

SCHOOL OF PHYSICAL SCIENCES
SOLAPUR UNIVERSITY, SOLAPUR
M.Sc - Electronic Science
Choice Based Credit System
w.e.f June 2016-17

Semester	Code	Title of the Paper	Semester exam			L	T	P	Credits
			Theory	IA	Total				
First		Hard core							
ES	HCT1.1	Semiconductor Devices	70	30	100	4	1	-	4
	HCT1.2	Network Analysis and Synthesis	70	30	100	4		-	4
	HCT1.3	Communication Systems	70	30	100	4		-	4
		Soft Core (Any one)							
	SCT1.1	Microcontrollers and Interfacing	70	30	100	4		0	4
	SCT1.2	Electromagnetic and Antennas	70	30	100	4		0	
								1	
		Practical							
	HCT 1.1	Practical HCP 1.1	35	15	50	-	-	2	6
	HCP1.2	Practical HCP 1.2	35	15	50	-	-	2	
	HCP1.3	Practical HCP 1.3	35	15	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP1.1	35	15	50	-	-	2	2
	SCP1.2	Practical SCP1.2	35	15	50	-	-	2	
		Total for first semester	420	180	600				25
Second		Hard core							
ES	HCT2.1	Control Systems	70	30	100	4	1	-	4
	HCT2.2	Digital Electronics and VHDL	70	30	100	4		-	4
		Soft core (Any one)							
	SCT2.1	PIC Microcontroller	70	30	100	4		-	4
	SCT2.2	Foundation of Nanoelectronics	70	30	100	4		-	
		Open elective (Any one)							
	OET2.1	Fundamentals of Electronics	70	30	100	4	-	4	
	OET2.2	Power Supplies	70	30	100	4	-		
								1	
		Practical							
	HCP 2.1	Practical HCP 2.1	35	15	50	-	-	2	4
	HCP2.2	Practical HCP 2.2	35	15	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP2.1	35	15	50	-	-	2	2
	SCP1.2	Practical SCP2.2	35	15	50	-	-	2	
		Open elective (Any one)							
	OEP2.1	Practical OEP2.1	35	15	50	-	-	2	2
	OEP2.2	Practical OEP2.2	35	15	50	-	-	2	
		Total for second semester	420	180	600				25

Third		Hard core								
ES	HCT3.1	Digital Signal Processing	70	30	100	4	1	-	4	
	HCT3.2	Microwave Electronics and Applications	70	30	100	4		-	4	
	Soft core (Any one)									
	SCT3.1	Data Communication and Networking	70	30	100	4		-	4	
	SCT3.2	RTOS	70	30	100	4		-		
	Open elective (Any one)									
	OET3.1	Antenna & Wave Propagation	70	30	100	4		-		
	OET3.2	Communication & Digital Electronics	70	30	100	4		-	4	
								1		
	Practical									
	HCP 3.1	Practical HCP 3.1	35	15	50	-	-	2	2	
	HCP3.2	Practical HCP 3.2	35	15	50	-	-	2	2	
	SCP 3.1	Practical SCP 3.1	35	15	50	-	-	2	2	
	Open elective (Any one)									
	OEP3.1	Practical OEP3.1	35	15	50	-	-	2	2	
	OEP3.2	Practical OEP3.2	35	15	50	-	-	2		
	Total for third semester		420	180	600				25	
Four		Hard core								
ES	HCT4.1	Optical Fiber Communication	70	30	100	4	1	-	4	
	HCT4.2	Power Electronics	70	30	100	4		-	4	
	HCT 4.3	Advanced microcontroller	70	30	100	4		-	4	
	Soft core (Any one)								1	
	SCT4.1	Satellite Communication	70	30	100	4		-	4	
	SCT4.2	VLSI Design	70	30	100	4		-		
	MP4.3	Major Project	140	60	200	-	-	-	8	
	Total for four semester		420	180	600				25	
Total										100

L = Lecture T = Tutorials P = Practical
4 Credits of Theory = 4 Hours of teaching per week
2 Credit of Practical = 4 hours per week
HCT = Hard core theory
SCT = Soft core theory
HCP = Hard core practical
SCP = Soft core practical
OET = Open elective theory
OEP = Open elective practical
MP = Major project

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HCT 1.1: Semiconductor Devices

**Total no. hours:60
Credits:4**

Unit – 1 **[7L + 3T]**

Crystal properties: semiconductor materials, crystal lattices, bonding forces in solids.

Growth of semiconductors: bulk crystal growth from melt, float zone process, epitaxial growth.

Unit – 2 **[12L +3T]**

Energy bands: energy band formation, Kronig – Penney model, metals, semiconductors and insulators.

Carrier concentration in thermal equilibrium: charge carriers in semiconductors – electrons and holes, effective mass, intrinsic and extrinsic materials, Fermi level, density of states, carrier concentration at equilibrium, law of mass action, temperature dependence of carrier concentration.

Carrier transport phenomena: Conductivity and mobility, carrier drift, effects of temperature and doping on mobility, high field effects, Hall effect. Diffusion of carriers, built in fields, continuity equation, Haynes – Shockley experiment.

Unit – 3 **[12L +3T]**

p-n junctions: Fabrication of p-n junctions, equilibrium conditions, contact potential, current flow at a junction, junction breakdown, capacitance of p-n junctions, charge storage and transient behavior.

Metal semiconductor junctions: Schottky barriers, rectifying and ohmic contact, heterojunctions.

p-n junction diodes: rectifiers, switching diodes, varactor diodes, tunnel diodes, photo diodes, solar cells, photo detectors, light emitting diodes.

Unit – 4 **[17L +3T]**

Bipolar transistors: BJT fabrication, transistor action, minority carrier distributions, terminal currents, Ebers – Moll model, switching.

Secondary effects: drift in base region, base narrowing, avalanche breakdown, injection level effects, emitter crowding.

Field effect transistors: Junction FET, working, VI characteristic, metal semiconductor FET, GaAs MESFET, high electron mobility transistor.

Metal insulator semiconductor FETs: construction, operation, ideal MOS capacitor, threshold voltage, MOSFET.

