M.Tech.

In

Microelectronics and VLSI Design

Techno College of Engineering Agartala

(An Engineering College affiliated to Tripura University)

(A Central University)

Approved by AICTE, MHRD, Govt. of India)

COURSE STRUCTURE

1st Semester: 700 Marks

Course Code	Course Name	Marks	L	T	P	C	Core/Elective	MOOC
EC 907 C	Semiconductor Device & Modelling	100 *(70+30)	04	0	0	04	C	
EC 908 C	Analog IC Design	100 *(70+30)	04	0	0	04	C	
EC 903 Ex	Elective Paper I	100 *(70+30)	04	0	0	04	E	
EC 904 Ex	Elective Paper II	100 *(70+30)	04	0	0	04	E	
CSK-III	JAVA Software/Python/C/C++	100 *(70+30)	04	0	0	04	CFC (Compulsory Foundation) (offered by CSE or IT) (As per TU Norms)	
EC 911 C	Design Laboratory I (Analog IC Design)	100 *(70+30)	0	0	04	02	C	
EC 912C	Design Laboratory II (any from Elective)	100 *(70+30)	0	0	04	02	C	
Total		**700**	**20**	**0**	**08**	**24**		

2nd Semester:700 Marks

Course Code	Course Name	Marks	L	T	P	C	Core/Elective	MOOC
EC 1008 C	Digital IC Design	100 *(70+30)	04	0	0	04	C	
EC 1009 C	VLSI Systems Design	100 *(70+30)	04	0	0	04	C	
EC 1010 Ex	Elective Paper III	100 *(70+30)	04	0	0	04	E	Yes
EC 1011 Ex	Elective Paper IV	100 *(70+30)	04	0	0	04	E	Yes
EC 1005 c	Term Paper Leading to Thesis	100 *(70+30)	0	0	04	02	C	
EC 1006 C	Project Design	100 *(70+30)	0	0	04	02	C	
EC 1007 C	Programming Lab	100 *(70+30)	0	0	04	02	C	
Total		**700**	**20**	**0**	**12**	**22**		

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3rd Semester: 700 Marks

Corse Code	Course Name	Marks	L	T	P	C	Core/Elective	MOOC
EC 1106 C	Dissertation Phase-I	200	0	0	16	08	C	
EC 1107 C	Thesis Seminar Interim Presentation &VIVA-VOCE	200	00	0	08	04	C	
EC 1108 C	Research Methodology	100 *(70+30)	04	0	0	04	C	Yes
EC 1109 C	Workshop and Seminars	100 *(70+30)	00	02	02	02	C	
EC 1110 C	Elective Paper V	100 *(70+30)	04	00	00	04	E	Yes
Total		**700**	**08**	**02**	**26**	**22**		

- **Student should opt any paper from any other Dept.**

4th Semester:600 Marks

Corse Code	Course Name	Marks	L	T	P	C	Core/Elective	MOOC
EC 1206C	Dissertation Phase - II	200	00	00	16	08	C	
EC 1207 C	Thesis Seminar Final Presentation &VIVA-VOCE	200	00	00	16	08	C	
EC 1208 C	Workshop and Seminars	100 *(70+30)	00	02	02	02	C	
EC 1209 Ex	Elective Paper VI	100 *(70+30)	04	00	00	04	E	
Total		**600**	**04**	**02**	**34**	**22**		

* 'x' will be replaced by 'A, B, C……..' for elective papers.
*(70+30) indicates 70 marks for external and 30 marks for internal assessment.
*Elective papers can be opted from parent department or other department if offered.
*Minimum credit required per semester is 16 and total credit required is 80.
(as per Tripura University norms)

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Elective Papers

Code (Code of Elective followed by numbers given below)	Course Name	L	T	P	C
A	Advanced Communication Techniques	04	0	0	04
B	Remote Sensing	04	0	0	04
C	Statistical Information Processing	04	0	0	04
D	Laser & Optoelectronics	04	0	0	04
E	Computer vision and Image Processing Fundamentals and Applications	04	0	0	04
F	Wireless & Mobile Communication	04	0	0	04
G	RFID	04	0	0	04
H	DSP and Communication networking	04	0	0	04
I	Digital Communication Networks & Protocol	04	0	0	04
J	Artificial Intelligence& Soft Computing	04	0	0	04
K	Digital Image Processing	04	0	0	04
L	Satellite Communication	04	0	0	04
M	Internet of Things (IoT)	04	0	0	04
N	Modern Data Transmission Technology	04	0	0	04
O	Modern Digital Communication Techniques	04	0	0	04
P	Introduction to Coding Theory	04	0	0	04

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Q	Mathematical Methods and Techniques in Signal Processing	04	0	0	04
R	Photonic Integrated Circuit	04	0	0	04
S	MOOCs/NPTEL (As they offer)	04	0	0	04
T	EMI/EMC	04	0	0	04
U	MIMO Communication Systems	04	0	0	04
V	VLSI design	04	0	0	04
W	Broadband Network and Network Management	04	0	0	04
X	Advanced Microprocessors and Microcontrollers	04	0	0	04
Y	Advanced Mathematical Techniques	04	0	0	04
Z	Electronic System Design	04	0	0	04
a	CAD for VLSI	04	0	0	04
b	VLSI Signal Processing	04	0	0	04
c	Mixed Signal IC Design	04	0	0	04
d	Low Power Circuits and Systems	04	0	0	04
e	RF IC Design	04	0	0	04
f	FPGA based design	04	0	0	04
g	MEMS & Microsystems Technology	04	0	0	04
h	Advanced Computer Architecture and Processor Design	04	0	0	04

