signal Processing

Topic	Contents
E1	Probability and Random Processes
E2	Digital Signal Processing
E3	Image Processing
E4	Neural Networks

A. PEC 901: Fundamentals of Electronics Engineering (30 Marks)

A1: LINEAR ALGEBRA (06 Marks)
Vector space, basis, linear dependence and independence, matrix algebra, Eigen values and Eigen vectors, rank, solution of linear equations – existence and uniqueness.
A2: STATISTICAL SIGNAL ANALYSIS (06 Marks)
Mean, median, mode and standard deviation, combinatorial probability, probability distribution functions - binomial, Poisson, exponential and normal, joint and conditional probability, correlation and regression analysis.
A3: CALCULUS (06 Marks)
Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.
A4: BASIC ELECTRONICS (06 Marks)
Small signal equivalent circuits of diodes, BJTs and MOSFETs, Simple diode circuits: clipping, clamping and rectifiers, Single-stage BJT and MOSFET amplifiers: biasing, bias stability, mid-frequency small signal analysis and frequency response, Simple op-amp circuits, active filters, Sinusoidal oscillators: criterion for oscillation, voltage reference circuits, combinational circuits, sequential circuits, data converters, basics of microprocessors.
A5: SIGNALS AND SYSTEMS (06 Marks)
Continuous-time signals: Fourier series and Fourier transform representations, sampling theorem and applications, Discrete-time signals: discrete-time Fourier transform (DTFT), DFT, FFT, Z-transform, interpolation of discrete-time signals, LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay, digital filter design techniques.

B. PEC 902: Communication Systems (120 Marks)

B1: Digital Communication (30 Marks)
Sampling and analog to digital conversion, quantization techniques, A-law and mu-law, pulse code modulation, digital multiplexing, line coding, pulse shaping for optimum transmission, ISI and ISI-free signals, band-limiting of rectangular pulses, raised cosine filtering, equalizers, measure of information, source encoding, error-free communication over noisy channel, channel capacity of discrete as well as continuous memoryless channel, Shannon's equation, channel capacity, introduction to entropy and source coding, introduction to channel coding techniques and error correcting codes, representation of digital modulated signal, ASK, PSK, FSK, QAM with mathematics and constellation diagram, spectral characteristics of digitally modulated signals, M-ary digital carrier modulation.
B2: Wireless Communication (30 Marks)
AWGN channels multipath fading channels and channel effects, channel models, basic principle of orthogonality, subcarrier setting in the spectrum, FDM vs orthogonal FDM, OFDM block diagram and explanation, pulse shaping and windowing in OFDM, synchronization in OFDM, pilot insertion in OFDM and channel estimation, PAPR, FFT points selection constraints, CDMA vs OFDM, spread spectrum modulation concepts, ML and Walsh-Hadamard sequences, PN code properties, DSSS transmitter, rake receiver block diagram, PN signal characteristics, spectral density, bandwidth and processing gain, interference rejection, anti-jam properties, energy and bandwidth efficiency, near far problem and power control, frequency hopping spread spectrum, time hopping, hybrid spread spectrum system.

B3: RF and Microwaves (30 Marks)

Transmission lines, equivalent circuit representation, theoretical foundation, circuit parameters for a parallel plate transmission line, general transmission line equation, microstrip transmission lines, terminated lossless transmission line, special termination conditions, sourced and loaded transmission line, Smith chart from reflection coefficients to load impedance, impedance transformation, admittance transformation, parallel and series connection, interconnecting networks, network properties and applications, scattering parameters- definition and meaning of S- parameters, basic resonator and filter configurations, special filter realizations, filter implementation, impedance matching using discrete components, microstrip line matching networks, amplifier classes of operation & biasing networks, low noise amplifier design, design and implementation of various mixers, VCO and definition of phase noise, noise power trade-off, resonator less VCO design, quadrature and single-sideband generators, PLLs, various RF synthesizer architectures and frequency dividers.

B4: Optical Communication (30 Marks)

Light transmission in fiber, V parameters, attenuation, dispersion, principle and operation of optical source, detectors, amplifiers, power budget, rise-time budget, link design, WDM systems, WDM system model, system requirement, system design considerations, multi-channel system design, system performance measurement parameters, power penalty in system, optical networks.

