Semester - V
Branch: Electronics & Communication Engineering

Sl. N.	Code	Course Title	Lecture	Tutorial	Practical	Credits
1	ECC501	Digital Signal Processing	3	1	0	4
2	ECC502	Digital Communication	2	1	0	3
3	ECC503	Microcontroller & Embedded system	2	1	0	3
4		Professional Elective –I	2	1	0	3
5		Open Elective –I#	2	1	0	3
		Total				16
Laboratory/Sessionals						
1	EC501P	DSP Lab	0	0	2	1
2	EC502P	Digital Communication Lab	0	0	2	1
3	EC503P	Microcontroller & Embedded system lab.	0	0	2	1
4	EC504P	Professional Elective –I Lab	0	0	2	1
5	EC505G	General Proficiency/seminar	0	0	2	2
				Total Credits		22

to be offered by other department

Code	**Professional Elective-I**
ECP504	Linear Control System
ECP505	Optoelectronics
ECP506	Electronic Devices

Code	**Open Elective-I (Any One)***
ECO507	Communication System
ECO508	Signal & System
ECO509	Digital System Design

* Not for ECE Students

Semester -VI
Branch: Electronics & Communication Engineering

Sl. N.	Code	Course Title	Lecture	Tutorial	Practical	Credits
1	ECC601	Microwave Engineering	3	1	0	4
2	ECC602	VLSI	2	1	0	3
3	ECC603	IoT	2	1	0	3
4		Professional Elective-I I	2	1	0	3
5		Open Elective –II[#]	2	1	0	3
		Total				16
Laboratory/Sessionals						
1	EC601P	Microwave Lab	0	0	2	1
2	EC602P	VLSI Lab	0	0	2	1
3	EC603P	IoT Lab	0	0	2	1
4	EC604P	Professional Elective –II Lab	0	0	2	1
5	EC605I	Internship/Tour and training/Industrial training	0	0	2	2
		Total				6
					Total Credits	22

to be offered by other department

Code	**Professional Elective-I I**
ECP604	Biomedical signal processing
ECP605	Electronic Measurement & Instrumentation
ECP606	Biosensor

Code	**Open Elective-II (Any One)***
ECO607	Digital Signal Processing
ECO608	VLSI
ECO609	Biomedical Electronics

* Not for ECE Students

SEMESTER V

	DIGITAL SIGNAL PROCESSING*

Module	Content	No. of Lectures
1	**Signals and systems:** Basic elements of DSP, concepts of frequency in Analog and Digital Signals, sampling theorem, Discrete time signals, systems analysis of discrete time LTI systems, Z transform, Convolution, Correlation.	**6**
2	**Frequency transformations:** Introduction to DFT, Properties of DFT, Circular Convolution, Filtering methods based on DFT, FFT Algorithms, Decimation in time Algorithms, Decimation in frequency Algorithms, Use of FFT in Linear Filtering, DCT, Use and Application of DCT.	**10**
3	**IIR filter design:** Structures of IIR, Analog filter design, Discrete time IIR filter from analog filter, IIR filter design by Impulse Invariance, Bilinear transformation, Approximation of derivatives (LPF, HPF, BPF, BRF) filter design using frequency translation.	**10**
4	**FIR filter design:** Structures of FIR, Linear phase FIR filter, Fourier Series, Filter design using windowing techniques (Rectangular Window, Hamming Window, Hanning Window), Frequency sampling techniques.	**8**
5	**Finite word length effects in digital filters:** Binary fixed point and floating point number representations, Comparison, Quantization noise, truncation and rounding, quantization noise power, input quantization error, coefficient quantization error, limit cycle oscillations-dead band, Overflow error-signal scaling.	**8**

Text Books:

1. J.G.PROAKIS & D.G.MANOLAKIS, Digital Signal Processing - Principles, algorithms & Applications, PHI, 2000.
2. .B.Venkataramani, M.Bhaskar, "Digital Signal Processors, Architecture, Programming and Application", Tata McGraw Hill, New Delhi, 2003
3. A.V. Oppenheim and Ronald W. Schafer, Discrete Time Signal Processing, 2nd Edition, PHI, 2000.
4. S.K.MITRA, Digital Signal Processing – A computer Based Approach, 2nd Edition, MGH, 2001.
5. Multi Rate Systems and Filter Banks – P.P.Vaidyanathan – Pearson Education.
6. Fundamentals of Digital Signal Processing using Matlab – Robert J. Schilling, Sandra L. Harris, Thomson, 2007