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A. Kaarmukan 26/11/24

Anirudha 26/11/24

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i	VLSI based Chip Design for Signal and Image Processing	04	0	0	04
j	Testing and Verification of VLSI Circuits	04	0	0	04
k	Embedded Systems	04	0	0	04

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EC -901 C	Advanced Optical Fiber Communication System

OVERVIEW OF OPTICAL FIBER COMMUNICATION: Introduction to optical commination communication, optical fiber, Types of optical fiber, cut-off wave length, Modes in optical fiber. Fabrication techniques of optical fiber.

DIFFERENT TYPES OF LOSSES IN OPTICAL FIBER: Attenuation, absorption, scattering losses, bending loss,**Dispersion:** Group velocity Dispersion, Polarization mode dispersion. **Nonlinearities in optical fiber:** Self Phase Modulation, Cross Phase Modulation, Four Wave Mixing.

OPTICAL SOURCE AND DETECTOR: LED, LASER, Laser diode, DFB laser, PIN photo detector, APD.

ADVANCED MODULATION FORMATS & Optical Modulators: OOK, BPSK, QPSK, QAM, PAM and other higher modulation formats. MZM, EAM, MRM.

ACTIVE AND PASSIVE OPTICAL COMPONENTS AND SUBSYSTEMS: Coupler, circulator, optical Filters, FBG, CFBG, MZDI, MRR, AWG, MUX/DEMUX, OADM, ROADM, wavelength converter, All-optical regenerator, Optical switches.

MULTIPLEXING TECHNIQUES: WDM, OFDM

OPTICAL AMPLIFIER: Erbium doped fiber amplifier, semiconductor optical amplifier, Raman amplifier.

OPTICAL RECEIVER: Receiver sensitivity, quantum limit, coherent receiver.

Optical system performance and monitoring system: eye diagram, eye opening penalty, Q, BER, OSNR, OTDR.

LINK ANALYSIS: Single channel point to point, WDM point to point.

PULSE PROPAGATION IN OPTICAL FIBER: Nonlinear Schrodinger equation, split step Fourier method.

Reference Books:

1. Fiber-Optic Communication Systems, by Govind P. Agrawal
2. Optical Networks-A Practical Perspective, by Rajiv Ramaswami, Kumar Sivarajan and Galen Sasaki
3. Optical fiber communications by Gerd Keiser-McGraw Hill
4. Optical fiber communications: Principles and practice by John M. Senior-Prentice Hall of India

EC 902 C	Advanced Microwave Engineering

Transmission Line Theory: Lumped element circuit model for transmission line, fieldanalysis, Smith chart, quarter wave transformer, generator and load mismatch, impedance matching and tuning.

Microwave Waveguides & Components: Microwave Waveguides, Passive Components,Microwave resonators, power dividers and directional couplers, Ferromagnetic devices and components, Strip Lines, Microwave Tubes.

Microwave Semiconductor Devices & Modelling: PIN diode, Tunnel diodes, Varactor diode, Schottky diode, IMPATT and TRAPATT devices, transferred electron devices, Microwave BJTs, GaAs FETs, low noise and power GaAs FETs, MESFET, MOSFET, HEMT.

EC 908 C	Analog IC Design

MOSFET Operation & Model: Device Structure I/V characteristics, second order effects, Capacitances, body bias effect, DIBL, MOS small signal Models, CMOS Technology

Basic Analog blocks: Basic concepts of amplification and biasing, Current sources and sinks, Current mirrors: Simple current mirror, cascade current mirror, low voltage current mirror, Wilson and Widlar current mirrors, voltage and current references, Current conveyer.

Single stage amplifier: Common source stage with resistive load, diode connected load, triode load, CS stage with source degeneration, source follower, CG stage, Gain boosting techniques, cascode, folded cascade.

Differential amplifier: Quasi differential amplifier, significance of tail current source, errors due to mismatch, qualitative analysis, common mode response, differential amplifier with MOS loads, single ended conversion. Differential amplifier characterization, ICMR, Slew Rate, PSRR, offset,

Frequency response of Amplifiers: Device high-frequency small-signal models; Device capacitances, ft calculation, Simplified high-frequency analysis of basic amplifiers, Miller's theorem, OCTC method for BW estimation. cascade amplifiers, differential amplifiers.

Feedback Amplifier: Feedback concept, negative & positive feedback, voltage/ current, series/shunt feedback, Practical feedback circuits, Loop gain and stability, Design Procedure for the feedback amplifiers

Layout: Introduction to Layout, Fingering, Inter-digitization, Common Centroid, Process gradients, electro-migration, and antenna effect

Text Books:

1. Design of Analog CMOS Integrated Circuits, by Behzad Razavi, McGraw-Hill
2. Analysis and Design of Analog Integrated Circuit, Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer, John Wiley & Sons
3. Adel S. Sedra, Kenneth C. Smith: Microelectronics Circuits, Oxford University Press

Reference Books/materials:

1. R. L. Geiger, Allen and Stradder, VLSI Design Techniques for Analog and Digital Circuits, McGraw-Hill Education, 2010.
   CMOS: Circuit Design, Layout, and Simulation by R. Jacob Baker, Wiley-IEEEPress(2019)

EC- 1001 C	Optical Networks

Introduction: Different kinds of attenuation in optical fiber, Optical bandwidth, Light Transmission in Optical Fibers, Signal Impairments Along the Lightpath; Optical Transmitters and Modulators, Optical Receivers.