BOOKS RECOMMENDED:

1. Bhattacharya Amitabh, "Digital Communication", Tata McGraw-Hill, 1st Ed., 2006.
2. Lathi B.P. and Ding Zhu, "Modern Digital And Analog Communication Systems", Oxford University Press, 4th Ed., 2010.
3. Ludwig Reinhold and Bretchko Powel, “RF Circuit Design”, Pearson Education, Reprint 2004.
4. Liao Samuel, “Microwave Devices And Circuits”. Pearson Education, Second Reprint, 2006.
5. Upena Dalal, “Wireless Communication”, Oxford University Press, 1st Ed., 2008.
6. Molisch Andreas F., “Wideband Wireless Digital Communication”, Pearson Education, 3rd Indian Reprint, 2003.
7. Gerd Kaiser, "Optical Fiber Communication", McGraw Hill, 4th Ed., 2008.
8. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks A Practical Perspective", Elsevier, Morgan Kaufmann Publishers, 3rd Ed., 2009.

C. PEC 903: VLSI Design (120 marks)

C1: Solid State Physics (30 Marks)

Particle in a well problem, electrons in solids, energy splitting and band formation, Fermi energy, density of states function, quantum confinement, tunneling, potential inside a semiconductor, semiconductor in Equilibrium, 2DEG model, energy band diagrams, carrier transport phenomena and models, direct/indirect semiconductors, mobility models, excess carriers in semiconductor, PN junction current, generation and recombination models, junction break down, Zener diode, metal semiconductor and hetero junctions.

C2: Digital Integrated Circuits (30 Marks)

Introduction to RTL, DTL TTL, Schottky TTL, I2L and ECL logic family, concept of Noise margin, fan out and propagation delay, basic BiCMOS circuits: static behavior, switching delay in BiCMOS logic circuits. MOS structure and operation, MOSFET structure and operation, MOSFET current- voltage characteristics, channel length modulation, substrate bias effect, MOSFET capacitances, MOSFET model, resistive-load inverter, saturated-load inverter, linear loaded inverter, depletion load inverter, graphical determination of VTC, calculation of VTC critical points, power dissipation and rise time - fall time, NMOS logic gates, fabrication process flow, CMOS N-Well process, layout design rules, full-custom mask layout design, stick diagrams.

C3: Digital VLSI Design (30 Marks)
Static and dynamic characteristics of CMOS inverters, definitions and calculations of delay times, inverter design with delay constraints, estimation of interconnect parasites, calculation of interconnect delay, switching power dissipation of CMOS inverters, delay estimation, logical efforts and transistor sizing, power dissipation, interconnect, combinational CMOS logic circuits, complex logic circuits, behavior of MOS logic elements, SR latch circuit, clocked latch and flip-flop circuits, CMOS D-latch and edge-triggered flip-flop, pass transistor circuits.
C4: Analog VLSI Design (30 Marks)
Small signal model for MOS, MOS resistors, current sink/source, current mirrors, differential, cascode and current amplifiers, output amplifiers, high gain amplifier architectures, design of CMOS operational amplifiers, design of two stage op-amps, cascode op-amps.
BOOKS RECOMMENDED 1. Streetman Ben G., "Solid State Electronics Device", PHI, 6th Ed. 2009 2. Sze S. M., "Semiconductor Devices, Physics And Technology", John Wiley and Son, 2nd Ed., 2002 3. Taub H. and Schilling D., "Digital Integrated Electronics", McGraw-Hill, International Ed., 2008. 4. Kang and Leblebici, "CMOS Digital Integrated Circuits: Analysis and Design", Tata McGraw-Hill, 3rd Ed., 2003. 5. Baker Jacob R., Harry W. Li and Boyce David E.,"CMOS: Circuit Design, Layout and Simulation", Wiley Interscience, 2003. 6. Weste and Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", Pearson Education, 3rd Ed., 2002. 7. Razavi Behzad, "Design of Analog CMOS Integrated Circuit", Tata McGraw-Hill, 2002. 8. Allen Philip and Holberg Douglas, "CMOS Analog Circuit Design", Oxford University Press, 2002.