References:

1. Solid state electronic devices: Ben G Streetman, PHI, 2003
2. Semiconductor Devices Physics and Technology: S M Sze, John Wiley, 2002
3. Foundation of Electronic Devices: M Sathyam& K Ramkumar
4. Semiconductor Devices: Kanaan Kano, Pearson Education, 2004.
5. Semiconductor Devices: Modelling and Technology, Nandita Das Gupta and Amitava Das Gupta, PHI, 2004.
6. Semiconductor Physics and Devices – Basic Principles, Donald A Neamen, TMH, 2003

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HCT 1.2 Network Analysis and Synthesis

**Total no. hours:60
Credits:4
[12L +3T]**

Unit - 1

Introduction:

Kirchoff's laws: Node voltage analysis and mesh voltage analysis, network solutions using first order differential equation, initial conditions in networks.

Analysis of networks using Laplace transformation: Basic theorems of Laplace transformation, examples of solutions of networks using Laplace transformation. Transforms of signal waveform: the shifted unit step function, the ramp and impulse functions. Waveform synthesis, the initial and final value theorems, convolution integral, convolution as summation.

Unit - 2

[12L +3T]

Impedance functions and network theorems: Concept of complex frequency, transform impedance and transform circuits, series and parallel combinations of elements, superposition and reciprocity, Thevenin's, Norton's, maximum power transfer and Tellegen's theorem.

Two-port parameters: Relationship of two-port variable, the open circuit impedance parameters, short-circuit admittance parameters, transmission parameters, inverse transmission parameters, the hybrid parameters, inverse hybrid parameters, relationships between parameter sets, series, parallel and cascade connection of two-port networks.

Unit -3

[12L +3T]

Resonance: Series resonance, impedance and phase angle of series resonant circuit, voltage and current in series resonant circuit. Effect of resistance on frequency response curve, bandwidth, selectivity and quality factor. Significance of Quality factor.

Parallel resonant circuit(Tank circuit), resonant frequency, variation of impedance with frequency, reactance curves, numerical problems based on above.

Unit - 4

[12L +3T]

Network synthesis: Introduction, scaling network functions, positive real functions, Hurwitz polynomials, driving point synthesis with LC elements, elementary synthesis operations, synthesis of dissipative networks- 2 terminal Rc and RL networks (Foster and Cauer forms), properties of RL and RC network functions.

References:

1. Network Analysis: Van Valkenburg, PHI, 2003
2. Network Analysis and Synthesis: Bakshi A V, Bakshi U A, Technical Publications, 2009.
3. Electric circuits: Joseph Edminister, Schaum's series-McGraw Hill.
4. Network analysis and synthesis: Franklin F Kuo, John Wiley and sons, 2nd edition.
5. Networks and systems: Roy Choudhury D, New Age International, 2004.

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HCT 1.3 Communication Systems

Total hours:60

Credits:4

Unit 1. A.M.& F.M. Transmitters and Receivers:

[12L +3T]

A.M Transmitter and Receiver:

Block diagram of High and Low level modulated A.M. Transmitters. The exciter, Class A, Class B, Class C modulated power amplifier circuits of sidebands and sideband transmission, balanced modulators.

Block diagram of A.M. receiver and A.M. Detectors, (circuits to be discussed), Class B audio amplifier

F.M. Transmitter and Receiver:

F.M. radio frequency band, Block diagram of F.M. transmitter, block diagram of VCO, frequency doubler , tripler.

Block diagram of F.M. receiver, F.M. detector (Slope and dual slope detector), PLL as FM detector. (Circuits to be discussed)

Unit 2. Digital Modulation and Techniques:

[12L +3T]

Pulse: Modulation systems: Sampling theorem, low pass and Band pass signals, PAM, PWM, PPM, Quantization of signals, Delta modulation (Basic introduction).

(Modulation and Demodulation Circuits) , TDM, FDM, Cross talk in TDM , Pulse time modulation, Generation of PTM, Demodulation of PTM,

Unit 3. Data formats:

[12L +3T]

Unipolar, Bipolar, RZ, NRZ, Transmission modes, simplex, Half duplex, full duplex, Asynchronous transmission. Amplitude shift keying, Frequency shift keying, Phase shift keying, Differential phase shift keying..

Unit 4. Spread Spectrum modulation:

[12L +3T]

Introduction, direct sequence spread spectrum, use of spread spectrum with code division multiple access (CDMA), Ranging using spread spectrum, frequency hopping spread spectrum, generation and characteristics of PN sequences, Acquisition (course synchronization) of a FM signal, acquisition of a DS signal, tracking of a DS signal.

Text Books:

- 1) Communication System, Analog and Digital
R.P. Singh and S.D. Sapre (THM)
- 2) Electronic Telecommunication System (4th Edition)
George Kennedy and Bernard Devisé (MGH)

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Credits:4

SCT 1.1 Microcontroller and Interfacing

UNIT I: 8051 Hardware

[12L +3T]

Introduction, 8051 Microcontroller Hardware, 8051 oscillator and clock, stack pointer, special function registers, input/output pins, ports and circuits, counters and timers, serial data input/output, interrupts, microcontroller design, timing subroutines, lookup tables for 8051, serial data transmissions

UNIT II: Digital Interfacing

[12L +3T]

ADC, DAC, shaft encoder, pushbutton, matrix keyboard, relay, LED, optocoupler, 7-segement, DC motor (PWM), Servo Motor (PWM).

UNIT III: Analog Interfacing

[12L +3T]

LM35, thermocouple, LDR, Humidity (HY-HS 220), thermister, voltage, current, tachogenerator.

UNIT IV: Smart Devices and Interfacing

[12L +3T]

LCD, RTC , GSM, GPS, PS2 keyboard, accelerometer.

References:

1. The 8051 Microcontroller (Book Only) (English) Author: Kenneth Ayala , Ayala
Publisher: Cengage Learning
2. Microcontrollers: Theory And Applications (Computer Engineering Series) (English)
1st Edition by Ajay A V Deshmukh Publisher: Mcgraw Hill Education
3. 8051 Intel Datasheet
4. User manual for LCD, RTC, GSM, GPS, PS2 keyboard, accelerometer.
5. IC Datasheets

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SCT 1.2 Electromagnetics and Antennas

Total no. hours:60
Credits:4

UNIT – I

[12L +3T]

Introduction: Transverse fields, TE and TM waves and their characteristics, TEM waves, TE and TM modes, velocity of propagation, attenuation in parallel plane guides, wave impedance, Smith chart, impedance matching with stubs, rectangular waveguides and Q of waveguides, Cut off frequencies, dominant mode, power transmitted in a lossless waveguide, power dissipation in a lossy waveguide.

