SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING

(Deemed to be University)

Syllabus for M.Tech. (Optoelectronics & Communications)

(WITH EFFECT FROM A.Y. 2017-18)

Prasanthi Nilayam – 515 134

Anantapur Dt., Andhra Pradesh, Ph: (08555) 287239, Fax: 286919

Website: www.sssihl.edu.in ; Email: registrar@sssihl.edu.in

Program Objective

The M.Tech program in Optoelectronics and Communications is unique in its content, bridging the gap between academia and industry. The program equips the students with a strong foundation in understanding the physics and technology of modern networking and communications systems along with hands-on training. Electives, soft skill training, Industrial visits and Industry live projects undertaken by students prepares them for entry into the corporate world with ease. The host of electives under three different streams enables students to specialize and learn advanced concepts in a particular area and become self sufficient to enter specific industry.

Above all healthy teacher-student interactions coupled with constant inputs from alumni ensure that students develop into individually competent, collectively compatible and socially responsible citizens.

Sri Sathya Sai Institute of Higher Learning

DEPARTMENT OF PHYSICS

SCHEME OF INSTRUCTION AND EVALUATION FOR M.Tech.(Optoelectronics and Communications)

(WITH EFFECT FROM 2017-18)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
SEMESTER – I:						
MTOC-101	Optoelectronics	3	3	IE2	T	100
MTOC-102	Digital Communication Systems	3	3	IE2	T	100
MTOC-103(T)	Fiber Optic Components	2	2	IE2	T	50
MTOC-103(P)	Practical: Fiber Optic Components	1	3	I	P	50
MTOC-104	Elective-I	3	3	IE2	T	100
MTOC-105	Elective-II	3	3	IE2	T	100
MTOC-106	Optoelectronics Lab	3	6	I	P	100
MTOC-107	Software Lab-I	3	9	I	P	100
MTOC-108	Semester End Viva voce	1	-	EI	SEV	50
SAWR-100N	Awareness Course-1: Education for Life – Individual Transformation **(Non-Credit)**	-	1	I	T	-
		22 credits	33			750 marks
MTOC-201(T)	Optoelectronic Sensors	2	2	IE2	T	50
MTOC-201(P)	Practical: Optoelectronic Sensors	1	3	I	P	50
MTOC-202	Optical Communication Systems	3	3	IE2	T	100
MTOC-203	Optical Networks	3	3	IE2	T	100
MTOC-204	Elective-III	3	3	IE2	T	100
MTOC-205	Elective-IV	3	3	IE2	T	100
MTOC-206	Network Lab	3	9	I	P	100
MTOC-207	Software Lab-II	3	6	I	P	100
MTOC-208	Semester End Viva voce	1	-	EI	SEV	50
SAWR-200N	Awareness Course-II: God, Society and Man **(Non-Credit)**	-	1	I	T	-
		22 credits	33			750 marks
MTOC-301	Elective-V	3	3	IE2	T	100
MTOC-302	Elective-VI	3	3	IE2	T	100
MTOC-303	Software Lab-III	2	6	I	P	50
MTOC-304	Semester End Viva Voce	1	-	EI	SEV	50
MTOC-401	Project Interim Review	-	20	I	PW	50**
		9 credits	32			350 marks
MTOC-401	Project	12	30	E2	PW	250***
		12 credits	30			250 marks
	TOTAL	65 Credits	128 hours			2100 marks

Contd…

Modes of Evaluation

Indicator	Legend
IE1	CIE and ESE ; ESE single evaluation
IE2	CIE and ESE ; ESE double evaluation
I	Continuous Internal Evaluation **(CIE)** only Note: 'I' does not connote 'Internal Examiner'
E	End Semester Examination **(ESE)** only Note: 'E' does not connote 'External Examiner'
E1	ESE single evaluation
E2	ESE double evaluation

Types of Papers

Indicator	Legend
T	Theory
P	Practical
SEV	Viva voce
PW	Project Work
D	Dissertation

Continuous Internal Evaluation (CIE) & End Semester Examination (ESE)

PS: Please refer to guidelines for 'Modes of Evaluation for various types of papers', and Viva voce nomenclature & scope and constitution of the Viva-voce Boards.

** The Project Work topic would be finalized by the end of the second semester, and the Project Work starts thereafter, continues in the third semester and gets completed in the fourth semester.

*** Total marks for the Project Work would be 300 marks, which would include 50 marks for the review of the Preliminary Report submitted by the student at the end of the third semester (please see **) + 100 marks for the Project Viva-Voce conducted at the end of the 4^{th} semester + 150 marks for the double evaluation of the Project Report at the end of the fourth semester.

Elective Courses

All electives are three credit courses. A student will be allowed to take any of the electives in the following categories of electives. He can take the guidance of course coordinator/ HOD for choosing the best possible elective. A*part from the electives listed in this program, students may be permitted to opt for electives listed under the M.Tech.(CS) program in consultation with the Heads of the departments of Physics and Mathematics & Computer Science. This permits flexibility and more choice for the students to learn subjects of their interest. This is in tune with the spirit of the Choice Based Credit System (CBCS) as envisaged by UGC.* The HODs / course coordinators will take the final decision to offer an elective based on the load of the faculty members and give permission.

PROGRAM ELECTIVES

Stream I: Optoelectronics

PE-OPT-1: Principles of Photonics
PE-OPT-2: Fourier Optics and Optical Engineering
PE-OPT-3: Optical Computing
PE-OPT-4: Optical Instrumentation
PE-OPT-5: Integrated Optics
PE-OPT-6: Optical System Design
PE-OPT-7: Biomedical Optics and Biophotonics

Stream II: Networking and Communications

PE-NC-1: Computer Networks
PE-NC-2: Ad Hoc Wireless Networks
PE-NC-3: Network Security
PE-NC-4: Broadband Communications
PE-NC-5: Signal Processing
PE-NC-6: Adaptive Signal Processing

Stream III: Very Large Scale Integration (VLSI) Technology

PE-VLSI-1: Principles of VLSI
PE-VLSI-2: VLSI Design & Test
PE-VLSI-3: FPGA Based Design
PE-VLSI-4: Embedded Systems
PE-VLSI-5: ASIC Design

OPEN ELECTIVES:

OE-1: Digital Image Processing
OE-2: Introduction to Computer Design and Operating Systems
OE-3: Geospatial Information Systems
OE-4: Introduction to Virtualization Technologies
OE-5: Software Engineering
OE-6: Reliability, Availability and Serviceability of Systems
OE-7: Microfluidics: Devices and Applications

CORE PAPERS

MTOC-101 Optoelectronics 3 credits

Course Objectives:
Teach fundamentals of light interaction with Semiconductor materials and vice-versa and to be able to understand how some of the optoelectronic devices like, LED, Laser Diode, Photodiodes and Photo-voltaic cells work.

Course Outcomes:
Student would be able to understand and explain the following: 1) PN junction diode working in homo junction and Heterojunctions, 2) Band diagrams, space charge region formation, 3) basic laser operation and difference between semi-conductor lasers and other lasers like He-Ne (gas laser) or NdYAG laser, 4) working of LED, 5) advantage of Heterostucture Laser diodes 7) photodiode types and their respective advantages like PIN diode and APD's & basic operation of Photovoltaic devices.

Syllabus:

Semiconductor Science (review): Semiconductors and Energy Bands, Band gap Diagrams, pn junctions; Science and engineering of light emitting diodes.

Stimulated Emission Devices: Laser Diodes, Fabry-Perot and distributed-feedback lasers; vertical-cavity surface-emitting lasers.

Photodetectors: pn junction, photodiode science and operation, avalanche and heterojunction photodiodes, phototransistors.

Photovoltaic Devices: Solar energy spectrum, device principles, I-V characteristics, equivalent circuit, temperature effects, materials, devices, and efficiencies.

Polarization and Modulation of light: Polarization, propagation in anisotropic media, birefringent devices, optical activity, electro-optic effects, integrated optical modulators, acousto-optic modulators, magneto-optic modulators;

**Complement technologies and future outlook: Organic and molecular optoelectronics;

References:
1. S. O. Kasap, Optoelectronics and Photonics: Principles and Practices, 1st ed., Pearson Education,2001.
2. S. L. Chuang, Physics of Photonic Devices, 2nd ed., New York: Wiley, 2009.
3. Saleh and Teich, Fundamentals of Photonics, 2nd ed. Wiley Interscience 2007.

