

**M. Tech. in Communication Engineering(CE)**

Sl. No.	Semester			
	I	II	III	IV
1	CE710	CE713	CE891/ CE898	CE899
2	CE711	CE714	CE899	
3	CE712	CE715		
4	<i>Elective 1</i>	CE716		
5	<i>Elective 2</i>	<i>Elective 3</i>		
6		<i>Elective 4</i>		
7		CE890		

**Total Credit Distribution**

Category	Minimum Credits to be Earned for award of M.Tech. Degree
Core Courses	24
Elective Courses	12
Mandatory Learning Courses	04
Major Project	20
<b>Total</b>	<b>60</b>

**Mandatory Learning Courses**

CE890 Seminar	2
CE891/ CE898 Practical Training / Minor Project (to be completed during vacation between 2nd & 3rd sem.)	2

**Major Project**

CE899 Major Project (3 <sup>rd</sup> & 4 <sup>th</sup> sem.)	20
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**CE Core Courses**

CE710 Digital Modulation & Spread Spectrum Systems	(4-0-0) 4
CE711 Mathematical Foundations for Communication Engineering	(3-0-0) 3
CE712 RF Circuits & Systems	(4-0-0) 4
CE713 Light wave Communication	(4-0-0) 4
CE714 Detection & Estimation Theory	(4-0-0) 4
CE715 Communication Engineering Lab	(0-0-3) 2
CE716 Advanced Digital Signal Processing	(3-0-0) 3

**Elective Courses**

(At least 2 electives must be chosen from CE Electives)

**CE ELECTIVES**

CE800 Digital Signal Compression	(3-0-0) 3
CE801 Error Control Coding	(3-0-0) 3
CE802 Wireless Communications & Networks	(3-0-0) 3
CE803 Cryptography	(3-0-0) 3
CE804 Radar Signal Processing	(3-0-0) 3
CE805 Optical Networks	(3-0-0) 3
CE809 Image & Video processing	(3-0-0) 3
CE810 Speech & Audio processing	(3-0-0) 3
CE813 Multimedia Communications	(3-0-0) 3
CE814 MIMO Communication Systems	(3-0-0) 3
CE815 Information Theory	(3-0-0) 3
CE816 Computer Communication Networks	(3-0-0) 3
CE817 Advanced Antenna Theory	(3-0-0) 3
CE 818 Photonic Devices	(3-0-0) 3
CE 819 Active RF Devices and Circuits	(3-0-0) 3
CE820 Soft Computing	(3-0-0) 3
VL815 Digital Signal Processing Architectures	(3-0-0) 3

#### **CE710 Digital Modulation and Spread Spectrum Systems (4–0–0) 4**

Review of fundamental concepts and parameters in Digital Communications, Performance of Carrier modulation Schemes: Performance of BPSK and QPSK in AWGN channel, Performance of binary FSK and M-ary PSK in AWGN channel, Minimum Shift Keying (MSK) Modulation, GMSK, Continuous Phase Modulation(CPM) Schemes; Channel Characterization and Modeling: Optimum Receivers for AWGN channels, Equalization Techniques; Orthogonal Frequency Division Multiplexing (OFDM):Carrier Synchronization, Timing synchronization; Spread spectrum signals for digital communications: Introduction to Spread Spectrum Modulation, DSSS, FHSS, CDMA signals, Code Acquisition and Tracking, Spread Spectrum as a Multiple Access Technique; Multichannel and Multicarrier Systems; Digital Communications through Fading Multipath channels; Multi User Communications.

#### **References:**

1. *J. Proakis, Digital Communications, McGraw Hill, 2000*
2. *J. Viterbi and J. K. Omura, Principles of Digital Communications and Coding, McGraw Hill, 1979*
3. *Marvin K. Simon, Jim K Omura, Robert A. Scholtz, Barry K.Levit, Spread Spectrum Communications, 1995.*
4. *Andrew J Viterbi, CDMA Principles of Spread Spectrum Communications, Addison Wesley, 1995.*