UNIT – II

[12L +3T]

Waveguide components and networks: Cavity resonators, Q of cavity resonator, cavities, slow wave structure, microwave hybrid circuits and S parameters, waveguide Tees, directional couplers, phase shifters, attenuators and slide screw tuner.

UNIT – III

[12L +3T]

Basic antenna parameters: Radiation pattern, radiation intensity, directivity, radiation resistance, efficiency and gain. Effective aperture antennas, effective height, dipole antenna, helical antenna, horn antennas and aperture antennas.

UNIT – IV

[12L +3T]

Antenna and arrays: Antenna characteristics, radiation, potential function and EM fields, potential function for sinusoidal oscillator, alternating current element, horn antennas, helical loop antennas. Array of two isotropic sources, principle of pattern multiplication. Array of n-isotropic point sources, principle of pattern multiplication technique, suppression of side lobes.

Reference Books:

- 1) John D Ryder: Network, lines and fields, 2/e PHI, 2003.
- 2) E. C. Jordan and K. E. Balmain: Electromagnetic wave and radiating systems, PHI, 1982.
- 3) S. Y. Liao: Microwave devices and circuits, PHI, 1980.
- 4) C. A. Balanis: Antenna theory-Analysis and Design, Harper Row, 1982.
- 5) D. Ganeshrao, B. Somanathnair and Deepa Raghunathan: Antenna and radio propagation Sanguine Tech. Pub. Bangalore 2007.

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HCT 2.1 Control Systems

Total no. hours:60

Credits:4

Unit 1: Introduction

[12L +3T]

Basic Concepts of Control System, Open loop and Closed loop systems, Classifications, effect of feedbacks on Control System performance, Transfer function, modeling and representation of Control system, concept of pole and zero, Linear mathematical physical systems, Electrical analogy, Block reduction techniques, Signal flow graph, Mason's gain formula

Unit 2: Time Domain Analysis and stability

[12L +3T]

Type and Order of Control system, Time Response of first and second order systems to unit step input. Steady state errors, Time Domain Specifications of Second Order System, Concept of Stability: absolute, relative and marginal, nature of system response, stability analysis using Hurwitz's criterion, Routh's criterion, Basic properties of Root Loci, construction of Root loci. Angle and magnitude condition for stable systems, concept of inverse root locus and root contour

Unit 3: Frequency Domain and State Variable Analysis

[12L +3T]

Steady state response of a system to sinusoidal input, Relation between time and frequency response for second order systems, Frequency response specifications, Stability Analysis with Bode Plots, Introduction to state space analysis, State space representation for i) Electrical Network ii) nth order differential equation iii) Transfer function, State model from transfer function using: Direct, parallel, cascade, decomposition methods

Unit 4: Control system components and controllers (only theoretical treatments)

[12L +3T]

Modeling and transfer function of control system components- Potentiometer, DC and AC Servomotors, gear trains, tacho-generators. Design concepts of ON-OFF, P, PI, PD, PID controllers, Compensator Networks-lag and lead.

Reference Books:

1. I.J. Nagrath, M.Gopal "Control Systems Engineering", 5th Edition, New Age International Publication
2. Ogata Katsuhiko, "Modern Control Engineering", 4th Edition, PHI.
3. Kuo B.C. Automatic Control System, PHI, New Delhi
4. Schaum's Series book "Feedback Control Systems"
5. Les Fenical "Control Systems", 1st Edition, Cengage Learning India.
6. Norman S. Nise "Control Systems Engineering", 4th edition, Wiley
7. Samarjeet Ghosh, "Control Systems Theory & Applications", 1st edition, Pearson education.
8. S.K. Bhattacharya, "Control Systems Engineering", 1st edition, Pearson education.

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HCT 2.2 Digital Electronics and Verilog HDL

Total Hours: 60

Credits: 04

Unit – 1

(15L +3T)

Combinational and Sequential Logic Designs: Combinational Logic Designs: Multiplexer, Demultiplexer, Encoder, Decoder, Arithmetic and Logic circuits, adder- Half adder, Full adder, Carry look ahead adder, n-bit adder, BCD adder, Full subtractor, binary multiplication and division, floating and fixed point arithmetic, Comparison circuits, comparator, 4 - bit comparator, parity generator/checker, ALU design (Design of all is expected).

Sequential Logic Designs: Design of ripple counter, ring counter, synchronous counter, Johnson's counter. Up - down counter, Shift registers, bi - directed shift register, Universal Shift register.

Unit – 2

(5L +3T)

Synchronous Sequence Machines: State diagram, State reduction, State assignment, implementation using flip flop. Finite state machines, Control Unit design

Unit – 3

(10L +3T)

PLD's and Architecture of commercial devices: Detail architecture, study of PROM, Simple PLD, PAL, PLA, Digital System design using PLD's, CPLD, FPGA, Xilinx XC95xx CPLDs.

Unit – 4

(18L +3T)

Verilog Programming and model for combinational and sequential logic: Introduction to VerilogHDL, Lexical Conventions, Ports and Modules, Operators, Gate Level Modeling, System Tasks & Compiler Directives, Test Bench, Data Flow Modeling, Behavioral level Modeling, Tasks & Functions.

Verilog model for combination Logic: Verilog Programming Examples-basic gates, 4 - bit binary adder, Multiplexer, Comparator, encoders, decoders.

Verilog Model for Sequential Logic: Flip - Flops, Latches, counters, Shift Register, State Machine.

Text Books:

1. Fundamentals of Digital logic Design with Verilog HDL – Brown, Vranesic – SiE (2nd edition).
2. Verilog HDL: A Guide to Digital Design and Synthesis, Samir Palnitkar, Prentice Hall, Second Edition, 2003.

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SCT 2.1 PIC Microcontroller

Total no. hours:60
Credits:4

UNIT I: Core Architecture

[12L +3T]

PIC microcontroller families (review) baseline, midrange, high-end, Introduction: PIC microcontroller features, PIC Architecture, Program memory, Overview & features PIC 18 FXXXX Flash microcontroller: Introduction, Architecture, functional pin description, various registers, program memory and data memory organization, Input / Output ports, Timers & Interrupts.

UNIT II: Instruction set

[12L +3T]

Instruction set, Instruction Format, Byte-Oriented Instructions, Bit-Oriented Instructions, Literal Instructions, Control Instructions (CALL and GOTO), Destination Designator (d), Addressing Modes CPU, MPASM assembler, directives, macros, MPLAB overview: MPLAB IDE, Toolbars, Select Development Mode and Device Type, Project wizard, Text Editor, Assembler debug tools- PicKit2, PicKit3, simulator, MPLAB Operations.