** Not for testing

* * *

MTOC-102 Digital Communication Systems 3 Credits

Course Objectives:
Understanding the fundamentals of all aspects digital communications from the information source to the receiver, including various types of source / channel coding and multiple access schemes.

Course Outcomes:
At the end of the course the students will be able to get an understanding and fair working knowledge of the various components of a typical digital communication system from the source to the receiver and their role in the overall scheme. The student should be able to calculate the BER for a given system and solve problems related to system design. Should be able to appreciate the need for different systems, using different Baseband and Bandpass modulation techniques and also be able to assess the performance using measurable like BER, eye diagrams and Eb/No ratio and constellation diagrams as well as solve problems related to these. Should be able to understand multiple access techniques and spread spectrum techniques, as well as solve problems related to these. Should be able to understand basic information theory concepts and simple source coding, channel coding schemes including Huffman compact codes , linear block and cyclic codes. Should be able to estimate the fundamental limits of capacity of a given communication channel.

Syllabus:

Signals and Spectra: Classification of Signals, Spectral Density, Autocorrelation, Random variables and random processes: Rayleigh, Rician, Gaussian and Poisson distributions, Signal Transmission through Linear Systems, Bandwidth of Digital Data

Baseband Modulation: Formatting Analog Information, Sources of Corruption: quantization noise, channel noise. PCM waveforms (Line codes): bipolar and unipolar NRZ, RZ, and variants. Power spectral Density of line codes. DPCM and Delta modulation. Detection of Binary Signals in Gaussian Noise, Maximum likelihood receiver: Matched filter and correlation receiver.

Bandpass Modulation and Demodulation/Detection: Signal Space representation, Coherent and incoherent detection of PSK, DPSK, FSK, MPSK, MFSK, and APK along with their Bit error performance. QPSK and QAM.

Multiple Access and Spread-Spectrum Techniques: Allocation of the Communications Resource. Overview and comparison of TDMA, FDMA, Multiple Access Communications System and Architecture. ALLOHA and S-ALLOHA algorithms. Spread-Spectrum Overview, Pseudo noise Sequences, Direct-Sequence Spread-Spectrum Systems, Frequency Hopping Systems, Synchronization, and Jamming Considerations.

Coding: Entropy, information rate, Coding to increase average information per bit, Huffman Coding, Shannon's theorem for Capacity of Gaussian Channel, Bandwidth- S/N tradeoff, Discrete Memoryless channel capacity. Channel coding: Linear Block codes, cyclic codes and their error correction/detection properties, Cyclic Redundancy Check, Coding strength.

****Multipath Fading:** Large scale and small scale fading, summary of the Key Parameters Characterizing Fading Channels, Mitigating the Degradation Effects of Fading: Vitterbi Equalizer and RAKE receiver.

**** Not for testing**

References

1. Bernard Sklar, 'Digital Communications: fundamentals and applications', Second Edition, Prentice Hall.

2. B. P. Lathi, "Modern Digital and Analog Communication Systems", 3rd ed., Oxford University Press, (Oxford Series in Electrical and Computer Engineering), (2000)

3. Simon Haykin, "Communication Systems", 4th ed., John Wiley, (2006).

* * *

MTOC-103(T) Fiber Optic Components 2 credits

Course Objectives:
Exposure to fundamentals of Fiber Optics and fiber optic based components used in optical networks. This course is designed to have a laboratory component to give practical exposure.

Course Outcomes:
understand the technology behind long distance optical communication; light guiding mechanism and physical characteristics of light propagation in optical fibers, understand different mechanisms that causes signal attenuation and dispersion, working principles of fiber based components such as directional coupler, fiber inline wavelength filters, fiber inline amplifiers, wavelength selective switches, isolators, ROADMs

Syllabus:

Review of propagation of light in optical fibers: fiber types and numerical aperture, ray analysis of propagation of light in a fiber; loss mechanisms in fibers; signal attenuation;

Modal analysis of step index fibers, characteristic equation, type of modes, single-mode fibers, mode cutoff and mode field diameter, pulse dispersion in single-mode fibers; chromatic and intermodal dispersion, fiber bandwidth and birefringent fibers and polarization mode dispersion.

Couplers, Isolators and Circulators; Multiplexers and Filters: Gratings, Fiber Bragg Gratings(FBG), Fabry-Perot Filters, Multilayer Dielectric Thin-Film Filters, Mach-Zehnder Interferometers, Acousto-Optic Tunable Filter;

Optical Add-drop Multiplexers (OADM): Fixed OADM, Reconfigurable-OADMs; Wavelength selective switch;

References:

1. Ghatak A and Tyagarajan K, “Introduction to Fiber optics”, Cambridge University Press, 1998.
2. Thyagarajan K and Ghatak A., Fiber Optic Essentials, Wiley Interscience, 2007.
3. Rajiv Ramaswami: “Optical Networks: A Practical Perspective” (3rd edition, 2010); Morgan Kaufman/Elsevier.
4. Keiser, Gerd: Optical Fiber Communications, 4th Ed., McGraw Hill (2009).

* * *

MTOC-103(P) Practical: Fiber Optic Components 1 credit

1. Basic Fiber cutting and polishing and launching light
2. Measurement of attenuation
3. Bend induced losses
4. Measurement of Mode field diameter.
5. Measurement of refractive index profile;
6. Measurement of NA;
7. Measurement of pulse dispersion and bandwidth;
8. Characterization of a 2x2 optical fiber coupler

Minimum any 5 of the above experiments

* * *

MTOC-201(T): Optoelectronic Sensors 2 Credits

Course Objectives:
To understand the engineering aspects of the Light Matter interaction in semiconductor materials and take advantage of the properties to build Sensors. This course has been designed with a laboratory component to give practical exposure.

Course Outcomes:
Building on the basic understanding of how light interacts with semi-conductor materials in MTOC 101, this course aims to develop the understanding of the Optoelectronic sensors classified into Waveguide based sensors, Free space based sensors, Integrated optical sensors.

Syllabus:

Sensors based on Guided waves sensing

Review: Fundamentals of waveguiding, waveguide sensors basic working principle.
(Ref 1: sec 1.1 -1.3)
Optical Fiber Sensors: Principle and applications of FBG based and Fiber gyroscope sensors.
(Ref 1: sec 1.4 -1.5; Ref 1 sec 18.1and 18.2)
Distributed Fiber optic Sensors: Principle of OTDR, Working, measurement parameters, and fault location in fiber optic line.
(Ref 1: sec 3.2, Ref 2: sec 14.6)

Sensors based on Free Space monitoring

Overview, Principle of working of spectrophotometers; Principle of Laser Doppler velocimetry: forward and backward scattering geometries; Principle of LIDAR applications in remote sensing and Environmental pollution monitoring.
Ref 1: Sec 11.1- 11.4.3; sec 20.1 – 20.6.1)

Sensors Based on Integrated optics / on chip sensing:

Surface Plasmon Resonance: Theory and Applications in Sensors and Biosensors;
(Ref 1: Chapter 5); Integrated optic waveguide based sensors: Overview of fabrication techniques of integrated optic waveguides;
Femtosecond laser based fabrication of optical waveguides and microfluidic channels;
Sensors based on integrated optic MZI, microfluidic/optofluidic Lab on chip based sensors
(Ref 1: sec 7.1, 7.2; Ref 3: Chapter 1; sec 5.1, 5.6.1, 5.6.2, 5.6.5; sec 11.4.1; sec 14.1, 14.2, 14.3, 14.4)

References:

1. An Introduction to Optoelectronic Sensors. Edited by: Giancarlo C Righini (CNR, Italy), Antonella Tajani (CNR, Italy), Antonello Cutolo (University of Sannio, Italy).
2. Optical Fiber Communications, 4th edition, Gerd Keiser,Tata McGraw-Hill,2009.
3. Femtosecond Laser Micromachining: Photonic and Microfluidic Devices in Transparent Materials, Edited by: Roberto Osellame, Giulio Cerullo, Roberta Ramponi; Springer (2012)

* * *

MTOC-201(P): Practical: Optoelectronic Sensors 1 Credit

Familiarization of working principle of:

1) UV- Vis, FTIR and Optical Fiber spectrophotometer
2) Raman spectroscopy
3) Interferometric based sensor
4) Photo-diode based sensors
5) Photo-transistor based sensors
6) SPCE based sensor
7) Stimulated emission based sensor
8) Fiber based sensor

Minimum 5 of the above + a mini project based on any of the sensors

* * *

MTOC-202 Optical Communication Systems 3 Credits

Course Objectives:

Understanding the fundamentals of all aspects Optical fiber communications and assess the design of an optical communication link in terms of the choice of source, fiber, optical amplifier, detector modulation / demodulation scheme.