Optical Networking: Introduction and Challenges: Advantages of optical network, WDM optical networks, WDM network evolution, WDM network construction, broadcast and select optical WDM network, wavelength routed optical WDM network.

Optical Networking Components: Couplers, Isolators & Circulators, Multiplexers & Filters, OLT, OADM, OXC, CLOS architecture, MEMS, wavelength convertors, Optical Line Amplifiers,Gratings, Bragg grating, Fiber Gratings, Arrayed waveguide gratings,Fabry-perot filters, thin-film filters, Mach-Zehnder interferometers.

SONET/SDH: SONET/SDH layers, Optical transport network, IP, routing and forwarding, MPLS.

timing analysis, floor-planning, placement and routing, extraction, post layout timing verification, extraction.

CMOS Process Technology: Fabrication process flow- basic steps, the CMOS n-Well process, layout design rules, stick diagram, full-custom mask layout design.

MOS Inverter (Static Characteristics): Resistive-load inverter, inverter with n-typeMOSFET load, CMOS inverter.

MOS Inverters (Switching Characteristics and Interconnects effects): Delay-time definitions, calculation of delay times, logical efforts, inverter design with delay constraints, estimation of interconnect parasitic, calculation of interconnect delay, Bus vs. Network-on Chip (NoC), switching power dissipation of CMOS inverters.

Combination CMOS Logic Circuits: MOS logic circuits with depletion n-MOS loads, CMOS logic circuits, complex logic circuits, CMOS transmission gates (pass gates), ratioed, dynamic and pass transistor logic circuits.

Sequential MOS logic circuits: Behavior of bi-stable elements, SR latch circuits, clocked latch and flip-flop circuits, CMOS D-latch, and edge-triggered flip-flop. Timing path, Setup time and hold time static, example of setup and hold time static, setup and hold slack, clock skew and jitter, Clock, reset and power distributions.

Semiconductor Memories: Memory Design, SRAM, DRAM structure and implementations.

Recent Trends in VLSI Design & its research issues in industry: System case studies. Design automation of VLSI Systems: basic concepts. Deep Sub-micron Technologies: Some Design Issues.

Text Book

1. N. H. E. Weste and C. Harris, "Principles of CMOS VLSI Design: A System Perspective, 3rdEdition, Pearson Education 2007.
2. CMOS Digital Integrated Circuits, Sung-Mo Kang,YusufLeblebici, 3rd edition, Tata McGrawHill, 2003

References:

1. J. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design Perspective, 2ndEdition, Prentice Hall 2004.

EC 1009 C	VLSI Systems Design

Design Methodology: Structured design techniques; Programmable logic; Gate array and sea of gates design; cell-based design; full custom design; Design flow; Design Economics.

Data path Subsystems: Adders; One/zero Detectors; Comparators; Counters; Shifters; Multipliers; Power and Speed Trade-off.

Memory and Array Subsystems: Memory controller and management, SRAM, DRAM, ROM, Serial access memories; CAM, PLAs; Array yield, reliability; Power dissipation in Memories.

Special purpose Subsystems: Packaging; power distribution; I/O pads;

Interconnect: Interconnect parameters; Electrical wire models, capacitive parasitic; Resistive parasitic; Inductive parasitic; Crosstalk; Advanced Interconnect Techniques.

Timing Issues: Timing classification; Synchronous design; Self-timed circuit design;

electromagnetic waves in microwave, between and optical spectrum. Application to measurement of temperature, humilities, rain, invertion layers, wave winds, turbulence etc.

Real-time processing of large volumes of data including high data rate signal and image processing, optical, accousto optical and optical and optical and optical-electronic hybrid processing, realtime pattern recognition processors for such airborne applications as target recognition, tracking, and terminal guidance.

Physical description of continuous image prosperities of the human visual system, sampling and quantization of imager, matrix representation of image forming and image processing systems, unitary transforms and image compression and image enhancement and restoration.

Volume scattering and emission theory. Radiation transfer method. Behaviour of various surfaces, vegetable connopies.

Principle of spectro radio metry, Meterological satellite system, radio meters, Infrared spectrometer and multispectral scanner, System on the LAND SAT satellites airborn scanner etc.

Reference Books:

1. Remote Sensing and GIS, Book by BasudebBhatta
2. Remote Sensing, Principles & Applications by by B. C. Panda

C	**Statistical Information Processing**

Review of random variables: Probability Concepts, distribution and density functions,moments, independent, uncorrelated and orthogonal random variables; Vector-spacerepresentation of Random variables, Vector quantization, Tchebaychef inequality theorem, CentralLimit theorem, Discrete &Continuous Random Variables.Random process: Expectations, Moments,Ergodicity, Discrete-Time Random Processes Stationaryprocess, autocorrelation and auto covariance functions, Spectral representation of random signals,Properties of power spectral density, Gaussian Process and White noise process.

Random signal modelling:MA(q), AR(p), ARMA(p,q) models, Hidden Markov Model &its applications ,Linear System with random input , Forward and Backward Predictions, LevinsonDurbin Algorithm.