D. PEC 904: Electronics System Design (120 marks)

D1: Linear Integrated Circuits (30 Marks)
Operational amplifier, basic op-Amp configuration, an op-amp with negative feedback, voltage series and voltage shunt configurations, difference amplifiers, instrumentation amplifier, specifications of an op-amp, DC error model, summing, scaling and averaging amplifiers, concept of negative resistance, voltage to current converter with floating and grounded load, current to voltage converter, integrator and differentiator, gyrator, frequency dependent negative resistance circuit, first order active filters, second-order active filters, multiple feedback filters (band pass and band reject filters), all pass filter, cascade design of filters, magnitude and frequency scaling concept, oscillators, phase shift and Wien bridge oscillators, square, triangular and saw tooth wave generators, Schmitt trigger, voltage comparator, voltage limiters and window detector, concept of clippers and clampers circuit using passive component, clippers and clampers using op-amp, peak detector, precision rectifiers, analog switches.
D2: Embedded Systems (30 Marks)
Brief review of 8-bit microcontroller (8051), programming, CPU block diagram, memory organization, ports and interfacing, high speed output, interrupts, ADC, PWM, timers, watch dog timer, serial port, I/O port, ARM processor architectures, registers, current program status register, pipeline, exception, interrupt and vector table, memory map, ARM and thumb mode memory management unit, ARM architecture, ARM architecture revision, cortex processor architecture, overview of C compiler, basic C compiler, C looping structure, register allocation, function calls, pointer aliasing, structure arrangement, bit fields, unaligned data and endianness, division, floating point, inline function and inline assembly.
D3: Digital System Design (30 Marks)
Arithmetic logic and shift micro-operation, conditional control statements, fixed-point and floating-point data, arithmetic shifts, instruction code and design of simple computer, processor organization,

design of Arithmetic Logic Unit (ALU), design of accumulator, barrel shifter, logarithmic shifter, Multipliers: Booth, array and Baugh Wooley, Finite State Machine (FSM), control organization, hard-wired control, micro program control, control of processor unit, PLA control, cache management , pipeline optimization, share memory, deadlock.

D4: Digital Signal Processing (30 Marks)

DFT, fast Fourier transform, Goertzel algorithm, approaches to design radix-m algorithm, implementation of DFT using convolution algorithm, the discrete time cosine transform, causality and its implications, linear phase FIR filters, frequency response of linear phase FIR filters, design of FIR filter using different windowing techniques, digital differentiator, Hilbert transform, frequency sampling method for designing FIR filters, realization of FIR filters, transversal structure, linear phase realization, lattice structure of FIR filter, polyphase realization of FIR filter, realization of digital filter, direct form-I realization, direct form-II realization, signal flow graph, cascade form, parallel form structure, lattice structure of IIR system, comb filter design, all-pass filter, minimum phase, maximum phase & non-minimum phase systems, tunable IIR digital filter, down sampling, spectrum of down sampled signal, up sampling spectrum of up-sampled signal.

BOOKS RECOMMENDED

1. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Ed., McGraw- Hill, Published: May 11, 2016.
2. Kenneth Ayala J., “8051 Microcontroller: Architecture, Programming & Applications”, Thomson, 1st Ed., 2006
3.Andrew Sloss, “ARM System Developer’s Guide: Designing and Optimal System Software”, Elsevier, 2004
4. Mano Morris, “Digital Logic and Computer Design”, 4th Ed., Pearson Education, 2006.
5. John Hennessy and David Patterson, "Computer Architecture - A Quantitative Approach", Morgan Kaufman, 3rd Ed., 2003.
6. Proakis J. G. and Manolakis D. G., "Digital Signal Processing: Principles, Algorithms and Applications", 4th Ed., Pearson Education, 2014.
7. Babu Ramesh P., "Digital Signal Processing", 4th Ed., SciTech Publication, 2008.