List of experiments:

1. Generation of elementary Discrete-Time sequences
2. Linear and Circular convolutions
3. Auto correlation and Cross Correlation
4. Frequency Analysis using DFT
5. Design of FIR filters (LPF/HPF/BPF/BSF) and demonstrates the filtering operation

6. Design of Butterworth and Chebyshev IIR filters (LPF/HPF/BPF/BSF) and demonstrate the filtering operations

7.Implementation of Decimation Process.

8. Implementation of Interpolation Process.

9. Finding Power and (or) Energy of a given signal

10.Design a LPF to remove high frequency noise from a sinusoidal signal.

11. Design a HPF to remove low frequency noise from a sinusoidal signal.

12. Design a BRF to remove 50 Hz noise from a sinusoidal signal.

	DIGITAL COMMUNICATION

Module	Course Content	No. of Lecture
1	**Introduction:** A historical perspective in the development of digital communication, Elements of digital communication system. **Source encoding:** Pulse code modulation, quantization noise, linear and non-linear quantization, companding. Differential pulse code modulation, delta modulation, adaptive delta modulation, Delta sigma modulation, linear predictive coders.	8
2	**Multiplexing:** Introduction to different type of multiplexing, Frequency Division & Time Division Multiplexing, Multiplexing hierarchy, synchronous and asynchronous multiplexing, pulse staffing and word staffing. **Baseband transmission:** Baseband signal receiver, integrate and dump type filter probability of error calculations, optimum filters, coherent reception, matched filter and its transfer function. Probability of error of matched filter. Regenerative repeater, Bit synchronization, In-phase and mid-phase synchronizer. Early late gate synchronizer. Frame synchronization.	8
3	**Different type of line coding:** UPNRZ, UPRZ, PNRZ, PRZ, Manchester, differential encoding and their spectral characteristic, self synchronization properties of some of the encoded signal. **Equalization:** Inter symbol interference (ISI), Purpose of equalization, Eye pattern, Nyquist criterion for zero ISI, fixed equalizer. Design of equalizer, Adaptive equalizer, Decision directed equalizer, Adaptive decision directed equalizer, Partial response signaling.	10
4	**Digital modulation techniques:** BPSK, DPSK. BFSK, MARY-PSK & -FSK, QPSK, MSK principles, QASK, Error calculation. **Spread-spectrum modulation:** Pseudo-Noise Sequence, A notion of Spread Spectrum, Direct-Sequence Spread- Spectrum with Coherent Binary Phase-Shift Keying, Processing Gain, Probability of Error, Frequency-hop Spread Spectrum, Code-Division Multiple Access.	8
5	**Information theory and coding:** Concept and measure of information, Entropy, Discrete and continuous messages, Message source, zero memory sources, extension of zero memory source, Markov source and their entropy, Channel with and without memory, Channel capacity, Hartlay a law. **Properties of code:** Uniquely decodable codes, Instantaneous codes, Kraft inequality and Macmillion inequality, Construction of instantaneous codes, Hoffman and Shannon-Fano coding, Error Coding.	6

Text Books:

1. S.Haykin, Digital Communications, John Wiley & Sons, 2009.
2. B.Sklar, Digital Communications, 2 nd Edition, Pearson Education, New Delhi, 2009.
3. John G.Proakis, Digital Communications, 3 rd edition, McGraw Hill, 1995.

List of experiments:

1) Pulse Amplitude Modulation using Natural and Flat-Top Sampling.

2) Pulse Amplitude Demodulation.

3) Pulse Position Modulation and Demodulation.

4) Pulse Width Modulation and Demodulation.

5)Signal Sampling and reconstruction

6)Amplitude modulation and demodulation

7) Frequency modulation and demodulation

8). Pulse code modulation and demodulation.