Statistical Decision Theory: Bayes' Criterion, Binary Hypothesis Testing, M-ary Hypothesis Testing, Minimax Criterion, Neyman-Pearson Criterion, Composite HypothesisTesting.Parameter Estimation Theory: Maximum Likelihood Estimation, Generalized Likelihood RatioTest ,Some Criteria for Good Estimators, Bayes' Estimation Minimum Mean-Square ErrorEstimate, Minimum, Mean Absolute Value of Error Estimate Maximum A Posteriori Estimate , Multiple Parameter Estimation Best Linear Unbiased Estimator ,Least-Square EstimationRecursive Least-Square Estimator.

Spectral analysis: Estimated autocorrelation function, Periodogram, Averaging theperiodogram (Bartlett Method), Welch modification, Parametric method, AR(p) spectralestimation and detection of Harmonic signals.

Information Theory and Source Coding: Introduction, Uncertainty, Information andEntropy, Source coding theorem, Huffman, ShanonFano, Arithmetic , Adaptive coding , RLE ,LZW Data compaction, , LZ-77, LZ-78. Discrete Memory less channels, Mutual information,channel capacity, Channel coding theorem, Differential entropy and mutual information forcontinuous ensembles.

Application of Information Theory: Group, Ring & Field, Vector, GF addition,multiplication rules. Introduction to BCH codes, Primitive elements ,Minimal polynomials,Generator polynomials in terms of Minimal polynomials, Some examples of BCH codes,&Decoder, Reed- Solomon codes & Decoder, Implementation of Reed Solomon encoders anddecoders.

Reference books:

1. Rosen K.H, "Elementary Number Theory", Addison-Wesley, 6th edition, 2010.

4. Semiconductor Optoelectronic devices – Pallab Bhattacharya, Prentice Hall of India, 1995 5. Semiconductor Optoelectronics – Jasprit Singh, Tata McGraw Hill, 1995
6. Optoelectronics - an Introduction – Wilson and Hawkes, Prentice Hall, 1998

E	**Computer Vision and Image Processing - Fundamentals and Applications**

Introduction to Computer Vision and Basic Concepts of Image Formation: Introduction and Goals of Computer Vision and Image Processing, Image Formation Concepts.
Fundamental Concepts of Image Formation: Radiometry, Geometric Transformations, Geometric Camera Models. Camera Calibration, Image Formation in a Stereo Vision Setup, Image Reconstruction from a Series of Projections.
Image Processing Concepts: Image Transforms. Image Processing Concepts: Image Transforms, Image Enhancement. Image Processing Concepts: Image Filtering, Colour Image Processing, Image Segmentation.
Image Descriptors and Features: Texture Descriptors, Colour Features, Edges/Boundaries. Object Boundary and Shape Representations.
Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency.
Fundamentals of Machine Learning: Linear Regression, Basic Concepts of Decision Functions, Elementary Statistical Decision Theory, Parameter Estimation, Clustering for Knowledge Representation, Dimension Reduction, Linear Discriminant Analysis. Applications of **Computer Vision:** Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Auto encoder, Machine Learning Algorithms and their Applications in Image Segmentation.
Applications of Computer Vision: Motion Estimation and Object Tracking, Gesture Recognition, Face and Facial Expression Recognition, Image Fusion.

Reference Books:

1. Forsyth & Ponce, "Computer Vision-A Modern Approach", Pearson Education.
2. M.K. Bhuyan , " Computer Vision and Image Processing: Fundamentals and Applications", CRC Press.
3. Richard Szeliski, "Computer Vision- Algorithms & Applications", Springer.

F	**Wireless & Mobile Communication**

Cellular Communication Fundamentals: Cellular system design, Frequency reuse, cellsplitting, handover concepts, Co channel and adjacent channel interference, interference reduction techniques and methods to improve cell coverage, Frequency management and channelassignment.GSM architecture and interfaces, GSM architecture details, GSM subsystems, GSMLogical Channels, Data Encryption in GSM, Mobility Management, Call Flows in GSM.2.5 GStandards: High speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS),2.75 G Standards: EDGE,
Spectral efficiency analysis based on calculations for Multiple access technologies:TDMA,FDMA and CDMA,Comparison of these technologies based on their signal separation techniques,advantages, disadvantages and application areas.Wireless network planning (Link budget andpower spectrum calculations)
Mobile Radio Propagation: Large Scale Path Loss, Free Space Propagation Model,Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering, Practical Link BudgetDesign using Path Loss Models, Outdoor Propagation Models, Indoor Propagation Models, SignalPenetration into Buildings. Small Scale Fading and Multipath Propagation, Impulse ResponseModel, Multipath Measurements, Parameters of Multipath channels, Types of Small Scale Fading:Time Delay Spread; Flat, Frequency selective, Doppler Spread; Fast and Slow fading.
Equalization, Diversity: Equalizers in a communications receiver, Algorithms for adaptiveequalization, diversity techniques, space, polarization, frequency diversity, Interleaving.

1. Li Tan, "Digital Signal Processing", Elsevier, 2011.
2. A.V. Oppenheim and Schafer, "Discrete Time Signal Processing", Prentice Hall, 1989.