#### **CE711 Mathematical Foundations for Communication Engineering (3–0–0)3**

Introduction to Probability and Stochastic Processes: Notion of multiple Discrete and Continuous Random Variables, Stochastic Processes, Sum of Random Variables, Statistical Inference, Gaussian Q-function, Marcum Q-function; Linear Equations, Matrices, Vector Spaces, Basis and Dimensions, Linear Mappings, Matrices and Linear operators, Determinants, Eigen values and Eigen vectors; Groups, Rings and Fields, Vector Spaces and Modulus, Field Theory, Algebraic extensions; Introduction to Queuing Theory and Number Theory

#### **References:**

1. *R D Yates, D J Goodman, Probability and Stochastic Processes, John Wiley and Sons, 1999*
2. *H. Stark, J.W Woods, Probability and Random Processes, Pearson Education, 2002*
3. *K. Huffman, R. Kunze, Linear Algebra, Prentice Hall of India, 1998*
4. *Bertasekas and R Gallagher, Data networks, PHI, 1989*

#### **CE712 RF Circuits and Systems (4–0–0) 4**

Review of Basic Transmission Line Theory, Planar Transmission Lines - Stripline, microstrip line, suspended stripline and coplanar line; Parallel coupled lines in stripline and microstrip – Analysis, design and characteristics. Microwave Network Analysis - Microwave network representation, Impedance and admittance matrices, Scattering parameters, Typical two-port, three port, four port networks; Impedance Matching Techniques - Smith chart, Matching networks using lumped elements, Single- and double-stub matching, Quarter wave transformer, Multi-section transformers -Binomial and Chebyshev. Basic Passive Components -Lumped elements in MIC, Discontinuities and resonators in microstrip, Balun. Analysis and design of stripline/microstrip components- Directional couplers, Power divider, Hybrid ring. Switches and Phase Shifters - PIN diode– Equivalent circuit and Characteristics, Basic series and shunt switches in microstrip; SPST and SPDT switches, Switched line, branchline coupled and loaded line phase shifters in microstrip. Applications in phased arrays. MIC Filters - Lumped element filter design at RF. Impedance and Low pass scaling, Frequency transformation, High impedance/Low impedance low pass filter, Parallel coupled band pass filter, Spur line band stop filter, Realization in microstrip and suspended stripline Basics of MIC, MMIC and MEMS technologies - Substrates used. Fabrication process. Relative advantages. Examples-Realization of lumped elements and filters in MMIC, Realization of planar transmission lines and filters in MEMS.

#### **References:**

1. *M.M. Radmanesh, Radio Frequency and Microwave Electronics, Pearson Education Asia, 2001.*

2. B. Bhat & S.K. Koul, *Stripline-like Transmission Line for Microwave Integrated Circuits*, New Age Intl. (P) Ltd., 1989.
3. D. K. Misra, *Radio Frequency and Microwave Communication Circuits – Analysis and Design*, John Wiley & Sons, 2001;
4. D. M. Pozar, *Microwave Engineering*, 2<sup>nd</sup> Edition, John Wiley & Sons, 1998.

#### **CE-713 Light Wave Communication (4–0–0) 4**

Importance of OFC; Light wave propagation in dielectric slab waveguides, Ray Theory, Numerical aperture, SI and GI waveguides, channel waveguides. Optical fibers: Types, fabrication techniques, attenuation, dispersion, Modes in SI and GI, DSF, DFF, PM fibers, plastic fibers, fiber bundles, connectors, couplers, power splitters etc. Optical Sources and detectors: Review of PN junction diodes, LEDs, Laser Diodes, Noise sources; Photo-detectors: PIN and APD design, Noise characteristics, Modulation of LEDs/LDs, drive circuits for LDs & PDs., high speed operation. OFC Systems: Simple networks and their analysis, BER calculations, WDM principle and techniques. Optical TDM etc, long haul DWDM. EDFAs and their applications to OFC. Optical Fiber Sensors. Coherent detection in OFC

##### **References:**

1. G.P. Agarwal, *Fiber Optic Communication Systems*, John Wiley 1997
2. Senior J., *Optical fiber communications, Principles & Practice*, PHI, 1992
3. Keiser G., *Optical fiber communications*, McGraw-Hill, 1999
4. A Selvarajan, S.Kar, T Srinivas, *Optical Fiber Communications*, TMH, 2002
5. William B. Jones, *Introduction to optical fiber communication systems*, OUP, 1998

#### **CE714 Detection and Estimation Theory(4–0–0) 4**

Hypothesis Testing, Neyman Pearson Lemma, UMP test, Decision Theoretic framework, Multiple-Decision Problem. Parameter Estimation - Unbiasedness, Consistency, asymptotic normality, sufficient statistics, minimax estimation, decision theoretic framework, Rao-Blackwell theorem, Cramer – Rao inequality. Estimation: Minimum mean square linear estimation, Wiener filter, Kalman filter, Levinson – Durbin and innovation algorithms.

