M. TECH IN ELECTRONICS AND COMMUNICATION ENGINEERING WITH SPECIALIZATION IN OPTOELECTRONICS AND COMMUNICATION SYSTEMS
Proposed course structure in M. tech in electronics and communication engineering
with specialization in Optoelectronics and communication systems

**First semester**

<table>
<thead>
<tr>
<th>Course code</th>
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### LIST OF ELECTIVES

#### First semester

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#### Second semester

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Module 1
Discrete time signals: properties of discrete time system, difference equation representation, sampling and digitization, Z transform inverse Z transform, discrete FT and its properties, FFT, decimation in time and frequency.

Module 2
Two dimensional Z-transforms digital filters, IIR and FIR filters, design of IIR and FIR filters, Window function.

Module 3
Fresnel Transform, Hilbert, Radon and Mellin transforms, two dimensional Fourier transform, convolution and correlation, effect of lens on wave front, FT property of lens, OTF, time and space integrating architecture, spectrum analysis, Vanderlugt filter.

Module 4
Image spatial filtering, SLMs AO, MO, EO, and LC based SLMs, optical numerical processing, simple arithmetic, evaluation of polynomials, optical implementation of matrix vector multiplication, differentiation, integration, partial differential equations.

Module 5
Optical Neural Network, characterization of ANN, supervised and unsupervised learning, neuron as nonlinear element, associative memory and vector matrix multiplication, double and multilayer NN, Hopfield net, optical implementation of neural networks.

TEXT:
1. Digital Signal Processing- Alan V Oppenheim & Ronald W Schafer, (Pearson Education)
3. Optical Signal processing-Fundamentals- Das (Spinger-Verlag, 1991)

REFERENCE:
1. Digital Signal Processing-A computer based approach- Sanjit K Mitra (TMH, 2nd Ed.)
Module I
Optical waveguide, Basic Optical Laws – ray theory of transmission, acceptance angle, numerical aperture, EM theory of optical propagation, modes in planar waveguides, phase and group velocity, phase shift, evanescent field, Cylindrical fibers, step index fibers, graded index fibers, modes, mode coupling, single mode fibers, cut off wavelengths, spot size.

Module II
Transmission characteristics of optical fiber, attenuation, absorption losses, intrinsic absorption, linear scattering losses, nonlinear losses, optimum wavelength for fiber optical communication, fiber bend losses, power launching methods and losses.

Module III
Dispersion effects in optical fibers, material and wave guide dispersions, inter modal dispersion, modal noise, overall fiber dispersion in multi mode fibers and single mode fibers, modal birefringence, polarization maintaining fibers.

Module IV
Optical fiber measurements, attenuation, OTDR, loss measurements, dispersion bandwidth, refractive index profile, optical sources and their characteristics, mono mode fiber characteristics, testing of optical fiber systems, eye pattern technique.

Module V
Integrated optics: Fabrication of channel waveguides, electro optic waveguides, i/p o/p couplers, EO and MO modulators. Applications of integrated optics, Grating lenses, optical components, spectrum analyzers, ADC.

TEXT:

REFERENCE:
1. Fiber Optic Communication – D C Agarwal (S. Chand)
5. Integrated Optics- R G Husperger(Springer Verlag, 1991)
OEC 3103 OPTO ELECTRONICS

Module I
Nature of light, light sources- black body radiation, Units of light, Electronic properties of semiconductors: effect of temperature on band gap, density of carriers in intrinsic and extrinsic semiconductors, consequence of heavy doping, conduction process in semiconductors, electron-hole pair formation and recombination, PN junction, carrier recombination and diffusion, injection efficiency, heterojunction, internal quantum efficiency, double hetero junction, quantum well and super lattices.

Module II
Opto Electronic Modulators: Basic principles, Polarization, birefringence, Electro optic Modulators-electro optic effect, EO materials. Kerr modulators, scanning and switching, Magneto Optic Modulators-Faraday effect, Acousto Optic Modulators

Module III

Module IV
Display devices: Photoluminescence, cathodo luminescence, CRT, Electroluminescence, Injection luminescence and LED- drive circuitry, Plasma panel display, LCD displays-liquid crystals, properties, Numeric displays.

