# Course Structure for M.Tech in Electronics with Specialization in Optoelectronics and Communication Systems

## First Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of Course</th>
<th>Int. Marks</th>
<th>Ext. Marks</th>
<th>Total Marks</th>
<th>Credits</th>
<th>Hrs/week</th>
<th>L</th>
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<tbody>
<tr>
<td>OEC3101</td>
<td>Digital &amp; Optical signal processing</td>
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**Electives**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of Course</th>
<th>Int. Marks</th>
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**Laboratory**

<table>
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<tr>
<th>Course Code</th>
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**Total Credits**: 18

## Second Semester

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<th>Course Code</th>
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<th>Int. Marks</th>
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**Total Credits**: 18
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### Fourth Semester

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### LIST OF ELECTIVES

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<th>Electives</th>
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#### Second semester

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

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

Module IV
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 V
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)

REFERENCE:
**OEC3102 FIBRE OPTICS**

**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 band width, 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 :**

2. Optical Fiber Communications - J M Senior (Pearson, 2nd Ed, 2006)

**REFERENCE:**

1. Fiber Optic Communication - D C Agarwal (S. Chand)
5. Integrated Optics - R G Husperger (Springer Verlag, 1991)
Module I
Nature of light, light sources- black body radiation, Units of light Electronic properties of semi
conductors: effect of temperature on band gap, density of carriers in intrinsic and extrinsic
semiconductors, consequence of heavy doping, conduction processes in semiconductors, electron-hole
pair formation and recombination, PN junction, carrier recombination and diffusion, injection
efficiency, heterojunction, internal quantum efficiency, double heterojunction, quantum well and super
lattices.

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

Module III
Opto electronic devices: LED-Materials, Power and efficiency, double hereostructure LED, LED
structures, performance characteristics. Laser: Basic concepts, Optical emission from semiconductors-
structures- gain guided lasers, index guided lasers, Distributed Feedback Lasers.

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, Photo conductive
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 coefficient 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 & 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 shortening, tunable cavities, properties of laser beam, experimental techniques to characterize laser beam.

Module V

TEXT:
2. Lasers-theory and application - Ghatak & Thyagarajan (Mcmillan,India,2003)
3. 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)
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


Module 2

**Signal space analysis:** Geometric Representation of signals, Gram Schmit Orthogonalization Procedure, Conversion 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 binary 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 tradeoff, Information capacity theorem, Information capacity of colored noise channels, Error control codes: discrete memory less channels, Linear block codes, cyclic codes,
convolution codes

TEXT:


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, gaussian beam, ABCD law, guassian beam focussing, anisotropic media.

Module IV

Module V
Diffraction: Fresnel and Fraunhoffer 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 I
**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 II
**Broadband services and QOS issues:** Quality of Service issues in networks- Integrated service architecture- Queuing Disciplines- Weighted Fair queuing- random Early Detection- Differentiated Services- Protocols for QOS support- Resource reservation – RSVP- Multi protocol label Switching- real Time transport protocol

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

Module IV
**Statistical Multiplexing in Communication Networks:** Multiplexing: Network performance and source characterization, Stream sessions in packet networks- deterministic analysis, stochastic analysis, circuit multiplexed networks, elastic transfers in packet networks

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

TEXT:

REFERENCES:
3. An Engineering approach to computer networking - S. Keshav (Addison Wesley 1st Ed, 1997)
5. Introduction to Optical fiber communication- Suematsu and Iga, John Wiley, 1982
Module I
Photobiology: Interaction of light with cells and tissues, photo-processes in Biopolymers, human eye and vision, photosynthesis. Photo-excitation: free space propagation, optical fiber delivery system, articulated arm delivery, hollow tube wave-guides. Optical coherence tomography, spectral and time-resolved imaging, fluorescence resonance energy transfer (FRET) imaging, nonlinear optical imaging

Module II

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

Module IV

Module V
Laser tweezers and laser scissors, design of laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, lasers for genomics and proteomics, semiconductor quantum dots for bio imaging, metallic nano-particles and nano-rods for bio-sensing. Photonics and biomaterials: Bacteria as bio-synthesizers for photonic polymers