##### **References:**

1. H. L. Van Trees *Detection, Estimation and Modulation Theory, Part I*, John Wiley, 1968.
2. Srinath, Rajasekaran and Viswanathan, *Introduction to Statistical Signal Processing with applications*, PHI, 1995.
3. Steven M. Kay, *Fundamentals of Statistical Signal Processing, Vol. I: Estimation Theory, Vol. II: Detection Theory*, Prentice Hall International, 1993
4. Papoulis A., *Probability Random Variables and Stochastic Processes*, McGraw Hill, 2002
5. H. Stark and J. W Woods, *Probability and Random Processes with applications to signal processing*, Pearson Education, 2002.

#### **CE 715 Communication Engineering Laboratory (0-0-3) 2**

Experiments should be based on the Core and Elective courses offered in the program.

#### **CE 716 Advanced Digital Signal Processing (3-0-0) 3**

2-D signals and systems, Analysis of 2D systems in spatial, frequency and transform domains; Short time Fourier Transform; Multirate Signal Processing: Decimation Interpolation, DFT filter banks, QMF filter banks, Multiresolution Signal analysis wavelets theory of sub band decompositions, Sub band coding and wavelet transforms, Application of wavelet transforms. Power spectral estimation; Higher order spectral estimation; Adaptive filters and applications. Recursive estimation and Kalman filters.

##### **References:**

1. P.P. Vaidyanathan, *Multirate systems and Filter banks*, Prentice Hall, 1993.

2. *S.J. Orfanidis, Optimum Signal Processing, McGraw Hill, 1989.*
3. *S. Haykin, Adaptive Filter Theory, Pearson, 1996*

### **CE800 Digital Signal Compression (3–0–0) 3**

Data Compression. Speech & image waveform characterization. Predictive coding. Transform coding. Subband coding, VQ based compression, Fractal coding of images. High quality video & audio compression for digital broadcasting. Standards for digital signal compression-data, speech, audio, image & video.

#### **References:**

1. *D. Salomon, Data Compression – the complete reference, Springer, 2000.*
2. *K. Sayood, Introduction to Data Compression, Pearson Education, 2000.*
3. *M.Nelson, The data compression book, BPB Publications, 2002.*
4. *Jayant & Noll, Digital coding of waveforms-Principles and applications to speech & video, PH, 1984.*
5. *Zi Nian Li, Fundamentals of Multimedia, Pearson Education, 2003.*

### **CE801 Error Control Coding (3–0–0) 3**

Coding for reliable digital transmission and storage. Groups, Rings, Vector Spaces, Galois Fields, Polynomial rings, Channel models, Linear Block codes, Cyclic codes, BCH codes, Reed Solomon Codes, Berlekamp-Massey and Euclid decoding algorithm, Decoding beyond the minimum distance parameter, Applications of Reed-Solomon codes, Convolutional codes, Decoding algorithms for Convolutional codes, Viterbi, Stack and Fano algorithms, Application of Convolutional codes. Codes based on the Fourier Transform, Algorithms based on the Fourier Transform, Trellis coded modulation, Combinatorial description of Block and Convolutional codes, Algorithms for the construction of minimal and tail biting trellises, Soft decision decoding algorithms, Iterative decoding algorithms, Turbo-decoding, Two-way algorithm, LDPC codes, Use of LDPC codes in digital video broadcasting, belief propagation (BP) algorithms, Space-Time codes.