Module V
Optoelectronic detectors: thermal detectors, Photon devices- Photo emissive detectors, Photoconductive detectors, Photomultipliers (PMT), Image intensifiers, Photo diodes-PIN & APD, photo transistors, Design of detector arrays, CCD, Solar cells.

TEXT:

2. Optical fiber communication- J M Senior (Pearson, 2nd Ed)
3. Fiber Optics and Optoelectronics- R P Khare (Oxford University Press, 4th Ed)

REFERENCES:

5. Semiconductor Optoelectronic Devices- Pallab Bhattacharya (Prentice Hall; 2nd Ed, 2001)
OEC3104 LASER TECHNOLOGY

Module I
Radiative transitions and emission line widths, radiative decay of excited states of atoms, spontaneous emission, and collisional depopulation in atomic and molecular gases, emission broadening, homogeneous and inhomogeneous broadening, radiation and thermal equilibrium, Planck's law for cavity radiation. Absorption and stimulated emission, Einstein A and B coefficients, Conditions for producing laser action, absorption and gain of a homogeneously broadened radiative transition, gain coefficients and stimulated emission cross section for homogeneous and inhomogeneous broadening.

Module II
Necessary and sufficient condition for laser action (population inversion and saturation intensity), growth of gain medium with homogeneous and inhomogeneous broadening, threshold requirements for a laser with and without cavity, laser oscillation above threshold and saturation of laser gain, Principle of laser amplifiers, requirement to obtain population inversion, rate equation for three and four level system, pumping threshold requirements, pumping parameters associated with optical and particle pumping.

Module III
Laser cavity modes: Fabry perot cavity modes, longitudinal and transverse modes, mode characteristics, spectral and spatial hole burning, stability of laser resonator, stability diagram, optimization of output coupling, unstable resonators, ring cavity.

Module IV
Q switching-general theory, active and passive Q-switching techniques, mode locking-general theory, active and passive mode locking, mode locking by pulse broadening, tunable cavities, properties of laser beam, experimental techniques to characterize laser beam.

Module V
Laser systems - General description, laser structure, excitation mechanism and applications of following lasers. He-Ne, Argon ion, CO₂, excimer, nitrogen, X-ray, free electron, dye, Nd: Yag, Nd: glass, Alexanderite and Ti: sapphire lasers, diode pumped solid state laser, OPO laser.
TEXT:

2. Lasers - theory and application - Ghatak & Thyagarajan (Mcmillian, India, 2003)

REFERENCES

1. Laser Electronics - J T Vardeyan (Prentice Hall India, 1995)
5. Laser Physics - Tarasov (MIR Pub Moscow 1983)
6 Quantum Electronics - Amnon Yariv (John Wiley, 3rd Ed)

OEC3105 DIGITAL COMMUNICATION

Module 1
Random variables and random process: Review of probability theory, Random variables, conditional Probability, Discrete and Continuous random variables, Cumulative distribution function, Probability Density function, Conditional PDF, expected value and variance of random variables, joint random variables
Random process: stationary process and wide sense stationary process, mean, correlation and covariance functions, Ergodic process, transmission of random process through LTI filter, power Spectral Density, Gaussian process, Rayleigh and Rician distributions

Module 2
Signal space analysis: geometric representation of signals, Gram Schmit Orthogonalization Procedure, Conversation of continuous AWGN channel into a vector channel, Likelihood detection, coherent Detection of signals in noise, Probability of error, Minimum energy signals, Bit vs symbol error probabilities, Union bound on the Probability of error

Module 3
Sampling process: Quantization, Sampling theorem, Interpolation Formula, Quadrature sampling of band pass signals, Reconstruction of a message process from its samples, signal distortion in sampling, practical aspects, PAM, PPM, PWM(Generation &Reconstruction-block level treatment only),Multiplexing-TDM, FDM.
Waveform coding techniques: PCM, Channel noise & error probability, Quantization noise & Signal to noise ratio, robust quantization, DPCM, Delta modulation, ADPCM, Linear Prediction