Course Outcomes:

· At the end of the course the students will be able to get an understanding and fair working knowledge of all parts and subsystems of an Optical fiber communication system. Given a customer specific demand the student should be able to choose the various components (Source, Fiber and Detector) and design and optimize an entire link, perform a power and rise time budget analysis, taking into consideration the need for optical amplifiers, mitigation of various nonlinear optical effects, dispersion compensation and power penalties due to various sources of imperfections that degrade the SNR/OSNR. Be able to predict the BER performance of a given optical link. Asses the need for coherent/incoherent optical detection and choose the right modulation scheme for a specific demand

Syllabus:

Overview of optical fiber communications

Optical Receiver operation: digital receiver performance calculations, high, low and trans impedance preamplifier, raised cosine filter

Digital links: Power and Rise time budget, Direct detection, Coherent detection; Homodyne, Heterodyne detection with ASK, PSK, FSK based SNR calculations

Analog Links: SNR calculations, Multichannel AM, and FM, Subcarrier multiplexing

Optical amplifiers: SOA, EDFA and Raman Amplifier

Nonlinear effects: SPM, FWM, SRS, Soliton

Mitigation of transmission impairments: Modal Noise, Mode Partition Noise, chirping, reflection noise, Dispersion compensation and Dispersion Management

Performance Measurement and Monitoring: OTDR, Eye pattern analysis

Transceivers: 40 GBit and 100 GBit transceiver technology, Construction and working of transcievers for 40G and 100G

References:

1. Optical fiber Communications by Gerd Keiser-5th Edition, Mc Graw Hill (2012)
2. Optical fiber Communications by John M. Senior, 3rd Edition
3. Fiber Optic Communication by G.P. Aggarwal
4. Optical Communication systems by John Gowar, 2nd Edition
5. http://www.fiber-optic-transceiver-module.com/category/fiber-optic-transceivers/40-100g-transceivers
6. http://www.lightwaveonline.com/articles/print/volume-29/issue-6/feature/challenges-and-key-technologies-for-coherent-metro-100g-transceivers.html
7. http://cubeoptics.hubersuhner.com/en/Solutions

* * *

MTOC-203: Optical Networks 3 Credits

Course Objectives:
Provide a thorough understanding of the fundamental principles of Optical networks covering network architecture, network design and protection along with details of OTN and PON.

Course Outcomes:
1. To get acquainted with different types of optical network architectures and their applications.
2. To study about different wavelength routing network.
3. Learn aspects of algorithms related to connectivity and packet switching and queuing.
4. Understand principles of passive optical networks and OTN

Syllabus:

Overview of Optical Networks: Telecommunications Networks, Circuit and Packet Switching; Demand for Optical Networks; Optical Layer, evolution and basics of Optical Networks.
Optical Networks: Architecture: SONET basics; Optical Layer and client layers: SONET, GFP, Ethernet, IP/MPLS; Network Topologies and Paradigms: Tree, Mesh and Ring; Circuit and Packet switching; Network components: WDM, OLT, OADM/ROADM, OXC,
Optical Networks: Design: Client models, Routing and traffic grooming, Traffic models; Optimization algorithms and methods – routing algorithms, integer and mixed integer linear programming, heuristic optimization algorithms; Design of Transmission Layer.
Network Reliability and Protection: Standard protection and restoration, rings, mesh topologies; SONET/SDH, Next Generation SONET, Fast reroute, Resilient Packet Rings; Generalizations: Quality of protection, network coding, protecting path segments, p-cycles.
OTN: Why OTN? (SDH limitations, WDM monitoring limitations - OTN,FEC, Payload Transparency, OTN Frame Structuring, OTN Overhead bytes for TCM, APS, communication channels, section monitoring, OPU overhead, FEC, OTN mapping and switching.
Passive Optical Networks: Evolution of PON, types of PON, usage of PON in commercial deployments, advantages of PON over traditional broadband systems;

References:

1. Rajiv Ramaswami: "Optical Networks: A Practical Perspective" 3rd ed., Morgan Kaufman/Elsevier (2010).
2. Prat, Joseph (Ed): "Next-Generation FTTH Passive Optical Networks: Research Towards Unlimited Bandwidth Access": (2008); Springer.
3. Casimer DeCusatis, "Handbook of Fiber Optics Data Communication: A practical guide to Optical Networking", III Ed, Elsevier Academic Press, 2008
4. Gilbert Held, "Deploying Optical Networking Components", McGraw Hill, 2001.
5. Biswanath Mukherjee, "Optical WDM Networks", Springer, 2006

* * *

PROGRAM ELECTIVES (PE)
Stream I: Optoelectronics

Stream Objectives:

The objective of the courses in this stream is to give exposure to fundamentals of Optoelectronics and optical system design considerations using principles of geometrical and physical optics, Fourier optics, optical computing, waveguide optics, nonlinear optics, photodetectors and light sources. The stream consists of 7 electives:

PE-OPT-1: Principles of Photonics: To provide fundamental principles of optics covering topics on geometrical and wave optics.

PE-OPT-2: Fourier Optics and Optical Engineering: To teach concepts of Fourier Optics and its applications

PE-OPT-3: Optical Computing: To learn fundamentals of integrated optics, optical devices like optical transistors and optical memories and optical processing techniques in neural networks.

PE-OPT-4: Optical Instrumentation: To teach the operating principles of various optical instruments right from simple magnifiers to high level medical systems, metrology instruments and imaging / night vision systems.

PE-OPT-5: Integrated Optics: To provide deeper understanding of integrated optics in its varied forms by covering topics on design, optimization, fabrication and characterization of integrated components like waveguides, couplers, lenses, integrated sensors, etc.

PE-OPT-6: Optical System Design: This elective is meant to give details of optical design procedures and computation of aberrations.

PE-OPT-7: Biomedical Optics and Biophotonics: To learn the fundamentals of interaction of light with biological tissues; understand different optical techniques useful in medical diagnosis and therapy.

Stream Outcomes:

Students who take 2 or more electives from this stream should at the end, be able to assess /design/ evaluate an optical system incorporating knowledge of geometrical and physical optics, Fourier optics, optical computing, waveguide optics, nonlinear optics, photodetectors and light sources. In short they should be competent optical engineers, with 'hands-on' knowledge along with sound theoretical foundations. They will also be able to apply their knowledge in the domain of medical imaging and diagnosis and build photonics based sensor.

PE-OPT-1: Principles of Photonics

Introduction to Photonics:

Geometrical Optics: Brief review, Applications in waveguiding in photonics - ray paths in fibers;

Wave Optics: Wave equations and Electromagnetic waves; Energy flow and absorption; Superposition of Waves and Interference: Two-beam interference, Multi-beam interference, Fabry-Perot interferometer, Group/phase velocity and dispersion - pulses in optical fibers;

Diffraction and Imaging: Fraunhoffer diffraction, Diffraction grating, Fresnel diffraction (concepts only), Resolution and Abbe limit - implications in imaging; Basic image formation; Far-field diffraction as Fourier transform; Application of Fourier optics to processing optical images;
Polarization: Jones vectors and Jones matrices, Fresnel equations, Evanescent waves, Birefringence, Polarization components and devices
Photonic devices: Laser basics, operation, Characteristics of laser beams; Acousto-optic modulation; Electro-optic modulation; Semiconductor photonic devices: Light emitting diodes (LED). Semiconductor lasers, Semiconductor photodetectors
Nonlinear photonic devices: Frequency conversion - harmonic generation and wave mixing, Kerr effect, nonlinear effects in optical fibers and their implications in communication systems.