#### **References:**

1. *Shu Lin and Danicl J. Costello Jr., Error Control Coding: Fundamentals and Applications, Prentice Hall, 2003.*
2. *S. B Wicker, Error Control Systems for Digital Communication and Storage, Prentice Hall International, 1995.*
3. *Blahut R. E, Theory and Practise of Error Control Codes, Addison Wesley, 1983.*
4. *Blahut R.E., Algebraic codes for Data transmission, Cambridge University Press, 2003.*
5. *Johannesson R and Zigangirov K.S ,Fundamentals of Convolutional codes, IEEE press, 1999.*
6. *V. S Pless and W. C Huffman, A. Vardy, Trellis structure of codes, Chapter 24 of Handbook of Coding Theory.*

### **CE802 Wireless Communications & Networks (3–0–0) 3**

Radio Propagation Characteristics: Models for path loss, shadowing and multipath fading (delay spread, coherence band width, coherence time, Doppler spread), Jakes channel model, Digital modulation for mobile radio, analysis under fading channels: diversity techniques and RAKE demodulator, channel coding techniques, multiple access techniques used in wireless mobile communications. Space time propagation, wireless channel, channel as a space time random field, space time channel and signal models, capacity of space time channels, spatial diversity, space time receivers, space time coding with channel knowledge, space time OFDM. Wireless networks – WLAN, Bluetooth. Suitable mini-projects in the areas of Space-Time codes and OFDM. The cellular concept: Frequency reuse: The basic theory of hexagonal cell layout: Spectrum efficiency, FDM / TDM cellular systems: Channel allocation schemes, Handover analysis, Erland capacity comparison of FDM / TDM systems and cellular CDMA. Discussion of GSM and CDMA cellular standards, Signaling and call control: Mobility management, location tracking. Wireless data networking, packet error modeling on fading channels, performance analysis of link and transport layer protocols over wireless channels: mobile data networking (Mobile IP): wireless data in GSM, IS - 95 and GPRS.

**References:**

1. *J.G. Proakis, Digital Communication, McGraw Hill, 2000.*
2. *G.L. Stuber, Principles of Mobile Communications, Kluwer Academic, 1996.*
3. *T.S. Rappaport, Wireless Communications: Principles and Practice, Prentice Hall, 2002.*
4. *Kumar, D. Manjunath and J. Kuri, Communication Networking, an Analytical Approach, Elsever, 2004*
5. *Paulraj, R. Nabar & D. Gore, Introduction to Space Time Wireless Communications, Cambridge University Press, 2003*
6. *C Sivarama Murthy and B S Manoj, Ad-Hoc Wireless Networks, Architectures and Protocols, PH, 2004.*

**CE803 Cryptography (3-0-0) 3**

Elementary Number Theory, Finite series, Arithmetic and Algebraic Algorithms, Secrete key and Public key Cryptography, Pseudo Random bit generators, Block and Stream Ciphers, Hash functions and Message digests, Public key encryption, Authentication, Digital Signatures, Zero Knowledge Interactive Protocols, Elliptic curve cryptosystems, formal verification, Crypt analysis, Hard Problems.

**References:**

1. *Koblitz N., A Course on Number Theory and Cryptography, Springer Verlag, 1986.*
2. *Menezes A. et. all, Handbook of Applied Cryptography, CRC Press, 1996*

**CE804 Radar Signal Processing (3-0-0) 3**

Radar and its composite environment, Review of Radar range performance computations, Detection Processes, Sequential and adaptive processes, Atmospheric effects, Sea and land Back scatter, Signal Processing concepts and waveform designs MTI & CW radars, phase coding techniques, FM pulse compression waveforms, Mateorogical radar and system performance analysis.

**References:**

1. *R.J Sullivan, Radar Foundations for imaging and Advanced Concepts, PMI, 2004.*
2. *F.E Nathanson, Radar Design Principles, Signal Processing and The Environment, PMI, 2004.*
3. *J.C. Toomay, Principles of radar, PMI, 2004.*

**CE805 Optical Networks (3-0-0) 3**

Introduction to Optical Networks, Propagation of Signals in an optical fiber, Optical Components, Modulation and demodulation, Transmission system engineering, client layer of the optical layer, WDM network Elements, WDM network designing, DWDM networks

**References:**

1. *R. Ramaswami and K.N. Sivarajan, Optical Networks, A Practical Perspective, Harcourt Asia Pvt. Ltd., 2000.*

**CE809 Image & Video processing (3-0-0) 3**

Digital image fundamentals – image acquisition, representation, visual perception, quality measures, sampling and quantization, basic relationship between pixels, imaging geometry, color spaces, Video spaces, analog and digital video interfaces, video standards. Two dimensional systems – properties, analysis in spatial, frequency and transform domains. Image transforms - DFT, DCT, Sine, Hadamard, Haar, Slant, KL transform, Wavelet transform. Image enhancement – point processing, spatial filtering, Image restoration – inverse filtering, de-blurring Video processing – display enhancement, video mixing, video scaling, scan rate conversion, Image compression – lossless and lossy compression techniques, standards for image compression – JPEG, JPEG2000. Video compression – motion estimation, intra and interframe prediction, perceptual coding, standards - MPEG, H.264