Module 4
Digital modulation techniques: Digital modulation formats, coherent binary modulation techniques – PSK, FSK, QPSK, MSK, Non-coherent binary modulation techniques-DPSK. Comparison of binary & quaternary modulation techniques. M-ary mod techniques – PSK, QAM, FSK (Block level treatment only)
Base band data transmission: discrete PAM signals, Power spectra of discrete PAM signals, Matched filter, Intersymbol Interference, Nyquist’s criterion for distortion less base band transmission, Eye pattern, Optimum linear receiver adaptive equalization.

Module 5
Information theory & coding: Information theory: Information, entropy, Information Rate, Channel capacity, Mutual information, Channel coding theorem, Capacity of Gaussian channel, S/N-Bandwidth trade off, Information capacity theorem, Information of colored noise channels, Error control codes: discrete memory less channels, Linear block codes, cyclic codes, convolution codes

TEXT:

1. Digital communication, Simon Haykin, (John Wiley & Sons, 2005)

REFERENCES:

2. Digital Communications Fundamentals and applications, Bernard Sklar, (Pearson 2006)
5. Error correction coding mathematical Methods and algorithms, T K Moon (Wiley, 2005)
OEC3106 MODERN OPTICS

Module I
Electromagnetic Theory, Maxwell’s equations, energy density and momentum of electromagnetic field, Polarization, Stoke’s Parameters, Jones Vectors and matrices. Electromagnetic waves in conducting medium, Polarization by birefringence, Total internal reflection, evanescent waves.

Module II
Interference, Michelson’s Interferometer, Mach-Zender Interferometer, Free Spectral Range and Finesse. of Fabry-Perot Interferometer, Multi-layer interference coatings and interference filters.

Module III
Propagation of Optical beams, ray vector and ray matrices, lens wave guides, rays in lens-like media, guassian beam, ABCD law, guassian beam focusing, anisotropic media.

Module IV

Module V
Diffraction: Fresnel and Fraunhofer diffraction, circular and rectangular apertures, cornu’s spiral, Fresnel zones, spatial filters and apodisation.

TEXT:
1. Optics- E Hecht(Addison Wesley; 4 edition)

REFERENCE:
1. Quantum Electronics - Amnon Yariv (John Wiley, 3rd Ed)
5. Optics and Lasers - M Young (Springer Verlag 2nd Ed.)
MODULE 1
Internet Architecture: Architectural concepts in ISO’s OSI Layered model, layering in the internet, TCP/ICP protocol stack. Transport layer-TCP and UDP. Network layer- IP, routing, internetworking, data link layer-ARQ schemes, LANs

MODULE 2
Broadband services and QOS issues: Quality of Service issues in networks-Integrated service architecture-Queuing Disciplines-Weighted Fair queuing—random Early Detection-Differentiated Services-Protocol for QOS support-Resource reservation-RSVP-Multi protocol label switching-real Time transport protocol

MODULE 3
Introduction to Queuing theory: Markov chain-Discrete time and continuous time Markov chains-Poisson process-queuing models for data gram networks-Little theorem-M/M/1 queuing systems-M/M/m/m queuing models-M/G/1 queue-Mean value analysis

Module 4
Statistical Multiplexing in Communication Networks: Multiplexing: Network performance and source characterization, Stream session in packet networks-deterministic analysis, stochastic analysis, circuit multiplexed analysis, elastic transfer in plastic networks

Module 5
Optical fiber networks: Data buses, LAN systems, network configuration, FDDI network, SONET and SDH network, ISDN and BISDN, high speed networks, industrial network, public network applications

TEXT

REFERENCE
3. An Engineering approach to computer networking-S.Keshav(Addision Wesley 1st Ed,1997)
5. Introduction to Optical fiber communication-Suematsu and Iga,John Wiley,1982
Module I

Module II

Module III
Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio- sensing, biosensors based on fiber optics, planar waveguides, evanescent waves, interferometric and surface plasmon resonance. Flow cytometry: Basics, fluorochromes for flow cytometry, DNA analysis.