9). a) Delta modulation b) Adaptive delta Modulation

10). BFSK modulation and Demodulation

11). BPSK modulation and Demodulation

12). TDM and FDM

13). Line Coding Schemes

	Microcontroller and Embedded System

Sl No	**Topics**	**No of Lectures**
1	Introduction to Microcontroller and Embedded Processor. The 8051 Architecture- Hardware- Oscillator and clock-program counter –data pointer-registers-stack and stack pointer-special function registers- -memory organization-program memory-data memory -Input / Output Ports –External memory-counter and timer-serial data Input / output-Interrupts.	09
2	8051 Assembly Language Programming-Structure of Assembly language-Assembling and running an 8051 program- Addressing modes-Accessing memory using various addressing modes- Instruction set- Arithmetic operations and Programs-Logical operations and Programs -Jump and Call instructions and Programs -I /O Pot Programs - Single bit instructions and Programs –Timer and counter - and Programs	10
3	8051 Serial Communication -Connection to RS-232- Serial Communication Programming- Interrupts Programming	08
4	**Hardware Interfacing:** Interfacing with Key Board, LEDs, Seven Segment, Basic concepts of LCD, ADC, DAC, Relays and their interfacing to microcontroller.	08
5	Basic concept of PIC microcontroller –Microcontroller Architecture – PIC16F Family	09

Text books/Reference books:

1. Kenneth J. Ayala, The 8051 microcontroller: architecture, programming and application, Penram International publication.

2. M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay, "The 8051 Microcontroller and Embedded Systems",Pearson Second Edition.
3. D. V. Hall. Microprocessors and Interfacing, TMH. Second Edition 2006.

List of experiments:

1. Write a simple programs for arithmetic operations – addition, subtraction, multiplication and division of 16 or 32 – bit numbers
2. Flashing of LEDS using Shift Register
3. Interfacing ADC
4. Interfacing DAC
5. Interfacing 7-Segment LED.
6. Interfacing of Analog Key pad.
7. Interrupt using on board push button
8. Interfacing real time clock.
9. Interfacing stepper motor.
10. Interfacing temperature sensor.
11. Interfacing Bluetooth module.
12. Interfacing Real Time Clock
13. Interfacing of micro SD Card.
14. Interfacing Wi-Fi Module

LINEAR CONTROL SYSTEM

Module	Course Content	No. of Lecture
1	**INTRODUCTION:** Concepts of Control Systems- Open Loop and closed loop control systems and their differences, Different examples of control systems- Classification of control systems, Feed-Back Characteristics, Effects of feedback, Mathematical models, Differential equations, Impulse Response and transfer functions.	7
2	**TRANSFER FUNCTION REPRESENTATION:** Block diagram representation of systems considering electrical systems as examples -Block diagram algebra - Representation by Signal flow graph-Reduction using mason's gain formula.	6
3	**TIME RESPONSE ANALYSIS:** Standard test signals - Time response of first order systems –Characteristic Equation of Feedback control systems, Transien response of second order systems- Time domain specifications–Steady state response-Steady state errors and error constants–Effects of proportional	10

	derivative, proportional integral systems. **STABILITY ANALYSIS IN S-DOMAIN:** The concept of stability–Routh's stability criterion – qualitative stability and conditional stability – limitations of Routh's stability.	
4	**ROOT LOCUS TECHNIQUE:** The root locus concept - construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci. **FREQUENCY RESPONSE ANALYSIS:** Introduction, Frequency domain specifications-Bode diagrams Determination of Frequency domain specifications and Phase margin and Gain margin Stability Analysis from Bode Plots. Polar Plots, Nyquist Plots Stability Analysis. Compensation techniques – Lag, Lead, and Lead-Lag Controllers design in frequency Domain, PID Controllers.	**10**
5	**State Space Analysis of Continuous Systems:** Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and it's Properties – Concepts of Controllability and Observability.	**6**

Text Books/Reference books:

1. Control Systems Theory and Applications - S. K. Bhattacharya, Pearson.
2. B.C. Kuo, Automatic Control Systems, 7th Edition, Prentice Hall of India, 2009.
3. I.J. Nagarath and M. Gopal: Control Systems Engineering, 2nd Edition, New Age Pub. Co. 2008.
4. Modern Control System with Advanced topics- S. K. Bharadwaj and S. K. Nagar, New Age Publication.
5. Control Systems - N. C. Jagan, BS Publications.
6. Control Systems - A. Ananad Kumar, PHI.
7. Control Systems - N. K. Sinha, New Age International (P) Limited Publishers