References:

1. Photonics Essentials: An introduction with experiments, T.P. Pearsall, McGraw-Hill, 2002.
2.Optics, E. Hecht, 4th ed., Pearson Education 2002,.
3. Photonics, R. Menzel, Springer, 2001.
4. Photonics and Lasers-An Introduction, R.S. Quimby, Wiley-Interscience, 2006.

* * *

PE-OPT-2: Fourier Optics and Optical Engineering

Theoretical background needed to analyze various optical systems: two-dimensional Fourier transforms, vector and scalar diffractions, Fresnel and Fraunhoffer approximations,

Properties of lenses, coherence theory, frequency analysis of optical imaging systems, spatial filtering, optical information processing, wave-front reconstruction imaging;

Introduction to CAD tools for lenses, optical filters, instrument design; flat panel displays, micromechanical optical systems.

References:

1. J.W.Goodman, " Introduction to Fourier Optics", 3rd ed., Roberts and Company Publishers, (2005)
2. Eugene Hect, "Optics", 4th ed., Addison-Wesley, (2003)

****

PE-OPT-3: Optical Computing

Introduction -- Fourier Optics -- Holograms
Optical Devices -- SLMS -- Integrated Optics -- LCD's
Optical Transistors -- Basic Building Blocks -- Interconnections

Optical Memory -- Optical Arithmetic And Matrix Computations Methodologies And Algorithms -- Architectural Models
RISC Machines -- Data flow Computers -- Optical Processing Techniques -- PAL -- Optical Computing And Neural Networks.

References:

1. Optical Computer Architectures , by Alistair D.Mcaulay. John - Wiley & Sons, 1991
2. Optical Computing , by Dror G.Feitelson , The MIT Press, 1988.

* * *

PE-OPT-4: Optical Instrumentation

Radiometry: basic concepts; Visual Systems: magnifiers and eyepieces;
Projection Systems: profile projectors;
IR and Medical Systems: thermal imaging instruments;
Metrology Instruments: interferometric instruments, online optical sensing of temperature and flow.
Unique features of the infrared region - materials, effect of temp on optical properties and athermalization methods
Optical design and material selection, tolerances, Reflective and transmitive infrared zoom systems, Night vision equipment; Applications in industry and defence;

References:

1. Malcara, D., Geometrical and Instrumental Optics,Academic Press, London, 2000.

2. Mann Allen, Infrared Optics and Zoom Lenses,SPIE, 2002.

3. R. Kingslake, Applied Optics and Optical Engineering, Vol. 4 and 5, Academic, 2002.

4. Michael Vollmer, Infrared Thermal Imaging: Fundamentals, Research and Applications,Wiley, 2010.

* * *

PE-OPT-5: Integrated Optics

Integrated optics introduction and overview: Advantages of Integrated Optics, Comparison of Optical Fibers with Other Interconnectors, Comparison of Optical Integrated Circuits with Electrical Integrated Circuits. Hybrid versus Monolithic Approach.

Review of Geometrical optics and Electromagnetism: Reflection, refraction. Review of Maxwell’s equations, propagating wave equation.

Optical waveguide modes: Review of optical modes TE, TM modes; Modes in planar waveguide, Analytical and theoretical description of modes in three layer planar waveguide structure

Waveguide fabrication techniques: Deposition techniques, Channel waveguide fabrication, femtosecond laser micromachining of waveguides in transparent glasses.

Coupling techniques: prism couplers, grating couplers; Couple mode theory of synchronous coupling, applications of directional couplers.

Losses in optical waveguides: Scattering losses, surface scattering losses, radiation losses in planar straight waveguides and curved channel waveguides. Propagation losses waveguides fabricated by femtosecond laser

Integrated optical sensors and devices: Femtosecond laser fabrication - Planar Splitters (Y) splitter. 3D splitters. MZI based RI sensors.

References:

1. R.G. Hunsperger, Integrated Optics: Theory and Technology, Sixth Edition, Springer Verlag, 2009.
2. Roberto Osellame, Giulio Cerullo, Roberta Ramponi (*Editors*), Femtosecond laser micromachining, First Edition, Springer, 2012.
3. B.E.A. Saleh and M.C. Teich, Fundamentals of Photonics, Second Edition, John Wiley & Sons, Inc., 2007.
4. R.G. Hunsperger, Ed., Marcel Dekker, Photonic Devices & Systems, 1994, ISBN 0-8247-9243-2
5. Ivan P. Kaminow and Tingye Li, "Optical Fiber Telecommunications IVA: Components" Academic Press 2002.

* * *

PE-OPT-6: Optical System Design

Introduction to Optical systems: Ray tracing procedures, Aberrations, Multi lens systems, Photometry of optical systems, Mirrors and prisms, Image evaluation, Optical systems, Optimization techniques.

Optical System Design Laboratory
Ray tracing - lay output of an optical system - Computation of Aberrationst - Design of aplanatic objective -Seidal aberrations - zonal spherical aberration - apochromatic objective - Tracing oblique meridional rays and skew rays - primary lateral colour - Triplet design

References:

1. Kingslake, R.,Optical System Design,2nd Edition, Academic Press, 2010.
2. Smith, W.J., Modern Optical Engineering, 3rd Edition, McGraw Hill, 2000

* * *

PE-OPT-7: Biomedical Optics and Biophotonics

1. **Introduction:** Light-Matter interactions, Rayleigh and Mie scattering; Optical Properties of Biological Tissues; Basics of Biotechnology & Cancer Biology
2. **Spectroscopy:** Fluorescence(FRET) & Up-conversion spectroscopy; Raman: SERS & CARS; Flow-cytometry;

3. **Imaging**: Confocal, Nonlinear & Multiphoton Microscopy/imaging, Super-resolution: NSOM technique, Adaptive optics for biomedical imaging. Tomography: OCT , Doppler OCT, Diffuse Optical OCT , Photo-acoustic tomography;
4. **Optical manipulation of biological materials:** Optical tweezers, Laser dissection & surgery, Neural excitation;
5. **Applications:** Optical biosensors: Glucose sensing, Optical diagnostics, Wireless/capsule Endoscopy, Photodynamic therapy.

References:

1. Valery V. Tuchin , "Handbook of Photonics for Biomedical Science", CRC Press, Taylor & Francis Group, 2010
2. Paras N. Prasad, Introduction to Biophotonics, Wiley & Sons (2003).

* * *

Stream II: Networking and Communications

Stream Objectives:

The electives under this stream cater to the aspects of networking and communications. The objective of this stream is to enable student to become competent in the field of computer and telecommunication networks with a working knowledge of the networking aspects, security requirements, TRAI regulations, signal processing requirements in communications, etc. The stream consists of the 6 electives:

PE-NC-1: Computer Networks: This is a fundamental course that teaches the principles of computer networks, different network layers and their significance, and the latest trends like software defined networks.

PE-NC-2: Ad Hoc Wireless Networks: To give the basic principles of wireless networks covering concepts of WAN, LAN, MAN and different protocols used in adhoc wireless networks. The course also covers aspects of energy management in wireless networks.

PE-NC-3: Network Security: Security in communications and networks is one of the hot topic of research. Continuous and efficient management of threats, methods of sending and receiving messages with embedded security bits, security aspects at different layers and concepts of cryptography are intended to be covered in this course.

PE-NC-4: Broadband Communications: This is a second level course designed to teach principles of broadband communications including mobile broadband, Wimax, cable broadband, wireless backhaul and aspects of passive optical networks.

PE-NC-5: Signal Processing: This course is designed to cover the fundamental aspects of various digital signal processing techniques.

PE-NC-6: Adaptive Signal Processing: This is a second level course on advanced signal processing concepts. The pre-requisite for this is the first level signal processing course (PC-NC-5).

Stream Outcomes:

Students who take 2 or more electives from this stream would at the end, become competent network engineers, having practical knowledge of data communications and networking, sufficiently equipped with the understanding of latest trends in networking industries and be able to take up design, development and testing related jobs.

PE-NC-1: Computer Networks

Introduction -Network edge, Network core, ISPs and Internet, Protocol Layers and service models, OSI, TCP/IP reference models.