Image segmentation – feature extraction, region oriented segmentation, descriptors, morphology, Image recognition

**References:**

- 1 R. C. Gonzalez and R E Woods, *Digital Image Processing*, Pearson Education, 2002
- 2 A K Jain, *Fundamentals of Digital Image Processing*, Pearson Education, 1989
- 3 W Pratt, *Digital Image Processing*, Wiley, 2001
- 4 Al Bovik, *Handbook of Image and Video*, Academic Press, 2000
- 5 Keith Jack, *Video Demystified*, LLH, 2001

**CE810 Speech & Audio processing (3 – 0 – 0 ) 3**

Speech Production – human speech production mechanism, acoustic theory of speech production, digital models for speech production. Speech perception – human hearing, auditory psychophysics, JND, pitch perception, auditory masking, models for speech perception. Speech Analysis – Time and frequency domain analysis of speech, speech parameter estimation, Linear prediction. Speech compression – quality measures, waveform coding, source coders, Speech compression standards for personal communication systems. Audio processing – characteristics of audio signals, sampling, Audio compression techniques, Standards for audio compression in multimedia applications, MPEG audio encoding and decoding, audio databases and applications. Speech synthesis – text to speech synthesis, letter to sound rules, syntactic analysis, timing and pitch segmental analysis. Speech recognition – Segmental feature extraction, DTW, HMMs, approaches for speaker, speech and language recognition and verification

**References:**

- 1 Douglas O'Shaughnessy, *Speech Communication – Human and Machine*, IEEE Press, 2000
- 2 L R Rabiner, *Digital Processing of Speech Signals*, Pearson, 1978
- 3 T.F Quatieri, *Discrete-time speech signal processing: Principles and Practise* Pearson, 2002
- 4 Zi Nian Li, *Fundamentals of Multimedia*, Pearson Education, 2003

**CE813 Multimedia Communications (3-0-0) 3**

Representation of Multimedia Data, Concept of Non-Temporal and Temporal Media, Basic Characteristics of Non-Temporal Media, Images, Graphics, Text, Basic Characteristics of Temporal Media, Video, Audio, Animation, Basics of Morphing, Hypertext and Hypermedia, Multimedia Presentations, Synchronization. Compression of Multimedia Data, Basic concepts of Compression, Still Image Compression JPEG Compression, Natural Video Compression, MPEG-1&2 Compression Schemes, MPEG-4 Video Compression, Audio Compression Introduction to Speech and Audio Compression, MP3 Compression Scheme, Management of Coded Data, Stream management in MPEG-4, BIFS, DMIF Multimedia System Design, General Purpose Architecture for Multimedia Processing, Operating System Support for Multimedia, Data, Resource Scheduling with real-time considerations, File System, I/O Device Management, Delivery of Multimedia data, Network and Transport Protocols, QoS issues, RTP and RSVP, Video-conferencing and video-conferencing standards, Overview of Voice over IP, Multimedia Information Management, Multimedia Data base Design, Content Based Information Retrieval, Image Retrieval, Video Retrieval, Overview of MPEG-7.

**References :**

1. Ralt Steinmetz and Klara Nahrstedt, *Multimedia : Computing, Communication & Applications*, Pearson Education Publications, 2004.

**CE814 MIMO Communication Systems (3-0-0) 3**

Overview of fundamentals of Digital Communications, The Wireless Channel, Detection, Diversity and Channel Uncertainty, Capacity of Wireless channels, Spatial Multiplexing and Channel modeling, Capacity and Multiplexing architectures, Diversity-Multiplexing tradeoff and Universal Space Time Codes, Multi-user Communication.

**References:**

1. David Tse, Pramod Viswanath, *Fundamentals of Wireless Communications*, Cambridge University Press, 2005.
2. E. Biglieri, *Coding for Wireless Channels*, Springer, 2007
3. E. Biglieri et al., *MIMO Wireless Communications*, Cambridge University Press, 2007.