E. PEC 905: Signal Processing (120 Marks)

E1: Probability and Random Processes (30 Marks)

Probability space, conditional probability and Bayes theorem, combinatorial probability and sampling models, discrete random variables, probability mass function, probability distribution function, random variables and distributions continuous random variables, probability density function, probability distribution function, joint distributions, functions of one and two random variables, moments of random variables conditional distribution, densities and moments, characteristic functions, Markov, Chebyshev and Chernoff bounds, detection and estimation, random sequences, almost sure (A.S.) convergence and strong law of large numbers convergence in mean square sense with examples from parameter estimation convergence in probability with examples convergence in distribution central limit theorem, random processes, stationary processes, mean and covariance functions, ergodicity, linear filtering of random processes, power spectral density, examples of random processes: white noise process and white noise sequence, Gaussian process, Poisson process.

E2: Digital Signal Processing (30 Marks)

DFT, fast Fourier transform, Goertzel algorithm, approaches to design radix-m algorithm, implementation of DFT using convolution algorithm, the discrete time cosine transform, causality and its implications, linear phase FIR filters, frequency response of linear phase FIR filters, design of FIR filter using different windowing techniques, digital differentiator, Hilbert transform, frequency sampling method for designing FIR filters, realization of FIR filters, transversal structure, linear phase realization, lattice structure of FIR filter, polyphase realization of FIR filter, realization of digital filter, direct form-I realization, direct form-II realization, signal flow graph, cascade form, parallel form

structure, lattice structure of IIR system, comb filter design, all-pass filter, minimum phase, maximum phase & non-minimum phase systems, tunable IIR digital filter, down sampling, spectrum of down sampled signal, up sampling spectrum of up-sampled signal.

E3: Image Processing (30 Marks)

Fundamentals of image, image enhancement in spatial domain & frequency domain, image degradation and restoration processes, noise 'models - spatial properties, noise probability density functions, periodic noise, estimation of noise parameters, restoration in the presence of noise and mean filters, order-statistics filters, adaptive filters, linear position-invariant degradations and estimation, geometric transformations - spatial transformation, gray-level interpolation, fundamentals of compression, image compression model, and error free compression, lossy predictive coding, and transform coding, preliminaries-set theory and logic operations in binary images, basic morphological operations - opening, closing operators, dilation and erosion, morphological algorithms - boundary extraction, region filling, extraction of connected components, convex hull, thinning, thickening, skeletons; extension of morphological operations to gray-scale images, detection of discontinuities - point, line and edges, edge linking and boundary detection-local processing, image segmentation techniques.

E4: Neural Networks (30 Marks)

Introduction to neural networks: biological and artificial neurons, learning in ANNs, perceptrons–classification and linear separability, XOR problem, network architectures, multilayer feedforward networks and recurrent networks, generalized delta rule, back propagation (BP) network, BP training algorithm, radial basis function (RBF) networks, applications of BP and RBF networks, recurrent networks and unsupervised learning, Hopfield network – energy, stability, capacity, application to optimization problems, counter back propagation network, Boltzmann machine, Kohonen's self-organizing feature maps, adaptive resonance theory, matrix associative memory, auto associative memories, hetero associative memories, bi-directional associative memory, applications of associative memories, history, convolution and pooling, LeNet, AlexNet, ZF-Net, VGGNet, GoogleNet, ResNet.

BOOKS RECOMMENDED

1. A Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and Stochastic Processes, McGraw Hill.

2. H. Stark and J. W. Woods, Probability and Random Processes with applications to Signal Processing, Pearson Education.

3.Proakis J. G. and Manolakis D. G., "Digital Signal Processing: Principles, Algorithms and Applications", 4th Ed., Pearson Education, 2014.

4. Babu Ramesh P., "Digital Signal Processing", 4th Ed., SciTech Publication, 2008.

5. Gonzalez R. C. and Woods R. E, "Digital Image Processing", 3rd Ed., Pearson Prentice Hall, 2008.

6. Simon Haykin, "Network N. A comprehensive foundation. Neural Networks", 2nd Ed., PHI, 1998.

7. Simon Haykin, "Neural Networks & Learning Machines", 3rd Ed., Pearson Education India, 2016.