UNIT III: On chip peripherals of PIC

[12L +3T]

Reset, clock, power up, power on reset, watchdog timer, configuration register, Timer, Counter, PWM, ADC – configuration and programming.

UNIT IV: External peripherals Interfacing with PIC

[12L +3T]

DAC, DC Motor, stepper motor, LCD, Graphics LCD, sensors (LM35, LDR, Humidity HY-HS 220, Thermocouple), relay, pushbutton, LED (Simple and Bicolour), optocoupler, serial port, I²C devices, SPI devices.

References :

1. Fundamentals of Microcontrollers and Applications In Embedded Systems (with the PIC18 Microcontroller Family) Ramesh Gaonkar Publisher: PENRAM INTL. PUBLISHING (INDIA) PVT. LTD.-MUMBAI
2. Microcontrollers: Theory And Applications (Computer Engineering Series) (English) 1st Edition by Ajay A V Deshmukh Publisher: Mcgraw Hill Education
3. Programming and Customizing the PIC Microcontroller (English) 1st Edition Author: Myke Predko Publisher: Mcgraw Hill Education
4. PIC18F4550 Datasheet
5. Devices Datasheet

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SCT 2.2 Foundation of nanoelectronics

Total no. hours:60

Credits:4

[12L +3T]

UNIT 1

Region of nanostructures, scaling of devices in silicon technology, estimation of technology limits, Uncertainty principle, Experiments on duality, Schrodinger's equation and its applications to square well potential, square potential barrier (1D).

UNIT 2

[12L +3T]

Infinite array of potential wells, Barrier penetration, applications to tunnel diode, Josephson effect, Perturbation theory and its applications, Scattering. Binomial and related distributions, Phase space, Statistical ensembles, applications of classical statistical mechanics, Quantum statistics, Brownian motion, Random walk problem. Concept of Chemical potential, partition function and its applications in computing thermodynamic quantities.

UNIT 3

[12L +3T]

Quantum electronic devices, electrons in mesoscopic structures, short channel MOSFET, split-gate transistor, electron wave transistor, electron spin transistor, quantum cellular automata, Bioelectronics, molecular processor, DNA analyzer as biochip, Molecular electronics, Fullerenes, nanotubes, switches based on Fullerenes and nanotubes.

UNIT 4

[12L + 3T]

Nanoelectronics with tunneling devices, resonant tunneling diode(RTD), three terminal RTDS, RTD based memory, basic logic gates and dynamic logic gates,

Principle of single electron transistor, Coulomb blockade.

Text / Reference Books:

1. Nanoelectronics and Nanosystems: K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2005).
2. Quantum Mechanics: Schiff L.I. , ""
3. Fundamentals of Statistical Mechanics and Thermal Physics: Reif

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OET 2.1 Fundamentals of Electronics

Total no. hours:60

Credits:4

UNIT 1 : Electronic Components

[12L +3T]

Circuit concept Units, Standards and Dimensions. Electric current, Electric charge, potential difference, Electric power and Energy. Circuit elements : Passive elements and active elements. Network Law's, Junction Law's (KCL), Mesh Law's (KVL) Application of Network Law's to simple dc networks theorems – Thevenin's theorem, Norton's theorem Max power transfer theorem.

UNIT 2 : Semiconductor Devices

[12L +3T]

Junction Diodes, p-n junction, an unbiased p-n junction, a biased p-n junction and V-I characteristics of p-n junction. Some special P-N junction: - Photodiodes, LED and Solar Cell. Junction transistor, Transistor static characteristic Self-bias or emitter bias, Two-port representation of Transistor (hybrid parameter) JFET: Static Characteristic of FET comparison of FET with Bipolar transistor.

UNIT 3: Operational Amplifier Characteristics and Applications

[12L +3T]

Introduction, Ideal Op-Amp, DC and AC Characteristics: Instrumentation Amplifier, V to I and I-V converter Precision rectifier, Differentiator and Integrator. Comparator Schmitt trigger wave generators (Square wave and Triangular wave) and first order Low pass and High pass filters.

UNIT 4: Special IC series

[12L +3T]

Op-Amp regulator, Design of power supplies using voltage regulator ICs, 555 Timer as Monostable and Astable operation.

Reference books:

1. D Chattopadhyaya, P.C. Rakshit, B Saha and N NPurkait: Foundations of Electronics, New Age International Edition.
2. D. Roy Choudhary and ShailJain : Linear Integrated Circuit, New Age International (P) Ltd.
3. P-Amp and Linear Integrated Circuits : R. A. Gaikwad, PHI of India Ltd.
4. A Texbook of Electronics (Second Edition) : S. L. Kakani and K. C. Bhandari
5. Electronic Principles : A. P. Malvino, TMH Edition.

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OET 2.2 Power Supplies

Total hours:60
Credits:4

Unit - 1 : Transformers

[12L +3T]

Basics and design considerations: Transformers rated for 230 Volts and 208 volts primary, transformer voltage, current, and turns ratios, step-up and step-down voltage transformers, VA ratings for transformers, current transformers, dimmerstats, Transformer cores – frequency response, size, shapes, copper wire current ratings, Transformer winding techniques – for single output, multiple outputs, center tap, transformers for switching power supply.

Unit – 2: Constant Voltage (CV) Power supplies

[12L +3T]

Constant Voltage (CV) Power supplies: Building blocks, Design, characterization. Zener regulator, emitter follower regulator, series regulator, shunt regulator, current limiting techniques, Switching mode regulator Constant Current (CC) and CV/CC Power supplies: Building blocks, Design, characterization. CC sources – using discrete transistor, monolithic transistors, controlled sources, Series regulator type CC supply, Guarded CC supply, Adjustable VL CC supply, Typical CV/CC supply.

Unit – 3 Power supplies using ICs

[12L +3T]

Power supplies using ICs: General purpose regulators, precision regulators, fixed voltage regulators, Switch mode regulators. Protection techniques: Protection against transients, RFI suppression, current limiting, voltage limiting.

Unit – 4 Heat Sinks

[12L +3T]

Heat Sinks: Effect of temperature on leakage current, current gain and power dissipation of active devices, thermal runaway, operation with and without heat silks, heat sink ratings, capabilities, practical considerations and mounting, heat sinks for ICs.