I	Digital Communication Networks and Protocol

Short introduction- Discrete time systems & signals,z-transform,difference equation,filter design by transformation-impulse and step invariant, bi-linear z-transform,matched z transform, signal model-AR,MA,ARMA,state variable model,lattice structure.
FIR filter design:frequency windowing technique,equi ripple chebyshev&butterworth criterion. Filter performance and design in presence of noise,FIR filters banks-subband decomposition.Inverse filtering deconvolution and equalization techniques- Weiner,linear prediction etc.,
Signal reconstruction: time frequency analysis STFT, WT,DSP hardware-design methodologies,popular architectures and overview of programming application notes.filter implementation: topology,scaling, co-efficient quantization,signal quantization,sensitivity analysis.Overview of communication & networking

Reference Books:

1. J.G. Proakis, Manolakis "Digital Signal Processing", Pearson, 4th Edition
2. A. K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall

J	Artificial Intelligence & Soft Computing

Reasoning, Machine Learning, Intelligent Search, Intelligent Planning, Perception, Applications in Expert Systems, Machine Vision and Robotics, Control, Signal Processing and Pattern Recognition. Applications in System Design, Prediction, Optimization and Identification problems, Use of Fuzzy Logic, Neurocomputing and Evolutionary Algorithms in the above problems.

Reference Books:

1. Artificial Intelligence & Soft Computing by Amit Konar
2. Artificial Intelligence & Soft Computing for beginners by Anindita Das

K	Digital image processing

Introduction and signal digitization, Pixel relationship, Camera models & imaging geometry, Image interpolation, Image transformation, Image enhancement, Image restoration, Image registration, Colour image processing, Image segmentation, Morphological image processing, Object representation ,description and recognition.

Books and References:

1. Digital Image Processing by Rafael C Gonzalez & Richard E Woods, 3rd Edition
2. Fundamentals of Digital Image Processing by Anil K Jain
3. Digital Image Processing by William K Pratt

Data Networks and their Design: Link layer design- Link adaptation, Link LayerProtocols, Retransmission. Mechanisms (ARQ), Hybrid ARQ (HARQ), Go Back N, SelectiveRepeat protocols and their analysis.
Queuing Models of Networks : Traffic Models , Little's Theorem, Markov chains, M/M/1and other Markov systems, Multiple Access Protocols , Aloha System , Carrier Sensing ,Examples of Local area networks,
Inter-networking: Bridging, Global Internet , IP protocol and addressing , Sub netting ,Classless Inter domain Routing (CIDR) , IP address lookup , Routing in Internet. End to EndProtocols, TCP and UDP. Congestion Control, Additive Increase/Multiplicative Decrease , SlowStart, Fast Retransmit/ Fast Recovery,
Congestion avoidance: RED TCP Throughput Analysis, Quality of Service in Packet
Networks. Network Calculus, Packet Scheduling Algorithms.

Reference Books:

1. D. Bertsekas and R. Gallager, "Data Networks", 2nd Edition, Prentice Hall, 1992.
2. Walrand, "Communications Network: A First Course", 2nd Edition, McGraw Hill, 2002.

XX	Software Defined Networking

Introduction to Programmable Networks, History and Evolution of Software Defined Networking (SDN), Fundamental Characteristics of SDN, Separation of Control Plane and Data Plane, Active Networking.
Control and Data Plane Separation: Concepts, Advantages and Disadvantages, the basics of OpenFlow protocol.
Network Virtualization: Concepts, Applications, Existing Network Virtualization Framework, Mininet A simulation environment for SDN.
Overview, Existing SDN Controllers including Floodlight and OpenDaylight projects. Customization of Control Plane: Switching and Firewall Implementation using SDN Concepts. Data Plane: Software-based and Hadrware-based; Programmable Network Hardware.
Programming SDNs: Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs. Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications.
Data Center Networks: Packet, Optical and Wireless Architectures, Network Topologies. Use Cases of SDNs: Data Centers, Internet Exchange Points, Backbone Networks, Home Networks, Traffic Engineering

Reference Books:

1. Thomas D. Nadeau, Ken Gray, "SDN: Software Defined Networks, An Authoritative Review of Network Programmability Technologies", O'Reilly Media, August 2013.
2. Paul Goransson, Chuck Black, Timothy Culver. "Software Defined Networks: A Comprehensive Approach", Morgan Kaufmann Publishers, 2016.
3. Fei Hu, "Network Innovation through OpenFlow and SDN: Principles and Design", CRC Press, 2014.
4. Vivek Tiwari, "SDN and OpenFlow for Beginners", Amazon Digital Services, Inc., ASIN: , 2013.
5. Nick Feamster, Jennifer Rexford and Ellen Zegura, "The Road to SDN: An Intellectual History of Programmable Networks" ACM CCR April 2014.
6. Open Networking Foundation (ONF) Documents, https://www.opennetworking.org, 2015.
7. OpenFlow standards, http://www.openflow.org, 2015.

O	Modern Digital Communication Techniques

Introduction to digital communication systems, Source Coding Characterization of Communication Signals & Systems Signal space Representation, Representation of Memory less Modulation Methods Nonlinear modulation methods, Optimal receivers of AWGN Receiver for non-ideal channel, Probability of error of different modulation schemes, Fundamentals of estimation and detection theory used in digital communication, Carrier phase and symbol timing synchronization techniques, Channel estimation and equalization techniques, Power Adaptation methods for colored noise channel.