Module IV

Module V

TEXT:

1. Introduction to Bio- Photonics- V N Prasad(Wiley – Interscience April 2003)

REFERENCE:

1. A Handbook of Optical Biomedical Diagnostics, SPIE press monograph vol pm 107

OEC3202 OPTICAL COMMUNICATION TECHNOLOGY

Module 1

Module 2

Module 3

Module 4

Module 5

TEXT:

REFERENCES:

1. Introduction to Optical Fibre Communication – Suematsu and Iga, (John Wiley,1982)
5. Fiber Optic Communication Systems – D C Agarwal(S Chand).

OEC 3203 OPTICAL SENSOR TECHNOLOGY

Module 1
Light beam as a light sensing tool, simple optical sensors, single and double optic levers, measurement of small displacements, radius of curvature-lamp and scale arrangement, angle of rotation, speed of rotation, stroboscope, method of triangulation, projected fringe technique, lidar for atmospheric remote sensing, lidar equation

Module 2
Interferometry for precision measurements, two beam Interferometry. Michelson interferometer, fringe displacement and fringe counting, heterodyne interferometer, super heterodyne Interferometry, electron speckle pattern Interferometry photo elastic measurements, Moiré technique

Module 3
Optical fiber sensors; general features, types of OFS, intrinsic and extrinsic sensors, intrinsic sensors, shutter based multi mode OFS, simple fiber based sensors for displacement, temperature and pressure measurements, reflective FOS and applications, Fiber Bragg grating based sensors.

Module 4
Light transmission in micro bend fibers, microbend OFS, measurements with microbend sensors, evanescent wave phenomenon, evanescent wave FOS, chemical sensors using EWFOS, distributed sensing with FOS, OTDR and applications, FO smart sensing

Module 5
Interferometric FOS: basic principles, interferometric configurations, Mach-Zender, Michelson and Fabry-Perot configurations-components and construction of
interferometric FOS, applications of interferometric FOS, applications of interferometric FOS, Sagnac interferometer, fiber gyro, OTDR and applications.

TEXT:


REFERENCES:

2. Optics-Ajoy Ghatak(TMH,2008)

OEC3204 LASER BASED INSTRUMENTATION

Module 1
Holography and speckle interferometry: Theory of hologram, recording and reconstruction, recording media, types of holograms, application of holography to character recognition and NDT, theory and applications of speckle interferometry

Module 2
Lasers in chemistry: Schemes of laser isotope separation, laser induced chemical reactions, infrared photo chemistry, ultra fast processes, laser induced fusion

Module 3
Laser Doppler Velocimetry: Principle of operation, velocimeter as an interferometer, performance parameters-scale factor relative error, accuracy of the Doppler frequency, size of the sensing region, Alignment and positioning errors, direction discrimination, particle seeding, Electronic processing of the Doppler signal(Time domain and frequency domain)

Module 4
Industrial applications: Absorption of laser radiation by metals, semiconductors and insulators, laser drilling, welding, cutting and surface cleaning optical fiber splicing, laser deposition of thin films.

Module 5
Laser in medicine: Photodynamic therapy, Laser angioplasty, Laser in surgery, Laser tissue welding, Low power Laser therapy, Surface-Enhanced Raman scattering (SERS) for biomedical diagnostics
1. Electro-Optical instrumentation-Sensing and Measuring with Lasers, Silvano Donati, (Pearson)

REFERENCE:

1. Optical Interferometry-P Hariharan (Academic Press; 2nd Ed)
7. Laser Spectroscopy-Demtroder(Springer,2nd Ed)
9. Laser Handbook Vol 2 and 3- Arecchi(Ed) and M L stich (North Holland 1972,1985)

OEC3205 INTEGRATED OPTICS

MODULE I:
Advantages of integrated optics-comparison of optical integrated circuits (OIC) with electronic integrated circuits-substrate materials for OIC- Modes in planar waveguide structure- channel waveguides, strip loaded wave guides.