Text / Reference Books:

1. Simplified design of linear Power supplies: John D. Lenk, Butterworth-Heinemann
2. Simplified design of switching power supplies: John D. Lenk, Butterworth-Heinemann
3. Regulated power supplies Irving M Gottlieb, TAB books
4. Practical Design of Power Supplies: Ron Lenk, IEEE press +McGraw hill
5. Electric Power Transformer Engineering: James H. Harlow, CRC Press

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HCT 3.1 Digital Signal Processing

Total hours:60
Credits:4

Unit 1: Discrete Time Signals and Linear Systems **[12L +3T]**

Introduction of DSP system, Advantages, Applications, Discrete time signals classifications and representation, Operations on signals, Discrete time system, Classification, Impulse response and convolution sum, Convolution methods, Solution of Difference equations, Impulse and step responses, Analog to digital conversion: Sampling theorem, Aliasing effect, Quantization, Reconstruction of analog signal.

Unit 2: Z-Transform and Analysis of Discrete Time System **[12L +3T]**

Z-transform and ROC, Z-transform of Finite and Infinite sequences, Properties of Z-transform, Inverse Z transform, System Function of LTI system, Inverse Z-transform, Transient and Steady state responses, Causality and Stability of System, Solution of difference Equations, Realization of Discrete time system by Direct form-I and Direct form-II, Cascade and parallel forms.

Unit 3: Z-Transform and Analysis of Discrete Time System **[12L +3T]**

Discrete Fourier Transform, IDFT, Properties of the DFT, Circular shift of sequence, Circular convolution, Circular convolution methods, Linear convolution from circular convolution, DFT of long duration sequence by overlap-save and overlap-add methods, FFT Algorithms: Radix-2 DIT and DIF algorithms to compute DFT and IDFT.

Unit 4: Design and Realization of Digital Filters **[12L +3T]**

FIR Filter Structure and Design: Direct and cascade forms, frequency sampling and linear phase structure. Windowing method, Frequency sampling method of design, IIR Filter structure and Design: Direct form, Cascade form, Parallel form, Impulse invariance, Bilinear Transformation method of design.

Reference Books:

1. John G Prokis, Manolakis, "Digital Signal Processing-Principles, Algorithms and Application", 4th Edition, Pearson Education Publication
2. Salivahanam, AVallavaraj, C. Guanapriya, "Digital Signal Processing", 1st Edition, Tata McGrawHill, New Dehli
3. P.RameshBabu, "Digital Signal Processing", 4th Edition, Scitech Publication.
4. P. Pirsch, "Architectures for Digital Signal Processing" John Wiley publication, New Delhi
5. B.Venkataramani, M. Bhaskar, "Digital Signal Processors", Architecture programming & applications, TMH, New Dehli

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HCT 3.2 Microwave Electronics and Applications

Total hours:60

Credits:4

Unit - 1 [12L +3T]

Introduction to microwaves:

Motion of an electron in an electric field and magnetic fields. Review of Gauss's law, Laplace's equation, Faraday's law and Ampere's law. Maxwell's equations, boundary conditions, Poynting's energy theorem.

Microwave frequency bands, microwave transmission lines - transmission line equations and solutions, reflection and transmission coefficients, standing waves and standing wave ratio, line impedance and admittance, Smith chart, impedance matching – single stub and double stub matching.

UNIT 2: Microwave waveguides and components: [12L +3T]

Rectangular waveguides, TE and TM modes, power transmission and power losses, excitation of modes in rectangular waveguides. Circular waveguides, possible modes, power transmission and power losses, co-axial waveguides. Microwave cavities – rectangular and circular cavity resonators, resonant cavities, Q factor of a cavity resonator. Waveguide tees, magic tee, hybrid ring, waveguide corners, bends and twists, two-hole directional coupler, hybrid coupler, microwave circulators and isolators.

Unit - 3 [12L +3T]

Microwave tubes:

High frequency limitation of conventional vacuum tubes, Klystron, multicavity klystron amplifier, helix and coupled cavity TWT, cylindrical magnetron – construction, principle of operation, performance characteristics and applications.

Microwave solid state devices, circuits and Strip lines and MICs:

Principle, structure, construction and working of Gunn diodes, modes of operation, LSA diode, READ diode, IMPATT, TRAPATT and BARRIT diode, HEMT, tunnel diodes, parametric devices. Characteristic impedance of microstrip lines, losses and Q-factor of micro strip lines, parallel strip lines, distributed parameters, characteristic impedance and attenuation losses, coplanar and shielded strip lines.

Unit – 4 [12L +3T]

Applications of microwaves: Radar systems, radar equation, duplexer, pulsed radar, CW Doppler radar, FMCW radar. Industrial applications of microwaves.

Microwave radiation hazards: HERP, HERO, radiation hazard limits, radiation protection.

References:

1. Microwave Devices and Circuits: Liao Samuel Y, PHI, 3rd edition
2. Solid state electronic devices: Streetman Ben G, PHI, 3rd edition.
3. Introduction to Electrodynamics: Griffiths D J, PHI, 4th edition.
4. Microwave engineering: Annapurna Das, Sisir Das, TMH, 9th edition.
5. Microwaves: David M Pozar, Wiley 3rd edition.
6. Electronic communication systems: Kennedy, TMH, 4th edition.
7. Foundations of microwave engineering: Robert E Collin, Wiley, 2nd edn.
8. Microwave engineering: Chatterjee R., PHI.

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SCT 3.1 Data Communication and Networking

Total hours:60
Credits:4

Unit1. Introduction to computer networks: **[12L +3T]**

Need, applications, line configurations, topology, categories of networks and internetworks. Layered reference model – need of layers, design issues of layers, ISO-OSI Model, IEEE standard 802 for LANs and WANs, bridges, high speed LANs.

Unit 2. Physical & Data Link Layers and Medium Access Sublayer: **[12L +3T]**

Physical Layer:

Transmission media: – Guided media-twisted pair, coaxial cable, optical fiber. Unguided media – RF allocation, terrestrial microwave, satellite communication, cellular telephone. –Design issues for physical layer, EIA 232 D interface standard, Modems – types, block schematic.

Data Link Layer:

Design issues, error detection and correction, elementary data link protocols, sliding window protocols. HDLC – types of stations, modes of operation, HDLC frame formats, additional features.