Reference books:

R	Photonic integrated circuit

Review of Electromagnetic Waves, Photonic integrated circuits: an introduction, Material technology for integrated optics, Introduction to guided wave optics,Integrated optical waveguide design,Coupling light in a waveguide system, Integrated photonic Passive devices, Integrated photonic Active devices, Semiconductor Light sources and Photodetectors, Material engineering and fabrication, A Photonic integrated circuit technology: Silicon, III-V and beyond, Application of Photonic circuit in Communication and Sensing

Reference Books:

1. Fundamentals of Photonics, B.E.A Saleh and M.C. Teich, Wiley, New York, 1991
2. Photonic Devices. Cambridge, J. Liu, Cambridge University Press, 2005.
3. Fundamentals of Optoelectronics, Clifford R. Pollock, Irwin, 1995.
4. Diode Lasers and Photonic Integrated Circuits, Larry A. Coldren Scott W. Corzine Milan L. Mašanović, Wiley-Interscience.

T	EMI/EMC

Natural and Nuclear sources of EMI / EMC : Introduction, Electromagnetic environment, History, Concepts, Practical experiences and concerns, frequency spectrum conservations. An overview of EMI / EMC, Natural and Nuclear sources of EMI.

EMI from apparatus, circuits and open area test sites : Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive intermodulation, crosstalk in transmission lines, transients in power supply lines, electromagnetic interference (EMI). Open area test sites and measurements.

Radiated and conducted interference measurements: Anechoic chamber, TEM cell, GH TEM Cell, characterization of conduction currents / voltages, conducted EM noise on power lines, conducted EMI from equipment, Immunity to conducted EMI detectors and measurements. UNIT-IV:ESD, Grounding, shielding, bonding and EMI filters : Principles and types of grounding, shielding and bonding, characterization of filters, power lines filter design. ESD, Electrical fast transients / bursts, electrical surges.

Cables, connectors, components: Introduction, EMI suppression cables, EMC connectors, EMC gaskets, Isolation transformers, opto-isolators, Transient and Surge Suppression Devices.

EMC standards- National / International .: Introduction, Standards for EMI and EMC, MIL Standards, IEEE/ANSI standards, CISPR/IEC standards, FCC regulations, Euro norms, British Standards, EMI/EMC standards in JAPAN, Conclusions.

Reference Books:

1. Engineering Electromagnetic Compatibility by Dr. V.P. Kodali, IEEE Publication, Printed in India by S. Chand & Co. Ltd., New Delhi,2000.
2. Electromagnetic Interference and Compatibility IMPACT series, IIT – Delhi, Modules 1 – 9.

References:

3.Introduction to Electromagnetic Compatibility, NY, John Wiley, 1992, by C.R. Pal.

U	MIMO Communication Systems

Introduction to Multi-antenna Systems: Motivation, Types of multi-antenna systems, MIMO vs. multi-antenna systems.

Diversity: Exploiting multipath diversity, Transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, Receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing, Spectral efficiency and capacity, Transmitting independent streams in parallel, Mathematical notation

The generic MIMO problem: Singular Value Decomposition, Eigenvalues and eigènvectors, Equalising MIMO systems, Disadvantages of equalising MIMO systems, Predistortion in MIMO systems, Disadvantages of pre

VLSI SYSTEM COMPONENTS CIRCUITS AND SYSTEM LEVEL PHYSICAL DESIGN: Multiplexers, Decoders, comparators, priority encoders, Shift registers. Arithmetic circuits – Ripple carry adders, Carry look ahead adders, High-speed adders, Multipliers. Physical design – Delay modelling ,crosstalk, floor planning, power distribution. Clock distribution. Basics of CMOS testing.

Reference Books:

1. Neil H.E. Weste and Kamran Eshraghian, Principles of CMOS VLSI Design, Pearson Education ASIA, 2nd edition, 2000.
2. John P.Uyemura "Introduction to VLSI Circuits and Systems", John Wiley & Sons, Inc., 2002.
3. Eugene D.Fabricius, Introduction to VLSI Design McGraw Hill International Editions, 1990.
4. Pucknell, "Basic VLSI Design", Prentice Hall of India Publication, 1995. 5. Wayne Wolf "Modern VLSI Design System on chip. Pearson Education, 2002.

W	Broadband Network and Network Management

Synchronous and Asynchronous Networks, Optical Fiber based Backbone and Information Superhighways, SONET & SDH standards. IP over SONET and WDM, STS & STM Framing, ATM and STM systems, ATM Layers. User Network & Network-Network Interfaces. Virtual paths and Virtual circuits, Cell Loss Effects, Intelligent Networks. Network Management and Control, TMN Architecture and Functional Requirements. Interface and Protocol Requirements, Information Modeling and Model representations. System Management Functions, OSI System Management, Internet SNMP, ODP/OMG. COBRA as technologies for TMN.

Reference Books:

1. Network Management: Principles and Practice 2nd Edition, Kindle Edition

X	Advanced Microprocessors and Microcontrollers

Intel 8086 (16-bit): Architecture, addressing modes, instruction set, assembler and crossassembler, input-output, system design using 8086. Intel 80386 and upgrades (32-bit): Basic programming model, addressing modes, instruction set, memory and I/O management, math coprocessor, upgrades of the 80386. A typical 16-bit microcontroller with RISC architecture and integrated A-D converter e.g. PIC18Cxxx family: advantages of Harvard architecture, instruction pipeline, analog input, PWM output, serial I/O, timers, in-circuit and self programmability. Instruction set. Typical application. Development tools.