List of experiments:

1.To Study the Response of First Order System

2.To Study the Transfer Function of a Feedback System

3.To Study the Root Locus Response of a 2nd Order system

4.To Study the Response of Nyquist Plot for a 2nd Order system

5.To Study the Response Bode Plot of 3rd Order system

6.To Study the Response of P, PI, PD and PID Controller

7.To Study the Response of Lead, Lag, and Lead-lag Compensator.

8.To study the role of feedback in DC speed control systems.

9. To study the role of feedback in DC position control systems.

10. To study digital control of a simulated system using an 8-bit microcomputer.

	OPTOELECTRONICS	
Module	**Course Content**	**No. of Lecture**
1	**INTRODUCTION: Difference between electronic, optoelectronic and photonic devices, Electrical and Optical Bandwidth,** Wave nature of light, Polarization, Interference, Diffraction, Absorption, Light Source	**7**
2	**ELEMENTS OF LIGHT AND SOLID STATE PHYSICS:** Basic principles of light propagation. Band structure of metals and semiconductors ,Semiconductors - band diagrams, direct and indirect band-gap, degenerate and non-degenerate semiconductors, intrinsic and extrinsic semiconductors.	**8**
3	**OPTICAL SOURCES** :LED Device structure, materials and characteristics. The Semiconductor Laser: Basic structure, theory and device characteristics	**10**
4	Semiconductor Optical Amplifiers(SOA) characteristics and some applications, EDFA.	**10**
5	**OPTICAL DETECTION DEVICES:** Types of photo-detectors, Photoconductors, Noise in photo-detection, Photodiodes, PIN diodes and APDs: structure, materials, characteristics, and device performance	**8**

Text books/Reference books :

1.B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007), Ch.16, 17, and 18.

2.P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).

3.J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).

4.G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3rd Ed. (2000), Ch.4, 6

List of experiments:

1. Semiconductor Parameter Analyzer / LED current-voltage characteristics.

2.Optical power and spectrum measurements / LED characterization.

3.Electrical probe station / Photodiode responsivity characterization.

4. Laser diode DC characteristics.

5.Multi-sim modelling of circuits with optoelectronic devices.

7 Pulsed (AC) measurements using LEDs, laser diodes, and photodiodes.

8 Circuits for amplifying photodiode signals.

9 Noise and shielding / Circuit construction techniques

10. Fiber optic transceiver modules

	ELECTRONIC DEVICES	
Module	**Course Content**	**No. of Lecture**
1	**Crystal Properties and charge Carriers in Semiconductors:** Elemental and compound semiconductor materials, crystal lattice structure, Bonding forces and energy bands in solids, charge carriers in semiconductors, carrier concentrations, drift of carriers in electric field	**6**
2	**Excess Carriers in Semiconductors:** Optical absorption, luminescence, carrier life time and photo conductivity, diffusion of carriers	**6**
3	**Junction Properties:** Equilibrium conditions, biased junctions, steady state conditions, reverse bias break down, transient and AC conditions. Metal semiconductor junctions.	**8**
4	**Transistors:** Metal-semiconductor-field-effect-transistors (MESFET), Metal-insulator-semiconductor-field-effect-transistors (MISFET), Metal oxide semiconductor field effect transistor (MOSFET): Construction, Operation and characteristics of above devices. Bipolar junction transistors: Fundamentals of BJT operation, amplification with BJTs.	**12**
5	**Some special devices:** Photodiodes, photo detectors, solar cell, light emitting diodes, semiconductor lasers, light emitting materials. Tunnel Diode: degenerate semiconductors, IMPATT diode; The transferred electron mechanism: The GUNN diode. P-N-P-N diode, semiconductor controlled rectifier (SCR), bilateral devices: DIAC, TRIAC, IGBT.	**8**

Text book:

1. Ben.G.Streetman & Sanjan Banerjee Solid State Electronic Devices (5th Edition) PHI Private Ltd, 2003

Reference books:

1. Yannis Tsividis: Operation & Mode line of The MOS Transistor (2nd Edition) Oxford University Press, 1999

2. Nandita Das Gupta &Aamitava Das Gupta- Semiconductor Devices Modeling a Technology, PHI, 2004.

List of experiments:

1. Rectifying and Breakdown Characteristics of pn-junctions and point contact diodes
2. Diode Rectifiers: Full wave and Half wave (with and without filters)
3. Silicon Controlled Rectifiers(SCR) characteristics
4. Bipolar Junction Transistor: input and output characteristic (a)common base,(b) common collector, and (c)common emitter configuration
5. CB, CE,CC transistors amplifier
6. ID-VD characteristics of junction field effect transistors
7. Uni-junction Transistor(UJT) and relaxation oscillator

8. Study of basic properties of operational amplifier: voltage follower, inverting and non-inverting amplifiers
9. Differentiator, Integrator, Phase shift oscillator by using operational Amplifier
10. Frequency response of RC-coupled amplifiers by using operational Amplifier
11. Voltage variable Resistance
12. Astable- Multivibrator using BJT

	COMMUNICATION SYSTEM	
Module	**Course content**	**No. of Lectures**
1	Signals and Signal Analysis: Periodic and non-periodic signals, Composite signals, Signal analysis, Time and frequency domain representation. Introduction to Data and signal fundamentals, Analog and digital signals.	**8**
2	Analog Transmission: Concepts of carrier signal, noise, modulating signal and modulated signal; Amplitude modulation – double sideband suppressed carrier, double sideband transmitted carrier, single sideband; Frequency modulation – Narrowband FM and wideband FM; Digital to analog conversion – Amplitude shift keying, Frequency shift keying, Phase shift keying, Quadrature amplitude modulation, Performance.	**8**
3	Digital Transmission: Problems with digital transmission, Different line coding schemes, Block coding schemes, Scrambling techniques; Analog to digital conversion – Sampling techniques, Sampling theorem, Pulse amplitude modulation, Pulse code modulation, Differential pulse code modulation, Delta modulation (along with advantages and disadvantages of each technique), Transmission modes (serial and parallel).	**10**
4	Multiplexing and Spreading: Concept of multiplexing, Frequency division multiplexing, Time division multiplexing – Synchronous and Statistical time division multiplexing.	**10**
5	Error Detection and Correction: Types of errors, Basic concepts of error detection and correction, Redundancy, Hamming distance, Error detection – Simple parity check codes, Two-dimensional parity check, Cyclic redundancy check, Polynomials and cyclic code analysis, Checksum, Error correction – Hamming code.	**8**

Text Books/Reference books:

1. S. Haykin, Digital Communications, John Wiley & Sons, 2009.
2. B. Sklar, Digital Communications, 2nd Edition, Pearson Education, New Delhi, 2009.
3. John G. Proakis, Digital Communications, 3rd edition, McGraw Hill, 1995.
4. BP Lathi Communication System BS Publication
5. Singh & Sapre, Analog Communication, TMH.

	SIGNAL AND SYSTEM

Module	Course Content	No. of Lecture
1	**SIGNALS AND SYSTEMS:** Continuous Time and Discrete Time signals, Exponential and Sinusoidal Signals, Unit Impulse and Unit Step Functions, Continuous and Discrete Time Systems, basic System Properties. **LINEAR TIME INVARIANT SYSTEMS:** Discrete Time LTI Systems, Continuous Time LTI Systems, properties of LTI Systems, causal LTI Systems Described by Difference equations.	**6**
2	**FOURIER SERIES REPRESENTATION OF PERIODIC SIGNALS:** Response of LTI systems to Complex Exponentials, Fourier series Representation of CT periodic Signals, properties of CT Fourier Series, Fourier Series representation of DT periodic Signals, properties of DFS, Fourier series and LTI Systems, Filtering, Examples of CT filters, Examples of DT filters. CONTINUOUS TIME FOURIER TRANSFORM: Representation of a periodic Signals by continuous FT, FT of periodic signals, convolution and multiplication property of continuous FT, systems characterized by Linear Constant Coefficient Differential Equations.	**9**
3	**TIME AND FREQUENCY CHARACTERIZATION OF SIGNALS AND SYSTEMS**: Magnitude and phase representation of FT, Magnitude and phase response of LTI systems, Time domain and Frequency domain aspects of ideal and non-ideal filters. **DISCRETE TIME FOURIER TRANSFORM (DTFT) and DISCRETE FOURIER TRANSFORM (DFT):** Properties of DTFT and DFT, convolution property, multiplication property, Duality, Systems characterized by Linear Constant Coefficient Difference Equations.	**9**
4	**SAMPLING:** Sampling theorem, Impulse sampling, sampling with zero order Hold, Reconstruction of signal from its samples using interpolation, Effect of under sampling **Z-TRANSFORM:** Z-transform, Region of convergence and its properties, Inverse Z transform, properties of ZT, Analysis and characterization of LTI systems using ZT, LTI Systems, System function algebra and block diagram representations.	**9**
5	**SIGNAL FLOWGRAPHS:** Impulse Response and Transfer function of linear Systems, Block diagrams, Signal flow graphs, Basic properties of SFG, SFG Terms, SFG Algebra, Gain formula, Application of gain formula to block diagrams.	**7**