Medium Access Sub layer: Channel allocation problem, multiple access protocols.

Unit 3. Network Layer: **[12L +3T]**

Design issues, Routing algorithms – shortest path, distance vector routing, link state routing, flow based routing, routing for mobile hosts, Congestion control – congestion prevention policies-leaky bucket algorithm, token bucket algorithm, congestion control in virtual circuit subnet and choke packets.

Unit 4. TCP/IP Protocol Suit Overview and Transport Layer: **[12L +3T]**

TCP/IP Protocol Suit Overview:

TCP/IP versus OSI model, TCP/IP and Internet, IP protocol and it's header format, addressing, subnetting, other network layer protocols – ARP, RARP, ICMP, IGMP.

Transport Layer:

TCP and its header format, congestion control in TCP, UDP and Domain name system (DNS).

Text/ Reference Books:

1. Data Communication and Networking Forouzan-IIInd edition
2. Data Communication P.C. Gupta
3. Computer Networks Tanenbaum

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SCT 3.2 RTOS

Total hours:60

Credits:4

- Unit 1:** Introduction to RTOS: Introduction, What is an RTOS, RTOS Scheduler, objects, services, Key characteristics of an RTOS. • Tasks: Introduction, Defining a task, task states and scheduling, task structures, synchronization, communication and concurrency. **[12L +3T]**
- Unit 2:** Kernel objects: Semaphores, queues, pipes, event registers, signals, and condition variables. • Exceptions and interrupts: Introduction, Exception v/s Interrupt, Applications of exceptions and interrupts, • **[12L +3T]**
- Unit 3:** Timer and timer services: Introduction, Real-time clock and system clock, Programmable interval timers, Timer ISRs, Timing wheels, soft timers. • I/O subsystem: Basic I/O concepts, The I/O subsystem. (4) • **[12L +3T]**
- Unit 4:** Memory Management: Introduction, Dynamic memory allocation in Embedded systems, Fixed-size memory allocation, blocking v/s non-blocking memory functions, H/W memory management units (5) • Commercially available RTOS (PSOS, ThreadX, VXWorks, Nucleus, WinCE), Introduction to VxWorks (2) **[12L +3T]**

References:

1. Real-Time Concepts for Embedded Systems, Qing Li, Caroline Yao, CMP Books.
2. An Embedded Software Primer, David E. Simon, Addison-Wesley.
3. Patterns for Time-Triggered Embedded Systems: Building Reliable Applications with the 8051 Family of Microcontrollers (with CD-ROM), Michael J. Pont, Addison-Wesley
4. Embedded C (With CD-ROM), Michael J Pont, Addison-Wesley.
5. Embedded Systems Building Blocks: Complete and Ready-To-Use Modules in C, Jean J. Labrosse, CMP Books.
6. C Programming for Embedded Systems, Kirk Zurell, RD Books (CMP Books)

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OET 3.1 Antennas and Wave Propagation

Total hours:60

Credits:4

UNIT 1: ANTENNA BASICS:

[12L +3T]

Introduction, Radiation Mechanism, Antenna Parameters-Radiation Patterns, Patterns in Principle Planes, Main Lobe and Side Lobes, Beam widths, Beam Area, Radiation Intensity, Beam Efficiency, Directivity, Gain and Resolution, Antenna Apertures, Aperture Efficiency, Effective Height, Antenna Theorems-Applicability and Proofs for equivalence of directional characteristics.

Radiation from Wires: Retarded Potentials, Small Electric Dipole, Quarter wave Monopole and Half wave Dipole Radiation characteristics

UNIT 2: WAVE PROPAGATION

[12L +3T]

Concepts of Propagation- frequency ranges and types of propagations. Ground Wave propagation - characteristics, Parameters, Wave Tilt, Flat and Spherical Earth Considerations, Sky Wave Propagation-Formation of Ionospheric Layers and their characteristics, Mechanism of Reflection and Refraction, Critical Frequency, MUF & Skip Distance Calculations for flat and spherical earth cases, Optimum Frequency, Virtual Height, Ionospheric Abnormalities, Ionospheric Absorption, Fundamental Equation for Free-Space Propagation, Basic Transmission Loss Calculations, Space Wave Propagation - Mechanism, LOS and Radio Horizon, Tropospheric Wave Propagation- Radius of Curvature of path, Effective Earth's Radius, Effect of Earth's Curvature, Field Strength Calculations, M-Curves and Duct Propagation, Tropospheric Scattering.

UNIT 3: ANTENNA ARRAYS, HF, VHF AND UHF ANTENNAS

[12L +3T]

Two element array, Principle of Pattern Multiplication, N element Uniform Linear Arrays - Broadside, End fire Arrays, EFA with Increased directivity, Binomial Arrays, Traveling wave radiators –basic concepts, Long wire antennas-field strength calculations and patterns, V-antennas, Rhombic Antennas and Design Relations, Small Loop antennas- Concept of short magnetic dipole, Helical Antennas, Yagi-Uda Arrays, Log periodic antennas.

UNIT 4: MICROWAVE ANTENNAS AND ANTENNA MEASUREMENT THEORY [12L +3T]

Reflector Antennas: Flat Sheet and Corner Reflectors, Paraboloidal Reflectors, Cassegrain Feeds. Slot antennas-Babinet's principle, Microstrip antennas, Horn antennas, Lens antennas (Qualitative treatment only) Antenna Measurements-Patterns Required, Set Up, Distance Criterion, Directivity and Gain Measurements (Comparison, Absolute and 3Antenna Methods).

TEXT BOOKS:

1. G.S.N Raju, "Antennas and Wave Propagation", 1st Edition Pearson Education, 2004.
2. K.D.Prasad, Satya Prakashan, "Antennas and Wave Propagation", Tech Publications, 3rd Edition, 2001.

REFERENCES:

1. C.A. Balanis, "Antenna Theory", 3rd Edition, John Wiley & Sons, 2012.
2. E. C. Jordan and K. G. Balmain, "Electromagnetic Waves and Radiating Systems", PHI, 2nd edition, 2000.
3. John D. Kraus and Ronald J. Marhefka, "Antennas and Wave propagation", TMH, 4rd Edition, 2010.