**CE 815 Information Theory (3-0-0) 3**

Entropy, Relative Entropy and Mutual Information, Asymptotic Equipartition Property, Entropy rate of a stochastic process, Data Compression, Channel Capacity, Differential Entropy, Gaussian Channel, Rate Distortion Theory, Information Theory and Statistics, Network Information Theory.

**References:**

1. T. M Cover and Joy A Thomas, *Elements of Information Theory*, John Wiley 2006.
2. R.E Blahut, *Principles and Practice of Information Theory*, Addison Wesley, 1987.

**CE816 Computer Communication Networks (3-0-0) 3**

Overview of OSI and TCP/IP models; TCP/IP Networks: The TCP/IP Architecture, The Internet Protocol, IPv6, User Datagram Protocol, Transmission Control Protocol, Internet Routing Protocols, Multicast Routing, DHCP and Mobile IP, Internet Routing protocols, Multicast Routing; ISDN and ATM Networks: Overview of ISDN (ISDN Channels, User Access, ISDN protocols, Broadband ISDN), BISDN Reference Model, ATM Layer, ATM adaptation Layer, ATM Signaling, PNNI Routing; Network Security and distributed applications: Security requirements and attacks, Encryption, authentication, digital signatures, Ipv4 and Ipv6 security, ASN.1, SNMP, SMTP, MIME, HTTP; Advanced Network Architectures/Protocols: IP forwarding Architectures, Overlay Model, MPLS, Integrated services in the Internet, RSVP, Differentiated Services, Real-Time Transport Protocol, Session Control Protocols; Queuing models, Little's Theorem, Markov chains – M/M/1, M/M/m, infinite server and m server loss systems, M/G/1, priority queuing, Networks of Queues Multiple Access Communication, Random Access Protocols. Scheduling: Stochastic Analysis: Stochastic traffic models, performance measures, Little's theorem, Brumelle's Theorem and applications, multiplexer analysis with stationary and Ergodic traffic, multi loop networks.

**References:**

1. Leon Garcia and Widjaja., *Communication Networks*, Tata McGraw-Hill, 2003
2. Stallings W. *Data and Computer Communications*. PHI, 2003
3. Kumar, D. Manjunath and J. Kuri. *Communication networking, An analytical approach*, Elsevier, 2004.
4. J.F. Hayes, *Modelling and analysis of Computer Communications Networks*, Plenum, 1984.
5. Bertsekas and Gallager, *Data Networks*, PH, 1992

**CE 817 Advanced Antenna Theory (3-0-0)3**

Planar Antennas - Microstrip rectangular and circular patch antennas- Analysis and design, Feeding methods; Circularly polarized microstrip antennas, Broadbanding techniques. Printed slot antennas. Array Theory – Linear array; Broadside and end fire arrays; Self and mutual impedance of between linear elements, grating lobe considerations. Planar array- Array factor, beamwidth, directivity. Example of microstrip patch arrays and feed networks. Electronic scanning. Broadband Antennas- Folded dipole, Sleeve dipole, Biconical antenna- Analysis, characteristics, matching techniques. Yagi array of linear elements and printed version, Log-periodic dipole array. Frequency Independent Antennas- Planar spiral antenna, Log periodic dipole array. Aperture Antennas- Field equivalence principle, Babinet's principle. Rectangular waveguide horn antenna, Parabolic reflector antenna. Antennas for mobile communication - Handset antennas, Base station antennas. Beam steering and antennas for MIMO applications. Active and smart microstrip antennas, Design and analysis of microstrip antenna arrays.

**References:**

1. C. A. Balanis, *Antenna Theory and Design*, John Wiley & Sons, 1997.

2. *J.D. Kraus, Antennas, McGraw-Hill, 1988.*
3. *R.A. Sainati, CAD of Microstrip Antennas for Wireless Applications, Artech House, 1996.*
4. *R. Garg, P. Bharhia, I. Bahl, and A. Ittipiboo, Microstrip Antenna design Handbook, Artech House.*
5. *J. R. James, P.S. Hall and C.Wood, Microstrip Antennas: Theory & Design, Peter Peregrinns , UK*