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

REFERENCES:
1. A Handbook of Optical Biomedical Diagnostics, SPIE press monograph vol pm107
Module I

Module II

Module III

Module IV

Module V

TEXT:
2. Optical Fiber Communications - J M Senior (Pearson, 2nd 2006)

REFERENCES:
1. Introduction to Optical Fibre Communication - Suematsu and Iga, (John Wiley ,1982)
5. Fiber Optic Communication Systems - D C Agarwal (S Chand).
OEC3203 OPTICAL SENSOR TECHNOLOGY

Module I
Light beam as a sensing tool, simple optical sensors, single and double optic levers, measurements 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 II
Interferometry for precision measurements, two-beam interferometry, Michelson interferometer, fringe displacement and fringe counting, heterodyne interferometer, super heterodyne interferometry, electron speckle pattern interferometry photoelastic measurements, Moiré technique

Module III
Optical fibre sensors: general features, types of OFS, intrinsic and extrinsic sensors, intensity sensors, shutter based multimode OFS, simple fibre based sensors for displacement, temperature and pressure measurements- reflective FOS and applications, Fibre Bragg grating based sensors

Module IV
Light transmission in microbend fibres, 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 V
Interferometric FOS: basic principles, interferometric configurations, Mach-Zender, Michelson and Fabri-Perot configurations- components and construction of interferometric FOS, applications of interferometric FOS, Sagnac interferometer, fibre gyro, OTDR and applications.

TEXT:

REFERENCE:
1. Optics - Ajoy Ghatak, (TMH, 2008)
OEC3204 LASER BASED INSTRUMENTATION

Module I
**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 II
**Lasers in chemistry:** Schemes of laser isotope separation, laser induced chemical reactions, infrared photochemistry, ultra fast processes, laser induced fusion

Module III
**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 & frequency domain)

Module IV
**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 V
**Lasers in medicine:** Photodynamic therapy, Laser angioplasty, Lasers in surgery, Laser tissue welding, Low-power Laser therapy, Surface-Enhanced Raman scattering (SERS) for biomedical diagnostics.

TEXT:
1. Electro-Optical Instrumentation- Sensing and Measuring with Lasers, Silvano Donati, (Pearson)

REFERENCES:
1. Optical Interferometry - P Hariharan (Academic Press; 2nd Ed)
7. Laser Spectroscopy- Demtroder (Springer, 2nd Ed)
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:
Waveguide fabrication techniques- electro optic waveguides- Losses in optical waveguides- measurements 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, Applications 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 Hunsperger ( Springer Verlag, 4thEd,1995)

REFERENCES
2. Elements of opto electronics and Fiber optics- ( ch 7) Chin-Lin Chen ( Irwin, 1966)
4. Guided wave opto electronics- ( ch 6) T Tamir (Editor Springer Verlag 1990)
Module I

**Photonics Technology**: Passive components- couplers, isolators, circulators, 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 Patchcords, Optical switches, WDMs, arrayed waveguide gratings, lensed fibres, 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 II

**Modulation and demodulation**: Signals 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, MONET.

Module III

**Optical Networks**: Network architecture, HFC, FTTC, Optical Access Network Architecture, deployment considerations- upgrading the transmission capacity, SDM, TDM, WDM, OTDM, Multiplexing and demultiplexing, Synchronization, broadcast OTDM Network, OTDM testbeds, Application areas- interexchange, undersea, local exchange networks.

Module IV

**Control and Management**: Network management function, configuration, performance and fault managements, channel health monitoring, dark and active fibre 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 V

**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.

**Texts:**
2. Optoelectronic Packaging - Nagesh R. Bassavanhally

**References:**
4. Optical Fiber Communication- (G Keiser TMH,4th Ed)
5. Reliability of passive optical components: Telcordia G R- 1209
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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- applications 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:
1. Optical networks- A practical perspective- Rajiv Ramaswami and kumar N Sivarajan, (Morgan Kaufmann, 2nd 2001)
3. Optical Fiber Communications- G G Keiser (TMH, 4th Ed)
5. Optical Fiber Communications Principles and practice- John M. Senior PHI, 1992