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OET - 3.2: Communication & Digital Electronics

Total hours:60

Credits:4

UNIT 1

[12L+3T]

Introduction to communication, need for modulation, modulation and demodulation techniques AM, FM and PM (Qualitative Analysis only), Block diagram of AM and FM transmitter and Receiver (Qualitative analysis) Sampling theorem, channel capacity, PAM, PPM, PWM and PCM, Digital modulation technique ASK, PSK, QPSK (Qualitative Analysis only).

UNIT 2

[12L +3T]

Introductory Aspects of Multiplexing and Multiple Accesses: FDM, TDM, FDMA, TDMA, CDMA and OFMDA.

Satellite Communication: Introduction, to Orbit, types of orbits, Block diagram of satellite transponder.

UNIT 3

[12L +3T]

Evaluation of Communication: 1 st generation, 2nd generation, 3rd generation & 4th generation mobile communication, Basics of cellular communication (GSM, CDMA)-Cell architecture, Base stations, relay stations and principles of communication, Introduction to Bluetooth, Wi-Fi, Wi-Max and LTE network.

UNIT 4.

[12L +3T]

Binary Systems: Introduction to Digital Systems, Number systems, binary number system, Decimal to binary & binary to decimal conversion, representation of binary using hexadecimal.

Boolean Algebra and Logic Gates: Basic definitions, operators of Boolean algebra, basic theorems and properties of Boolean algebra, basic gates -AND, OR, NOT, XOR, NAND, NOR - only truth table & gate representation, Boolean functions, canonical or standard forms,

REFERENCE BOOKS:

1. Floyd T L “ Digital Fundamentals”, 7th Edition. (Pearson Education Asia), 2002
2. M. Morris Mono, Digital Logic and Computer Design, 4 th Edition, Pearson, 2009
3. Simon Haykins, An Introduction to Analog and Digital Communication, Wiley Student Edition, 2008.
4. B. P. Lathi, Modern digital and analog Communication systems, 3rd Edition 2005 Oxford University press.
5. Harold P.E, Stern Samy and AMahmond, Communication Systems, Pearson Edition, 2004.
 1. Dennis Roody and John Coolen, Electronic Communication, 4th Edition, 2008.

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HCT 4.1 Optical Fiber Communication

Total hours:60

Credits:4

Unit 1. Introduction and Transmission characteristics of optical fibers:

[12L +3T]

The general optical communication system, Advantages and disadvantages, Ray theory of transmission, Mode theory, Types of optical Fibers

Transmission characteristics of optical fibers:

Attenuation, Material absorption, losses in fibers, Linear and Nonlinear scattering losses, fiber bend loss, Mid-infrared and Far-Infrared transmission. Dispersion: Intermodal and Intramodal dispersion, Dispersion modified Single mode fibers.

Unit 2. Optical fibers and cables, Joints and Couplers:

[12L +3T]

Preparation of optical fibers, Liquid phase and vapour phase deposition techniques, Fluoride glass fibers.

Cables: Fiber strength, durability and stability of fiber transmission characteristics, cable design

Optical Fiber Joints and Couplers:

Fibers alignment and joint loss. Fiber splices, connectors, Fiber couplers

Unit 3. Optical sources and Optical detectors:

[12L +3T]

Optical sources:

LASERS basic concept, optical emission from semiconductors. Semiconductor Injection Laser, Injection laser structures and characteristics, Laser fiber coupling, Non-semiconductor Lasers, Laser Modulation. LED) LED power and efficiency, LED structures, characteristic and Modulation techniques

Optical detectors:

Introduction, device, types, optical detection principals, absorption, quantum efficiency Responsivity, Long wavelength Cutoff. Semiconductor photo diodes with and without internal gain. Mid-infrared and photoconductive detectors, PN, PIN, Avalanche Photo diodes, Phototransistors.

Unit 4: Optical fiber Measurements, Receiver performance considerations and Applications:

[12L +3T]

Optical fiber Measurements:

Attenuation, Dispersion, Refractive index profile, cutoff wavelength, Numerical aperture, fiber diameter and field measurements.

Receiver performance considerations: Noise, Receiver noise, Receiver structures, FET preamplifiers, High performance amplifiers.

Applications:

Public Network, Military, Civil, Consumer, Industrial and Computer applications.

Reference:

1. Optical fiber communications – principles and practice. John. M. Senior
2. Optical communications By David Gover
3. Optical communications By KEISER

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HCT 4.2 Power Electronics

(w.e.f June 2016-17)

Total no. hours: 60

Credits: 4

UNIT 1:

Forced commutation, Thyristor protection and Thyristor choppers ckt. [12L +3T]

Forced commutation: SCRs with DC supply, forced commutations; class A, B, C, D, E and F circuits and analysis

Thyristor protection: Over voltage and over current protections, dv/dt and di/dt protections, design of snubber circuits, RFI protection, gate resistance

Thyristor choppers circuits

Principles of step-down and step-up choppers with R and R-L loads, impulse commutated chopper, impulse commutated three thyristor choppers, resonant pulse choppers/supplies

UNIT 2:

Switched mode power supply [12L +3T]

SMPS, comparison with conventional power supply, buck regulator, boost regulator, Buck-Boost regulator, Cuk regulator

UNIT 3: Controlled Rectifiers

[12L +3T]

Single phase circuits, Half and Full controlled bridge rectifier with resistive R and R-L load with and without freewheeling diode, series and dual converter, power factor improvement.

Three phase circuits: Half wave controlled rectifier, Half controlled rectifier, Half controlled bridge rectifier, Fully controlled bridge rectifier with R and R-L load, three phase dual converter

UNIT 4 : A-C power control

[12L +3T]

A-C On/off and phase controls, uni and bidirectional controllers with R and R-L loads, three phase half and full wave controllers with R and R-L loads.