Application Layer: Principles, Web and HTTP, FTP, SNMP, DNS.

Transport Layer: Services, Multiplexing and demultiplexing, principles of reliable data transfer, connection oriented transport, TCP, Connectionless support, UDP, 37 Congestion control.

Network Layer and Routing : Service models, datagram service virtual circuit service, routing principles, routing algorithms, IP protocol, routing in internet, IPV6, Multicast routing.

Link Layer and LAN: The Data Link Layer services, Error Detection and Correction, Multiple Access protocols, LAN addresses and ARP, Bridges, Routers.

Software Defined Networks: SDN Introduction: What is SDN; SDN Architecture; concept of OpenFlow; Benefits of SDN; Open Networks OS (ONOS);

Network Function Virtualization: NFV as an implementation of SDN

References:

1. Computer Networks : A Top Down Approach Featuring the Internet , by
Jim Kurose, Keith Ross, 3rd Ed, Pearson Education 2004
2. Data And Computer Communications by William Stallings, VIIth edn , Pearson
Education, 2005.
3. Computer Networks by Andrew S.Tanenbaum, IV Ed, Pearson Education 2003
4. S. Keshav , "An Engineering Approach to Computer Networking" Addison Wesley, (1997)
5. https://sites.google.com/site/sdnreadinglist/
6. http://www.cs.princeton.edu/courses/archive/fall13/cos597E/papers/nfv.pdf
7. Pankaj Berde et al., ONOS: Towards an Open, Distributed SDN OS, Open Networking Laboratory, USA.

* * *

PE-NC-2: Ad Hoc Wireless Networks

Basics of Cellular and Wireless Data Networks:
Mobile radio propagation, characteristics of wireless channel- path loss, fading, interference, Doppler shift. Modulation techniques, Multiple access techniques TDM, FDM, CDM & SDM. Voice coding. IEEE 802 Networking standard

Wireless LANs and PANs: Fundamentals of WLANs, IEEE 802.11 HIPERLAN standard, Bluetooth and Zigbee

Wireless WANs and MANs: Cellular concept, handoffs. Cellular architecture – 1G, 2G, 3G, LTE Wireless local loop, wireless ATM 802.16 standard. Wireless Intenet: Address mobility, inefficiency of transport & application layer protocols, Mobile IP, TCP in wireless domain WAP

Ad hoc wireless networks: Cellular and ad hoc wireless networks & applications. Issues in ad hoc wireless networks –routing, multicasting, QoS, Self organization, energy management, scalability.

Mac Protocols for Ad hoc wireless networks: Designing a MAC protocol- Hidden and exposed terminal problem, lack of central coordination. Classification – contention based protocols

Routing Protocols for Ad hoc wireless networks: Mobility, Bandwidth constraint, resource constraints. Classification based on routing information, routing topology. Table driven, Hybrid routing protocols.

QoS, Energy management in Ad hoc wireless networks: QoS parameters, issues & challenges, solutions. Need for energy management, classification

Introduction Wireless Sensor networks: Applications of sensor networks. Issues and challenges in design. Sensor network architecture – layered & clustered. Data dissemination – flooding, gossiping. Data gathering, Quality.

References:
Ad hoc wireless Networks- Architecture & protocols by C.Siva Ram Murthy and B.S.Manoj, Pearson Educaion (2004)
Wireless communications- Principles and Practice, 2nd ed., Theodore S. Rappaport, PHI, (2008)
Wireless Network Evolution, by 2G to 3G, Vijay K. Garg, Pearson Education, 2002.

* * *

PE-NC-3: Network Security

Introduction: Computer Security Concepts, Security Attacks, Security Services, Security Mechanisms.

Symmetric Encryption: Principles, Symmetric Block Encryption Algorithms, Random and Pseudorandom Numbers, Stream Ciphers and RC4, Cipher Block Modes of Operation

Message Authentication and Hash Functions: Approaches to Message Authentication, Secure Hash Functions, Message Authentication Codes**.**

Public key Cryptography: Principles, Public-Key Cryptography Algorithms, Digital Signatures

Key Distribution and User Authentication: Kerberos, X.509 Certificates, Public-Key Infrastructure

Network Access Control: Network Access Control, Extensible Authentication Protocol
Cloud Security: Cloud Security Risks and Countermeasures, Data Protection in the Cloud, Cloud Security as a Service

Transport-Level Security: Web Security Considerations, Secure Sockets Layer (SSL), Transport Layer Security (TLS), HTTPS, Secure Shell (SSH)

Wireless Network Security: Wireless Security, IEEE 802.11 Wireless LAN Overview, IEEE 802.11i Wireless LAN Security

Electronic Mail Security: Pretty Good Privacy (PGP), S/MIME

IP Security: IP Security Overview, IP Security Policy, Encapsulating Security Payload, Combining Security Associations; functions of TRAI

References:

1. Network Security Essentials: Applications and Standards by William Stallings, 5th edition, Pearson Education Inc., 2014. (Key book)
2. Introduction to Computer and Network Security: Navigating Shades of Gray by Richard R. Brooks, 1st edition, 2013.
3. Network Security: Private Communication in a Public World by Charlie Kaufman, Radia Perlman, Mike Speciner, 2nd edition, 2002.

* * *

PE-NC-4: Broadband Communications

Broadband Communication: Introduction; Network Classification (LAN, MAN, WAN, PAN, etc.); Network Software (Protocol Hierarchies, Connection-oriented vs Connectionless, Services and Protocols); Broadband Communication and types of broadband communication;

Mobile Broadband: 3G: Introduction to 3G Mobile technology, Evolution of the 3G technology, Spectrum requirements for 3G, Technolgies used in 3G;

4G: Introduction to 4G Mobile technology, spectrum requirements, technologies used, evolution of the technology;

Wireless Broadband (Wimax): Mobile Wimax, technologies used in WIMax, advantages and disadvantages of WiMax;

Cable Broadband: DOCSIS, usage of cable broadband services, cable broadband network architecture;

Wireless backhaul: Requirement for wireless backhaul, techonologies used in wireless backhaul - TDM, Circuit Emulation, Carrier Ethernet, Parameters which influence the selection of technology, hybrid networks

Passive Optical Networks: Evolution of PON, types of PON, usage of PON in commercial deployments, advantages of PON over traditional broadband systems;

References

1. The Evolution of Mobile Technologies – Qualcomm
2. MIT Lecture series – Telecom: Wireless networks
3. Komal, 4G Technology, International Journal of Electronics and Communication Engineering, Vol 6, (1), pp.67- 73, 2013.
4. http://www.highspeedexperts.com/know-your-docsis/
5. http://www.highspeedexperts.com/internet-services/cable/
6. 3G.Evolution HSPA and.LTE for Mobile Broadband, Ed. II, Dahlman, Parkvall, Skold, Beming.
7. Mobile.Broadband.Including.WiMAX.And.LTE-Mustafa Ergen
8. http://www.fujitsu.com/downloads/TEL/fnc/whitepapers/Fujitsu_Wireless_Backhaul.pdf
9. http://www.ndc.fi/wp-content/uploads/2015/04/6024_Mobile_Backhaul.pdf
10. Mobile Backhaul for Dummies, Ed Tittel, Taylor Salman, Chris York.
11. http://www.netmanias.com/en/post/techdocs/5904/lte-network-architecture/lte-network-architecture-basic
12. Introduction to wireless LTE 4G architechture, L-F Pau

* * *

PE-NC-5: Signal Processing

Discrete time signals and Systems & Z-transforms Discrete time systems, Linear time invariant systems and properties, Frequency Domain Representation of discrete time signals and systems, discrete time Fourier transform and properties, Z transform Definition, properties and Inverse z-transform

Discrete Fourier Transform & Fast Fourier Transform: Representation of Periodic sequences by Discrete Fourier series, Fourier transform of periodic signals, Sampling Fourier transform, Fourier representation of finite duration sequences by Discrete Fourier transform (DFT), properties of DFT, Linear convolution using the DFT (Overlap save and Overlap add methods), Computation of Discrete Fourier Transform (FFT**):** The Goertzel Algorithm, Decimation-in-Time FFT algorithm, Decimation-in-Frequency Algorithms