MODULE II:
Wave guide fabrication techniques - electro optic wave guides - Losses in optical waveguides - measurement of waveguide losses, waveguide input/output couplers, coupling between waveguides.

MODULE III:
Electro optic and acousto optic modulators - Direct modulation of semiconductor lasers - integrated optical detectors - depletion layer photodiodes, APD, PIN and MSM photodiodes - modification of spectral response of detectors.

MODULE IV:
Quantum well modulators, Quantum well detectors, SEED, Application of Integrated optics - RF spectrum analyser, ADC.
MODULE V:
IO optical disk readhead OIC temperature and voltage sensor, optoelectronic IC transmitter and receiver, Devices and systems for Telecommunications, Opto-microwave applications.

TEXT:
1. Integrated optics- Theory and Technology- R.G Hunsberger (Springer Verlag, 4th Ed, 1995)

REFERENCES
2. Elements of opto electronics and Fiber optics- (Ch 7) Chin-lin Chen (Irwin, 1996)
4. Guided wave opto electronics - (Ch 6) T Tamir (Editor Springer Verlag 1990)

OEC 3206 INDUSTRIAL PHOTONICS

Module 1:
Photons Technology: Passive components - couplers, isolators, terminators, attenuators, multiplexers and filters. Fused fiber components based on Biconical taper Technology, Star and tree couplers. Fiber delay lines, clip-on couplers, Fiber gratings. Mode conditioning patch cords, optical switches, WDM’s, arrayed wave guide gratings, lensed fibers, thermally expanded core fibers, polarization maintaining components. Active components: Media converters, Mode converters, Transponders, Optical Nodes, Regenerators, modulators, Optical Cross Connects, EDFA, Raman amplifiers

Module 2:
Modulation and Demodulation: Signal formats, direction detection, receivers, coherent detection, test beds-Lamdanets, STARNET, Rainbow, wavelength Routing network. Optical layer in network, node design, networking design and operation, Routing wavelength assignment .Wavelength routing test beds, AON, NTTR, ONTC, and MONET.

Module 3:
Module 4:
Control and management: Network management function configuration performance and fault Managements, channel health monitoring, dark and active fiber monitoring, Optical protection – effect of PDL and PMD on high speed optical networks, attacks on fiber networks, Intrusion detection and prevention techniques, Network test equipments – OTDR measurements

Module 5:
Reliability Concepts: Concepts on product reliability, Reliability of optical components, Thermal stability, factors affecting the reliability of fused fiber components, reliability tests and test setups, High power optical requirements, Effect of dirt on fiber endfaces, Reliability and Test standards in fiber optics
Packaging and Cabling concepts: basics of optical alignments, alignment stations, algorithms, epoxy bonding, epoxy dispensing systems, soldering, laser welding, glass soldering, packaging of fused fiber devices, micro optic based components, laser diode packaging, Integrated Optic components

TEXT:

2. Optoelectronic packaging - Nagesh R. Bassavanhally

REFERENCES:

4. Optical Fiber Communication – (3rd Ed) G. Keiser
5. Reliability of passive optical components. Telcordia G R -1209
OEC3207 ADVANCED OPTICAL COMMUNICATION

Module I:

Introduction to optical components- optical amplifier-types-issues in optical amplifiers-photonic switching-cross connect-wavelength conversion-multiplexer-demultiplexer-filters-tunable filters-introduction to OIC and its applications.

Module II:


Module III:

WDM technology introduction- WDM optical networking evolution- enabling technologies for WDM optical networks- WDM optical network architecture-DWDM – issues in WRN.

Module IV:

OTDM Technology-important issues in OTDM- optical solitons- application of solitons. Optical pulse compression - fiber grating compressor - soliton effect compressor.

Module V:

FTH and PON technology- proposed architectures and issues of fiber to home (FTH) – passive optical networks (PON) - near space communication- open air optical communication-Inter satellite link hops (ISI) - Introduction to all optical networks (AON).Military, civil consumer and industrial applications.

REFERENCES:

3. Optical Fiber Communications – G G Keiser (TMH , 4th Ed)