Text / Reference Books:

1. Power Electronics by M.H. Rashid, PHI
2. Power Electronics – P.C.Sen
3. Power Electronics – Williams ELBS
4. Simplified design of linear Power supplies: John D. Lenk, Butterworth-Heinemann
5. Simplified design of switching power supplies: John D. Lenk, Butterworth-Heinemann
6. Regulated power supplies Irving M Gottlieb, TAB books
7. Practical Design of Power Supplies: Ron Lenk, IEEE press +McGraw hill
8. Electric Power Transformer Engineering: James H. Harlow, CRC Press

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HCT 4.3 Advanced Microcontroller

Total hours:60

Credits:4

UNIT 1: AVR Microcontroller Architecture

[12L +3T]

Introduction to AVR, Architecture and Hardware Resources of AVR Microcontrollers. Architecture: The Arithmetic Logic Unit, Program and Data Memories, Downloadable Flash Program Memory, SRAM Data Memory, General-Purpose Register File, I/O Register, Data Memory, Peripherals, Timer/Counter, Watchdog Timer, Serial Peripheral Interface SPI, Universal Asynchronous Receiver and Transmitter, Analog Comparator, I/O Ports, Reset and Interrupt System, Interrupt Vector Table

UNIT 2: AVR Instruction Set

[12L +3T]

AVR programming model and Instruction set: Memory Addressing Modes, Register Direct Addressing, I/O Direct Addressing, SRAM Direct Addressing, SRAM Indirect Addressing, Constant Addressing Using the LPM Instruction, Jumps and Calls, Instruction Set, Reset and Interrupt Handling, Watchdog Handling, Stack, Program Constructs, Conditional Branches, Program Loops, Refreshing Port Pins and Important Registers, Polling Inputs

UNIT 3: Arduino and Programming

[12L +3T]

Arduino SBC Boards – Arduino boards types, IDE, Keywords, Language reference, Library programs:- Analog Read, Serial read/write, Digital Read/ write, DC Motor, Stepper motor, LCD , Sensors (LM- 35, LDR, Humidity, Thermocouple) , PWM, Relay, Switch, LED (Simple and Bicolour), Optocoupler, GSM, Bluetooth etc.

UNIT 4: Introduction to ARM

[12L +3T]

Introduction to RISC/ARM, ARM 7 Core, Processor Functional Block Diagram Programmers Model: Data Types, Processor modes, Registers, General Purpose Registers, Program Status Register, CP15 Coprocessor, Memory and memory mapped I/O, Pipeline, Exceptions, Interrupts and Vector table, Architecture revisions, ARM Processor Families.

TEXT/REFERENCE BOOKS:

1. Richard H. Barnett, Sarah A. Cox, Larry D. O'Cull, "Embedded C Programming and the Atmel AVR", Thomson.
2. John Morton, "AVR: An Introductory Course", Newnes.
3. Claus Kuhnel, "AVR RISC Microcontroller Handbook", Newnes.
4. Dhananjay Gadre, "Programming and Customizing the AVR Microcontroller", TMH.
5. Steve Furber , "ARM System –On –Chip architecture", Addison Wesley.
6. David Seal "ARM Architecture Reference Manual", Addison Wesley, England; Morgan Kaufmann Publishers
7. Andrew N Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide - Designing and Optimizing System Software", Elsevier
8. Atmega16/32 Datasheet
9. www.Arduino.cc

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SCT 4.1 Satellite Communication

Total hours:60

Credits:4

Unit 1. Satellite Orbital Mechanics and Launchers

[12L + 3T]

History, Overview: Satellite Communication in 2000.

Orbital Mechanics, Look angle determination, Orbital perturbations, Orbital determination, Launchers and Launch Vehicles, Orbital effects in communication system performance.

Unit 2. Satellites Subsystems and Satellite Link Design:

[15L+ 3T]

Satellites Subsystems:

Satellite Subsystems, Attitude and control systems (AOCS), Telemetry, Tracking, Command and Monitoring, Power systems, Communication subsystems, Satellite antennas, Equipment reliability and space qualification.

Satellite Link Design:

Introduction, Basic transmission Theory, System Noise Temperature and G/T Ratio, Design of Downlinks, Satellite Systems using Small Earth Stations, Uplink Design,.

Unit 3. VSAT, LEO and Non_Geo-Stationary Satellite Systems:

[12L + 3T]

Introduction, Overview of VSAT Systems, Network Architecture VSAT Earth Station Engineering

Low Earth Orbit and Non_Geo-Stationary Satellite Systems:

Introduction , Delay and Throughput consideration, Operational NGSO constellation design: Iridium, Teledesic

Unit 4. DBS Television and Radio systems and Satellite Navigation, GPS Systems:

[9L +3T]

C- Band and Ku- Band, Home Satellite TV, Digital DBS TV, Satellite Radio Broadcasting

Satellite Navigation and the Global Positioning System:

Introduction, Radio and Satellite Navigation, GPS Position Location Principles.

Text/ Reference Books:

1. Satellite Communications – Timothy Pratt, Charles Bostian, Jeremy Allnut

John Wiley & Sons (II Edition)

Reference Books:

1. Satellite Communications – Dennis Roody, McGraw Hill

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SCT 4.2 VLSI Circuits and Systems

Total hours:60

Credits:4

Unit 1: Basic Physics of MOS Devices

(12L + 3T)

MOS Device structure and physical operation, MOS I-V characteristics, Second order effects in MOS devices, MOS structure capacitances, Small signal model of MOS, Long channel and short channel devices.

Current sources and Amplifier Design

Basic and cascode current mirrors, Single stage Amplifiers: Basic concepts, Common source stage, Common gate stage, Cascode stage. Differential amplifiers : Differential and common mode operations.

Unit 2: CMOS Inverter

(12L + 3T)

CMOS Inverter: Transfer characteristics, MOS transistor circuit model, latch-up in CMOS circuits. Static and Dynamic behavior of CMOS Inverter MOS circuit design fundamentals: MOS layers, stick diagrams, lambda based rules for NMOS and CMOS process, layout diagrams, Static and dynamic power consumption in CMOS Inverter.

Unit 3: CMOS combinational and Sequential circuit Design

(20L + 3T)

Static CMOS logic design: Complementary CMOS design, DCVSL, Ratioed logic, Pass Transistor logic, Transmission gate logic. Dynamic CMOS logic design: Basic Principles, Speed and power dissipation, Issues in Dynamic design, cascading in dynamic design.

Static latches and registers, Dynamic latches and registers, Alternative register styles: Pulse registers and Sense based amplifiers, Latch vs. Register- based pipelines structures, NORA-CMOS design.

Unit 4: Timing issues in Digital circuits

(4L + 3T)

Classification of Digital systems, Basics of synchronous timing, clock distribution networks, Synchronizers and arbiters.

References:

1. Digital Integrated Circuits: A Design Perspective- Jan M. Rabaey, Anantha Chadrakasan, Borivoje Nikolic, 2E, PHI 2005.
2. Design of Analog CMOS Integrated Circuits-Behzad Razavi, McGraw-Hill, 2000.
3. Microelectronic circuits: Theory and applications- Adel Sedra, Kenneth Smith, Oxford University Press, 6E-2013.