Introduction to Time-Frequency Analysis: Fundamentals of multi-rate systems: basic multi-rate operations (interpolation and decimation), Polyphase representation, Applications of multi-rate systems, Introduction to Short Time Fourier Transform (STFT) and limitations, Introduction to Wavelet transforms and relation to multi-rate filter banks

Study of DSP Architectures: Basic Building blocks of DSP systems: ALU, Multipliers, Dividers, MAC, Barrel shifter, DSP processor architecture, Implementation considerations, finite word length effects, DSP architectures : Texas instruments TMS 320C54x; Analog Devices Blackfin processor overview, memory and I/o Management , on-chip resources and programming

Lab/Practical Session: Learning DSP programming techniques on Blackfin/TMS DSP architectures and implement FIR and IIR filters, Fast Fourier Transform

References:

1. Discrete-Time Signal Processing, Alan V. Oppenheim and Ronald W. Schafer, Ed III, Prentice Hall, 2009
2. Digital Signal Processing - S. Salivahanan, A Vallavaraj and C Gnanapriya, McGraw Hill, 2009.
3. Multirate systems and Filter Banks by P.P.Vaidyanathan
4. Digital Signal Processing (with MATLAB), Sanjay Sharma, S. K. Kataria & Sons, Ed 5, 2010.
5. Digital Signal Processor Architecture, Programming and Application, by B.Venkataramani and M.Bhaskar ,TMH 2002.

* * *

PE-NC-6: Adaptive Signal Processing

PREREQUISITES

1. First course in Signals and Systems as well as DSP is a prerequisite.
2. Familiarity with linear algebra and random process theory will be helpful.

Introduction to Adaptive Filters.

1. Adaptive filter structures, issues and examples.
2. Applications of adaptive filters:
    a. Channel equalization, active noise control
    b. Echo cancellation, beamforming.

Discrete time stochastic processes.

1. Re-visiting probability and random variables.
2. Discrete time random processes.
3. Power spectral density - properties.
4. Autocorrelation and covariance structures of discrete time random processes.
5. Eigen-analysis of autocorrelation matrices.

Wiener filter, search methods and the LMS algorithm.

1. Wiener FIR filter (real case).
2. Steepest descent search and the LMS algorithm.
3. Extension of optimal filtering to complex valued input.
4. The Complex LMS algorithm.

Multi Rate Analysis and DWT:

1. Need for Scaling function.
2. Multi Resolution Analysis, Two Channel Filter Banks, Perfect Reconstruction Condition.
3. Relationship between Filter Banks and Wavelet Basis.
4. DWT, Structure of DWT Filter Banks.
5. Daubechies Wavelet Function, Applications of DWT.

6. Application of Multirate signal processing: Subband Coding of Speech Signals, Quadrature Mirror Filters, Transmultiplexers, Over Sampling A/D and D/A Conversion

Introduction to Modern Spectral Analysis & Estimation

1. Spectrum Estimation: Introduction, Correlogram method, Periodogram Computation via FFT, properties of Periodogram method such as bias analysis, window design considerations
2. Parametric Methods for line Spectra: Models of sinusoidal Signals in Noise, Non-linear least squares method. High Order Yule Walker method, Min – Norm Method, ESPRIT Method, Forward – Backward Estimation

References

1. "**Adaptive Filter Theory**" by S. Haykin, Prentice Hall, Englewood Cliffs, NJ, 1991 (Second Ed.).
2. **"Multirate Filtering for Digital Signal Processing: MATLAB Applications"** by Milic Ljiljana, 2009
3. "**Modern Spectral Estimation: Theory and Application**", by S. M. Kay, Prentice Hall,. 1988.

* * *

Stream III: VLSI Technology

Stream Objectives:

This stream is designed to give additional edge to the students of this M.Tech. program by way of specializing in VLSI technology. With basic knowledge of optoelectronics, fiber optics and communications learnt from the core papers, the students can opt to pursue this stream to be able to go over to semiconductor industry. The stream consists of the 5 electives:

PE-VLSI-1: Principles of VLSI: To teach basic principles of VLSI with introduction to CMOS theory, IC design and characteristics and implementation strategies.

PE-VLSI-2: VLSI Design & Test: To teach design aspects using VHDL and verification techniques.

PE-VLSI-3: FPGA Based Design: This is a specialized course on FPGA based systems and their architecture.

PE-VLSI-4: Embedded Systems: To teach the aspects of embedded architecture, distributed embedded architecture networks and characteristics.

PE-VLSI-5: ASIC Design: This course introduces ASIC design, programmable ASIC logic cells, ASIC interconnects and ASIC design software.

Stream Outcomes:

Students who take 2 or more electives from this stream would be familiar with the principles and practical aspects of VLSI and would be competent enough to pursue career in semiconductor industries in design, development and testing of semiconductor integrated circuits.

PE-VLSI-1: Principles of VLSI

1. **MOSFET & CMOS Inverter : MOS transistor theory** – Ideal I-V & C-V characteristics – Non-ideal effects – DC transfer characteristics of CMOS inverter – Dynamic characteristics of CMOS inverter

2. **IC Manufacturing Process** : Manufacturing steps of CMOS ICs – Simplified process flows – Layout design rules – Trends in process technology – IC packaging

3. **Designing Combinational Logic Circuits** : Static CMOS design (complementary CMOS, Ratioed Logic, Pass-Transistor Logic) – Dynamic CMOS design (basic principles, speed / power dissipation, cascading dynamic gates) – Physical design of gates – Stick diagrams

4. **Circuit Characterization** : Circuit characterization & performance estimates – Delay estimates – Logical effort & transistor sizing – Power estimates – Interconnect – Design Margins - Reliability

5. **Designing Sequential Logic Circuits** : Sequencing static circuits – Design of latches & flip-flops – Max-delay & min-delay constraints – Clock skew

6. **Arithmetic Building Blocks & Memory Array Subsystems** : Datapaths in digital processor architectures – Adder/Subtractor, Multiplier, Shifter, Comparator, Counter, Division - Memory core (Static RAM, Dynamic RAM, Read only memory)

7. **Implementation Strategies for Digital ICs & Design Economics** : Custom circuit designs – Semicustom design flows – Standard cells – Compiles cells – Prediffused arrays – Prewired arrays – FPGAs – Cost estimates – Datasheets

References:

1. Neil H.E. Weste, David Harris & Ayan Banerjee, "CMOS VLSI DESIGN – A Circuits and Systems Perspective" 3rd Ed, Pearson Education / Dorling Kindersley (India) Pvt Ltd (2006)

2. Jan M. Rabaey, Ananth Chandrakasan & Borivoje Nikolic, "DIGITAL INTEGRATED CIRCUITS – A Design Perspective" 2nd Ed, PHI Learning Pvt. Ltd (2014)

***

PE-VLSI-2: VLSI Design & Test

1. **Verilog HDL** : Overview of digital design with Verilog – Hierarchical modeling concepts – Basic Verilog concepts – Data types – Modules and ports – Gate level modeling – Data flow modeling – Behavioral modeling – Test benches – Logic synthesis with Verilog

2. **Logic Design with Behavioral Models** : Behavioral models of combinational logic – Cyclic behavioral models of Flip-flops and Latches – Multiplexers, encoders, decoders –

Algorithmic state machines – design of counters, shift registers, register files – Datapath controllers

3. **Synthesis of Combinational and Sequential Logic** : Introduction to synthesis – Synthesis of combinational logic – Synthesis of sequential logic with latches, explicit state machines and register logic – Synthesis of implicit state machines, registers.
4. **Design Verification** : Functional verification – Verification techniques - Post-synthesis design validation – Static timing analysis – Timing specifications
5. **VLSI Testing & DFT** : Concepts of VLSI testing – Challenges in VLSI testing – Fault models – Levels of abstraction in VLSI testing - Testability analysis – DFT basics – Scan cell designs – Scan architectures – Scan design rules – Scan design flow
6. **Logic Testing** : Circuit defects and faults – Fault detection and testing – ATPG for combinational logic – Fault coverage and defect levels – Test generation for sequential logic – Fault collapsing – Fault simulations – Logic BIST
7. **Memory Testing** : RAM functional fault models (Dynamic faults, Functional test patterns and algorithms, March tests, Word oriented memory) – Memory Built In Self-Test