Books and References:

1. Barry B. Brey, The Intel Microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium pro Processor, Pentium II, Pentium III, Pentium 4, and Core2 ... - Architecture, Programming, and Interfacing.
2. Nilesh B. Bahadure, Microprocessors: The 8086/8088, 80186/ 80286, 80386/80486 and the Pentium Family.
3. Muhammad Ali Mazidi, PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18, 1e Paperback – 1 January 2008 by (Author)

Y	Advanced Mathematical Techniques

Books and References:
Constantine A. Balanis, Antenna Theory: Analysis and Design, 4th Edition.
Sanjay Kumar, SaurabhShukla, Wave Propagation and Antenna Engineering

Z	**Electronic System Design**

Signal Conditioning, Instrumentation and isolation amplifiers, analog filtersand analog switches. Signal measurement in the presence of noise: synchronous detection, signal averaging. Noise in electronic systems: design of low noise circuits.
Interfacing of analog and digital circuits. Programmable circuits, architecture of a typical FPGA and its application. Case studies. A/D and D/A conversion: sampling and quantization, antialiasing and smoothening filters. Switched capacitor circuits and applications.
Books and References:
Jens Lienig , Hans Bruemmer, Fundamentals of Electronic Systems Design 1st ed. 2017 Edition.

XX	**Discrete mathematics**

Logic: Proposition and Predicate Logic, introduction to proof techniques, Advanced proof techniques, resolution, induction, Set theory and relations, Various types of relations and functions, Combinatorics Part I: permutations, combinations, sum rule, product rule, pigeon-hole principle, Ramsey numbers, Combinatorics Part II: Combinatorial proofs, Catalan numbers, counting using recursion, principal of inclusion-exclusion, advanced counting techniques, Recurrence equations and various methods of solving recurrence equations, Cardinality theory, countable and uncountable sets, Cantors diagonalization, uncomputable functions, Graph theory Part I: basic definitions, Eulers theorem, bipartite graphs and matching, Halls marriage theorem, various operations on graphs, Graph theory part II: isomorphism, vertex-connectivity, edge-connectivity, Euler graphs and Hamiltonian graphs, various characterizations, vertex and edge coloring, Abstract algebra: groups, rings, fields, Basic number theory: modular arithmetic, prime numbers and properties, GCD, Chinese remainder theorem, Fermats little theorem, RSA cryptosystem.

Books and References:

1. Kenneth Rosen, Discrete Mathematics and Its Applications Seventh Edition.
2. Kenneth H. Rose, Discrete Mathematics and Its Applications: With Combinatorics and Graph Theory.

a	**CAD for VLSI**

Different types of VLSI design styles: Full custom, standard cell based, gate array based, programmable logic, field programmable gate arrays etc. VLSI Design flow. High level design (scheduling, allocation and binding), CAD tools for VLSI design.
Logical effort, path effort, logical effort calculation for different gates and circuits, logical effort to estimate minimum path delay, Logical effort of optimum transistor sizing.
VLSI Design automation-partitioning (problem formulation, cost function, different partitioning approach, Kernighan-Lin, Fiduccia-Mattheyses and simulated annealing heuristic for partition), Floor

Fundamentals of data converters; Nyquist rate A/D converters (Flash, interpolating, folding flash, SAR and pipelined architectures); Nyquist rate D/A converters - voltage, current and charge mode converters; Oversampled A/D and D/A converters.

Basic PLL topology, dynamics of simple PLL, phase detectors, Phase frequency detector, Loop filters, Charge Pump PLLs, Ring Oscillator, VCO

Text Books:

1. Design of Analog CMOS Integrated Circuits, by Behzad Razavi, McGraw-Hill
2. R. Gregorian - Introduction to CMOS Opamps and Comparators. Wiley

Reference:

1. T. Carusone, D. Johns and K. Martin - Analog integrated circuit Design

d	**Low Power Circuits and Systems**

Introduction: Need for Low power VLSI chips - Low Power Design Methodology - Logic synthesis for Low power.

Sources of power dissipation in CMOS circuits: static power dissipation-diode leakage power, sub-threshold leakage power, gate, and other tunnel currents; dynamic power dissipation - short circuit power, switching power, Glitching power; degrees of freedom.

Power Analysis and Estimation: Gate level Analysis, Architecture level Analysis, Data Correlation Analysis, Monte-Carlo Simulation, Probabilistic Power Analysis. Statistical Techniques - Estimation of Glitching Power - Sensitivity Analysis - Circuit Reliability - Power Estimation at the circuit level - High level Power Estimation - Estimation of maximum power.

Static Power Optimization Techniques: Leakage current in deep sub micrometer transistors- Transistor Leakage Mechanism, Leakage Current Estimation. Multiple threshold voltages, various approaches for the fabrication of multiple threshold voltage transistors, variable threshold voltage CMOS (VTCMOS), transistor tracking approach, run time leakage power- multiple-threshold voltage (MTCMOS), power gating technique and various issues related to power gating approaches, state retention strategy, power management techniques, dual-Vt technique, delay, and energy constrained dual-Vt techniques.