### **CE 818 Photonic Devices (3-0-0) 3**

Importance of optical/photonic devices and OEICs, Thin film or channel waveguides and their fabrication techniques; Electro-optic modulation; Acousto-optic modulation; Magneto-optic modulation. Optical processes in semiconductors: e-h pair formation and recombination; Franz-Keldish & Stark effect; Quantum well structures. LEDs and LDs: Structure, device performance, modulation Characteristics, drive circuits. Photo-detectors: pin & APDs(review); noise and sensitivity. High speed operation. Modulation and switching of LDs: SEEDs, Electro-optic modulators, QW modulators, Bistable devices. OEICs: fabrication, some specific OEICs(integrated LD, modulators, transmitter) Amplifiers: Semiconductor amplifiers, EDFA

#### **References:**

1. *Pallab Bhattacharyya, Semiconductor OE devices, PHI, 1995*
2. *A.K.Ghatak and K.Thyagarajan, Optical Electronics, Cambridge University Press, 1989*
3. *B. E. A. Saleh, M. C. Teich, Fundamentals of photonics, Wiley Inter science, 1991.*
4. *J. Singh, Optoelectronics: An introduction to materials & devices, McGraw Hill, 1996.*
5. *J. Wilson & J. F. B. Hawkes, Optoelectronics: An introduction, Prentice Hall India, 1992.*

### **CE 819 Active RF Devices and Circuits (3-0-0) 3**

Transistor Amplifiers - Types of amplifiers. S- parameter characterization of transistors; MESFETs - Equivalent circuit model. Single stage amplifier design- unilateral and bilateral cases, Amplifier stability, Constant gain and noise circles, DC bias circuits for amplifiers; Detectors and Mixers - Point contact and Schottky barrier diodes- Characteristics and equivalent circuit, Theory of microwave detection, Detector circuit design. Types of mixers. Mixer theory and characteristics. SSB versus DSB mixers. Single-ended mixer and single-balanced mixer- Design and realization in microstrip. Double balanced and image rejection mixers; Oscillators - Oscillator versus amplifier design, Oscillation conditions; Gunn diode – Modes of operation, Equivalent circuit. Design of Gunn diode oscillator in microstrip. FET oscillators. Frequency tuning techniques. Switches and Phase Shifters - PIN diode- Equivalent circuit and Characteristics, Basic series and shunt switches in microstrip; SPST and SPDT switches, Switched line, branchline coupled and loaded line phase shifters in microstrip. Applications in phased arrays. Oscillators - Oscillator versus amplifier design, Oscillation conditions. Gunn diode – Modes of operation, Equivalent circuit. Design of Gunn diode oscillator in microstrip. FET oscillators. Frequency tuning techniques.

#### **References:**

1. *D. K. Misra, Radio Frequency and Microwave Communication Circuits – Analysis and Design, John Wiley, 2004.*
2. *G. Gonzalez, Microwave Transistor Amplifiers – Analysis and Design, Prentice Hall, 1997.*
3. *D. M. Pozar, Microwave Engineering, John Wiley, 1998.*
4. *S.K. Koul and B. Bhat, Microwave and Millimeter Wave Phase Shifters, Vol.II- Semiconductor and Delay Line Phase Shifters, Artech House, 1991*
5. *G.D. Vendelin, A.M. Pavo and U.L. Rhode, Microwave Circuit Design using Linear and Non-linear Techniques, 1990.*

### **CE820 Soft Computing (3–0–0) 3**

Introduction to learning systems - Feed forward Neural Networks - Perception - Multilayer Perception Propagation algorithm and its variants - Improving generalization by various methods. Recurrent Neural Networks Hopfield net Boltzmann machine and Mean field learning solving combinatorial optimization problems using recurrent Neural Networks. Unsupervised Neural Networks. Competitive

learning Self-organizing maps Growing cell structures Principal component analysis. Basics of fuzzy sets. Genetic algorithms: Population based search techniques, evolutionary strategies, mathematical foundations of genetic algorithms, search operators, genetic algorithms in function and combinational optimization, hybrid algorithms, application to pattern recognition

**References:**

1. *S. Haykin, Neural Networks: A comprehensive foundation, Pearson, 1999*
2. *J. M. Zurada, Introduction to artificial neural networks, Jaico publishing, 1997.*
3. *B. Yejanarayana, Artificial Neural Networks, PHI, 1999*
4. *C. Mohan and S. Ranka, Neural networks, Benram publications, 2004.*