References:

1. Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL", PHI Learning Pvt Ltd (2013)
2. Samir Palnitkar, "Verilog HDL – A Guide to Digital Design and Synthesis" 2nd Ed, Dorling Kindersley (India) Pvt Ltd / Pearson Education (2013)
3. Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen, "VLSI Test Principles and Architectures", Reed Elsevier India Pvt Ltd (Elsevier) (2011)

***

PE-VLSI-3: FPGA Based Design

1. **FPGA-Based Systems** : Digital design and FPGA based system design – Techniques – Hierarchical design – Design abstraction – Methodologies
2. **FPGA Fabrics** : FPGA architectures – SRAM-Based FPGAs – Permanently programmed FPGAs – Chip IO – Circuit design of FPGA fabrics – Architecture of FPGA fabrics
3. **Combinational Logic** : The logic design process – Modeling with HDLs – Combinational delay, fanout, path delay – Power and energy optimization – Arithmetic logic – Logic implementation of FPGAs
4. **Sequential Logic** : Sequential machine design process – Sequential design styles – Rules for clocking – Performance analysis – Power optimization

5. **Architecture** : Behavioral design – Datapath-controller architecture – Design processes – Design standards – Design verification

6. **Large-scale Systems** : Busses – Protocols and specifications – Logic design for busses – Microprocessor and system busses

Reference:

1. Wayne Wolf, "FPGA-Based System Design", Dorling Kindersley (India) Pvt. Ltd / Pearson Education Inc (2009)

****

PE-VLSI-4: Embedded Systems

1. **Embedded Architecture:** Introduction, embedded computers, design process – requirements, specifications, architectural design,components, system integration, formalism for system design.
2. **Embedded Processor and Computing Platform:** ARM Processor, data operations, flow of control, SHARC Processor, memory organization, parallelism with instructions, bus configuration, memory devices, I/O devices, component interfacing.
3. **Networks :** Distributed embedded architecture, networks for embedded systems , CAN bus, Ethernet, Myrinet, Internet , communication analysis , performance Analysis, allocation and scheduling .
4. **Real Time Characteristics:** Clock driven approach , weighted round robin approach , dynamic versus static systems , release times and deadlines , earliest deadline first algorithm (EDF), scheduling
5. **System Design Techniques:** Design methodologies, requirement analysis, specification, System analysis and Architecture design , Quality Assurance, examples.

References:

1. Raj Kamal, "Embedded System: Architecture, Programming and Design" 6th ed., Tata McGraw-Hill (2003)

2. Furber, "Arm System-On-Chip Architecture", 2nd ed., Pearson Education India (2001)

****

PE-VLSI-5: ASIC Design

1. INTRODUCTION TO ASICS, CMOS LOGIC AND ASIC LIBRARY DESIGN

Types of ASICs - Design flow - CMOS transistors CMOS Design rules - Combinational Logic Cell - Sequential logic cell -Data path logic cell – Transistors as Resistors -Transistor Parasitic Capacitance- Logical effort - Library cell design - Library architecture.

2. PROGRAMMABLE ASICS, PROGRAMMABLE ASIC LOGIC CELLS AND PROGRAMMABLE ASIC I/O CELLS

Anti fuse - static RAM - EPROM and EEPROM technology - PREP benchmarks - Actel ACT - Xilinx LCA - Altera FLEX - Altera MAX DC & AC inputs and outputs - Clock & Power inputs - Xilinx I/O blocks.

3. **PROGRAMMABLE ASIC INTERCONNECT, PROGRAMMABLE ASIC DESIGN SOFTWARE AND LOW LEVEL DESIGN ENTRY**

Actel ACT -Xilinx LCA - Xilinx EPLD - Altera MAX 5000 and 7000 - Altera MAX 9000 - Altera FLEX - Design systems - Logic Synthesis - Half gate ASIC -Schematic entry - Low level design language - PLA tools - EDIF- CFI design representation.

4. **LOGIC SYNTHESIS, SIMULATION AND TESTING**

Verilog and logic synthesis -VHDL and logic synthesis - types of simulation -boundary scan test - fault simulation - automatic test pattern generation.

5. **ASIC CONSTRUCTION, FLOOR PLANNING, PLACEMENT AND ROUTING:**

System partition - FPGA partitioning - partitioning methods - floor planning - placement - physical design flow - global routing - detailed routing - special routing - circuit

References:

1. Lionel Bening and Harry D. Foster, "Principles of Verifiable RTL Design Second Edition - A Functional Coding Style Supporting Verification Processes in Verilog" 2nd ed., Springer (2001)
2. Application Specific Integrated Circuits (ASIC), Smith, Pearson Edication India 1997
3. Application Specific Integrated Circuits (ASIC), VLSI systems series, by Michael John Sebastian Smith, 1997

* * *

OPEN ELECTIVES (OE)

OE-1 Digital Image Processing 3 credits

Course Objectives:

The course will expose students to basic digital image processing and their applications to solve real life problems. Upon completion of this course, students will be familiar with basic image processing techniques for solving real problems.

Course Outcomes:

Student will also have sufficient expertise in both the theory of two-dimensional signal processing and its wide range of applications, for example, image restoration, image compression, and image analysis

Syllabus:

1. **Fundamental Steps in Digital Image Processing** - Components of an Image Processing System-Digital Image Fundamentals Image Sampling and Quantization-Representing Digital Images - Spatial an Gray-Level Resolution, Aliasing and Moire Patterns Zooming and Shrinking Digital Images- Some Basic Relationships Between Pixels - Linear and Nonlinear Operations-Image Enhancement in the Spatial Domain. Log Transformation-Power-Law Transformations – Piecewise - Linear Transformation Functions Histogram Processing-use of

Histogram Statistics for Image Enhancement – Foundation: Use of Second Derivatives for Enhancement: The Laplacian - Use of First Derivatives for Enhancement-The Gradient - Combining Spatial Enhancement Methods- Image Enhancement in the Frequency Domain- The One-Dimensional Fourier Transform and its Inverse -The Two-Dimensional DFT and Its Inverse - Filtering in the Frequency Domain - Butterworth Filters - Gaussian Filters - The Laplacian in the Frequency Domain –

Color Image Processing Color Fundamentals -Color Models -The RG13 Color Model - The CMY and CMYK Color Models -The HSI Color Model – Pseudocolor Image Processing.

Image Compression Fundamentals - Variable-Length Coding - LZW Coding - Bit-Plane Coding - Lossless Predictive Coding - Lossy Compression - Lossy Predictive Coding - Transform Coding -Wavelet Coding – Image Compression Standards – Jpeg- Mpeg-1 &2 standards-

Image Segmentation-Detection of Discontinuities Point Detection-Line Detection -Edge Detection -Edge Linking and Boundary Detection - Thresholding - Use of Boundary Characteristics for Histogram Improvement and Local Thresholding-Thresholds Based on Several Variables - Region-Based Segmentation - Basic Formulation- Region Growing- Region Splitting and Merging - Segmentation by Morphological Watersheds-Basic Concepts- Dam Construction - Watershed Segmentation Algorithm

References:

1. Image Processing, Analysis, and Machine Vision by M. Sonka, V. Hlavac, and R. Boyle, IIIrd Edn, Thomson Learning, 2008.
2. Digital Image Processing by Rafael. C. Gonazalez & Richard E. Woods. IInd Edn, Pearson Education, 2002.
3. Machine Vision : Theory, Algorithms, Practicalities by Davies, E.R, Academic Press, Latest edition
4. Fundamentals of Digital Image Processing by Anil. K. Jain, Eastern Economy Edn, Prentice Hall of India 1997.

***

OE-2: Introduction to Computer Design and Operating Systems: 3 credits

Course Objectives:
This course gives a general understanding of structure of modern computers and functions of operating systems

Course Outcomes:
Describe the general architecture of computers, describe, contrast and compare differing structures for operating systems , understand and analyze theory and implementation of: processes, resource control (concurrency etc.), physical and virtual memory, scheduling, I/O and files

Syllabus:

Computer Design: Basic structure of Computers. Machine Instructions and Programs. ARM, Motoral and Intel Instruction Sets. Input/Output Organization. The Memory System. Arithmetic. Basic Processing Unit. Pipelining. Embedded Systems.