Dynamic Power Optimization Techniques: Supply voltage scaling approaches: parallelism, pipelining, using multiple supply voltage, module level voltage selection, clustered voltage scaling, level converters, multiple supplies inside a block, supply voltage limitations, Optimum supply voltage, multi-level voltage scaling (MVS), dynamic voltage and frequency scaling (DVFS), adaptive voltage scaling (AVS), System level approach- hardware/software co-design, encoding techniques, clock gating, gated clock finite state machines (FSMs), pre-computational logic, basic approach of minimizing glitching power, Dynamic CMOS and Pass-transistor logic styles.

Low Power Static RAM Architectures: Organization, MOS Static RAM Memory Cell, Banked Organization, Voltage Swing Reduction, Power Reduction.

Low Voltage CMOS VLSI Technology: BICMOS and Silicon on Insulator (SOI) Technology. Recent Trends in low power VLSI Designs & its research issues in industry.

Text Books:

1. Anantha P Chandrakasan and Robert W Brodersen, "Low Power Digital CMOS Design", Kluwer Academic Publishers, Holland, 1995.
2. Ajit Pal, "Low Power VLSI Circuits and Systems", Springer, 2015.

References:

Sequential Circuit Design: Finite State Machines, Moore and Mealy Machines; State diagrams, State table, State assignment, derivation of next-state and output expressions, state minimization; State assignment for low power operation; CAD tools for FSM synthesis.

Advanced features of modern FPGAs: Block RAMs, Embedded processor, Communication ports, Analog interface.

Typical case studies: Simple logic functions – Decoder, encoder, multiplexer, demultiplexer, BCD to seven-segment decoder, keyboard/display interface; memory elements and arrays; sequential machine design – sequence generators, timing generators, a typical machine design (example: vending machine); A simple CPU design.

Design analysis: Static timing analysis, Power analysis, Resource utilization, noise, clock network, DRC, debugging methods.

FPGA as a Hardware Debugging platform: Hardware troubleshooting methods, Looking into the chip – Logic State Analyzer and its use; Concept of Hardware emulation – simulation vs. Emulation, FPGA as a Hardware emulator, Break-points and their utility, setting break-points in FPGA based design.

Text Books:

1. Fundamentals of Digital Logic with Verilog Design by S. Brown and Z. Vranesic (McGraw Hill.)

Reference Books:

1. A Verilog HDL Primer by J. Bhasker (B.S. Publications).

g	**MEMS & Microsystems Technology**

MEMS device fabrication process
Lumped Modeling, Statics, Dynamics, Quasi static analysis, Energy Methods
Elasticity, Structures, Thermal Energy Domain, Fluids, Electronics
Effect of noise, Feedback systems
Integration of MEMS systems, Scaling effect, Reliability of MEMS devices
Case studies in MEMS.

Text Books:

1. Microsystem Design by Stephen D. Senturia, Springer

Reference Books:

1. Micro and Smart Systemsby K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre G.K. Ananthasuresh, Wiley

h	**Advanced Computer Architecture and Processor Design**

Instruction Set Architecture (ISA) and Microarchitecture: ISA Principles and Trade-offs, RISC and CISC, Instruction Classes, Semantic Gap, Translation, MIPS and X86 ISA.Single Cycle and Multi Cycle Microarchitecture, Control and Data path

Test pattern generation for sequential circuits: ad-hoc and structures techniques scan path and LSSD, boundary scan

Built-in self-test techniques: LBIST and MBIST. Verification: logic level (combinational and sequential circuits), RTL-level (data path and control path). Verification of embedded systems. Use of formal techniques: decision diagrams, logic-based approaches.

ASIC/IP Verification, direct and random testing, Error detection and correction codes.

Text Books:

1. Essentials of Electronic Testing, M. L. Bushnell and V. D. Agrawal, 3rdKluwer Academic Publishers 2002

References:

1. Delay Fault Testing for VLSI Circuits,A. Krstic and K-T Cheng, 3rd Kluwer Academic Publishers. 2003
2. Testing of Digital Systems, N. K. Jha and S. Gupta, 2nd, Cambridge University Press. 2003
3. Digital Systems Testing and Testable Design, M. Abramovici, M. A. Breuerand A. D. Friedman, 3rd, Wiley-IEEE Press. 1994
4. Fault Tolerant and Fault Testable P. K. Lala, 4th, Hardware Design,Prentice-Hall. 1986

k	**Embedded Systems**

Introduction to Embedded systems: Motivation based on applications of embedded systems, Basics of Embedded systems, functional blocks

Modeling of Embedded system: Mathematical modeling of physical systems to fit into embedded systems, Continuous Dynamics, Discrete Dynamics, Hybrid Systems, actor models, Composition of State Machines

Cyber physical system architecture and Industry 4.0, Background of Industry standards, Cyber physical system, IoT, Industry 3.0, Industry 4.0

Microcontrollers, Sensors, Actuators, **Basics of Microcontrollers**, 8951, Arduino microcontroller development board, I/Os, Sensors, Actuators

Data networking, Data communication techniques, Internet, Ethernet, WiFi, Bluetooth and Cellular, LoRa

Case study in embedded system, Case study based on applications

Text Books:

1. Introduction to Embedded Systems - a Cyber Physical Systems Approach, By Edward Ashford Lee, Sanjit Arun kumarSeshia
2. Principles of measurement systems. By Bentley
3. Industry 4.0 the industrial internet of things, by Alasdair Gilchrist
4. Data Communications And Networking (SIE) by Behrouz Forouzan