Text Books/Reference books:

1. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, Signals and Systems Prentice Hall India, 2nd Edition, 2009.

2. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms, and Applications, 4th Edition, PHI, 2007.
3. Robert A. Gable, Richard A. Roberts, Signals & Linear Systems, 3rd Edition, John Wiley,1995.

	DIGITAL SYSTEM DESIGN

Module	Course Content	No. of Lecture
1	**INTRODUCTION:** Introduction to Number Systems and Boolean Algebra Digital and Analog Basic Concepts, Number Base Conversion - Complement Codes, Binary Arithmetic , Binary codes: BCD, Weighted codes -2421, 8421, gray code - Binary Logic functions, Boolean Algebra, Theorems and Properties of Boolean Algebra. **MINIMIZATION OF BOOLEAN FUNCTION:** Minimization techniques in digital Logic Canonical forms, Generation of Switching Equations from Truth Table - K-map(Karnaugh map) 2 ,3 and 4 variables, K map v terms - Quine Mc-Cluskey minimization technique, Quine Mc-Cluskey using Don't Care Terms - Mixed logic Combinational circuits.	8
2	**COMBINATIONAL CIRCUIT DESIGN:** Design with basic logic gates, comparators, data selectors, priority encoders, decoders, full adder, serial binary adder, parallel binary adders-ripple-carry adder, carrylook ahead adder; Parallel prefix adders- Carry select Adder, Conditional sum adder, Kogge-stone Adder, Brent-kung adder, Verilog models.	8
3	**SEQUENTIAL CIRCUIT DESIGN:** Memory elements and their excitation functions SR, JK, T, and D latches and flip-flops, master slave JK flip-flop, edge-triggered flip-flop, synchronous and asynchronous counters, finite-state machine, sequence detector, minimization and transformation of sequential machines, Registers, Verilog models.	10
4	**TESTING OF COMBINATIONAL CIRCUITS:** Fault models, structural testing: path sensitization Logic families: TTL and CMOS Logic circuits, Transfer characteristics, fan-in, fan-out, noise margin, rise time and fall time analysis, realization of Boolean equations using CMOS logic.	8
5	**MEMORY:** Types of memories, MOS SRAM cells, DRAM, SDRAM, DDR SDRAM, DDR2 SDRAM, DDR4 SDRAM, organization of a SRAM, Organization of SDRAM, Periphery circuitry of Memory, Flash memory, SD card.	6

Text books:

1. John M Yarbrough,-Digital Logic Applications and Design, Thomson Learning,2001.

2. Donald D. Givone, ―Digital Principles and Design‖, McGraw Hill, 2002.

3. Charles H Roth Jr., Larry L. Kinney ―Fundamentals of Logic Design, CengageLearning, 7th Edition.

Reference books:

1. D. P. Kothari and J. S Dhillon, ―Digital Circuits and Design‖, Pearson, 2016,

2. Morris Mano, ―Digital Design‖, Prentice Hall of India, Third Edition.

3. K. A. Navas, ―Electronics Lab Manual‖, Volume I, PHI, 5th Edition, 2015.