OS Fundamentals: Operating System Services, Kernel Architecture, Processes, Structure of Process, Process Control, Process Scheduling and Time, Interprocess Synchronization, Interprocess Communication and Synchronization,
Memory Management Profiles, Virtual Memory, Swaping, File Management, Internal Representation of Files, File systems, Protection and Security.
Implementation: Input/Output – Principles and Programming. Design of a Kernel of a Multitasking OS (KMOS). Implementation of KMOS.
Case Study: Unix.

References:

1. Maurice J. Back, The Design Of the Unix Operating System, Prentice-Hall of India Private Limited (2006).
2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Computer Organization, Tata McGraw-Hill Education (2011).
3. Milan Milenkovic, Operating Systems, Tata McGraw-Hill Education (2001).

* * *

OE-3: Geospatial Information Systems 3 credits

Course Objectives:
The purpose of this course to introduce students to the fundamentals of Geospatial Information Systems (GIS) theory and technologies

Course Outcomes:
Create GIS and cartographic outputs for presentation and dissemination, Specialized knowledge and skills: Create mapping applications

Syllabus:

Geospatial Information Systems – Concepts
Cartographic Principles and Geo referencing
Spatial Data Structures, Spatial Data – sources (including Remote Sensing) and Manipulation
Geo-database concepts and management : Spatial Analysis
GIS Solutions for Communications, Agriculture, Transportation
Geospatial Information Modeling, Additional Applications of GIS- Energy Networks, Urban Infrastructure.

References:

1. Chang, “An Introduction to Geospatial Information Systems”, McGraw Hill (2009)

2. Ian Heywood, An Introduction to Geographic Information Systems – 2002, Prentice Hall, U.K.
3. George B. Korte, The GIS Book - Fifth Edition - 2005, Onword Press, New York
4. Wilpen L. Gorr, Kristen S. Kurland, Carnegie Mellon University, GIS Tutorial Workbook for Arc View 9 – 2005 (1 – 4) ESRI Press, Redlands, California, USA

***

OE-4: Introduction to Virtualization Technologies 3 credits

Course Objectives:
The purpose of this course to introduce students to the fundamentals of Virtualization technologies

Course Outcomes:
Gain understanding of Virtualization techniques, appreciate differences in hardware and software virtualization, work with Intel VT-x and AMD-V instructions and data structures for multi-processor and multi-core systems, understand memory virtualization and management.

Syllabus:

Introduction: Virtualization approaches, its uses and monetization, Processor virtualization theory – trap and emulate, Virtualization techniques – paravirtualization, full virtualization, ring aliasing and binary translation.

Hardware Technology: Intel VT-x instructions, operating modes, processor datastructures, MSRs, multi-processor and multi-core systems working with Intel VT-x. AMD-V instructions and datastructures. Virtualization of Interrupts – handling and performance. SMP guests and performance. Security features. Hardware and software virtualization differences.

Resource Virtualization: Memory virtualization and management – Intel extended page tables and AMD nested page tables. Device virtualization. Virtualized NICs. PCI Express IOV, Intel VT-d and AMD IOMMU solutions.
Case Study: VMWare, Microsoft, XEN, LXC, KVM.

References:

1. Sean Campbell, Michael Jeronimo, Applied Virtualization Technology - Usage Models for IT Professionals and Software Developers, Intel Press.
2. Tom Clark, Storage Virtualization: Technologies for Simplifying Data Storage and Management, Addison-Wesley Professional (2005).
3. Chris Wolf, Erick M. Halter, Virtualization: From the Desktop to the Enterprise, Apress (2005)

* * *

OE-5: Software Engineering 3 credits

Course Objectives:
The purpose of this course to introduce students to the conceptualization, design, testing and comparison of application specific softwares

Course Outcomes:

 Correctly create a model of the structure and behavior of a software system.
 Design and implement, in a programming language, an executable solution to a given problem using common software principles and best practices.
 Apply appropriate software testing techniques and evaluate the quality of a software product at module, integration, and system granularity levels.
 Select and adapt suitable elements from among conventional and evolving software development life-cycle processes and apply the resulting process to a software project.

Syllabus:

Introduction: The Problem Domain, S/W Engineering Challenges, S/W Engineering Approach. Software Processes: Software Process, Desired Characteristics, Development Process Models, Other Software Processes.

Software Requirements Analysis and Specification: Software Requirements, Problem Analysis, Requirements Specification, Functional Specification with Use Cases, Validation, metrics.

Planning a software project: Planning Process, Effort Estimation, Project Scheduling and Staffing, Software Configuratoin Management Plan, Quality Plan, Risk Management, Project Monitoring Plan.

Function oriented design: Design Principles, Module Level Concepts, Design Notation and Specification, Structured Design Methodology, Verification, Metrics.

Object oriented design:OO Analysis and Design, OO Concepts, Design Concepts, UML Design Methodology, Metrics. Detailed design: Detailed Design, PDL, Verification, Metrics.

Coding & Testing : Programming Principles and Guidelines, Coding Process, Refactoring, Verification, Metrics. Testing fundamentals, Black-box Testing, White-box Testing, Testing Process, Defect Analysis and Prevention.

References:
1. An Integrated Approach To Software Engineering by Pankaj Jalote, 3rd Ed., Narosa Publishing House, (2005).

***

OE-6: Reliability, Availability and Serviceability of Systems: 3 credits

Course Objectives:
The purpose of this course to introduce students to the concepts and understand Reliability, Availability, and Serviceability (RAS) principles

Course Outcomes:
- Understand the characteristics of hardware and software failure
- Learn need for different types of redundancy and techniques

- Be able to detect faults, and assess the damages
- Schedule tests and learn fault tolerance testing
- Understand architectures for highly reliable, available and serviceable systems

Syllabus:

Reliability, Availability and Serviceability basics – Hardware and Software Failure characteristics, Reliability Parameters, MTBF, FITS, MTTR, Availability, Downtime. Software and Hardware Redundancy types and techniques, fault coverage, computational integrity, fault detection methods fault identification algorithms, exception handling, damage assessment and fault confinement, system diagnostics, diagnosis algorithms, system recovery and distribution, reconfiguration techniques, repairable systems, algorithms based fault tolerance testing techniques, test scheduling, test pattern generation, fault injection testing, fault tolerant computer communication networks, fault tolerance of software. System Architectures for highly reliable, available and serviceable systems.

References:

1. Service Availability: Principles and Practices, Edited By Maria Toeroe and Francis Tam, OpenSAF.
2. Anderson, L., and Lee, P. A., Fault Tolerance, Principles and Practice, Prentice Hall, 1981.
3. Siework, C. P. and Swartz, R. S., Theory and Practice of Reliable System Design, Mc-Graw Hill, 1982.

* * *

OE-7: Microfluidics: Devices And Applications- 3 credits

Course Objectives:

The purpose of this course is to introduce students to the basics of microfluidics and applications.

Course Outcomes:

- Understand the need for various types of microfluidics technologies and their relative merits
- Understand the basic physics of microfluidic devices with specific reference to optofluidic devices and the related limitations
- Be able to design a microfluidic sensor for a specific application related to bio-medical / chemical sensing

Syllabus:

Introduction and General overview of Applications:
Microfluidics classification; Glass, Polymer and Paper based microfluidics their advantages and limitations.

Basic principles in microfluidics:
General principles of microfluidic flow, Design principles for microfluidic devices.

Device fabrication: Soft lithography, femtosecond laser processing, printing technologies

Optofluidic Device Applications: Biological, chemical and optical sensing applications, point-of-care diagnostics and drug discovery.

References:

1. Patric Tabeling, Introduction to Microfluidics, Oxford ,2005.
2. Frank A. Gomez (Editor), Biological Applications of Microfluidics, Wiley,2008
3. Roberto Osellame, Giulio Cerullo, Roberta Ramponi (Editors), Femtosecond laser micromachining, First Edition, Springer, 2012.
4. Sang-Joon John Lee, Narayan Sundararajan, Microfabrication for Microfluidics, Artech House, 2010.
5. Trung Nguyen and Stev, Fundamentals and Applications of Micro- fluidics,2nd Ed. Artech House; 2006.

* * *