DELHI TECHNOLOGICAL UNIVERSITY
SCHEME OF TEACHING & EVALUATION
MASTER OF TECHNOLOGY IN MICROWAVE & OPTICAL COMMUNICATION (MOC)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN

XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
    C – credit of the course (4/3/2),
    MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	MOC501	Advance Electromagnetic Theory	Core	4	3	0	2	15	25	20	40	-	**17**
	2	MOC503	Optical Communication Systems	Core	4	3	0	2	15	25	20	40	-	
Group B	3	MOC5401/5403/…………	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	MOC5301/5303/…………	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	MOC5201/5203/…………/ UEC5201/5203/…………	Elective 3/University Elective I	Elective	2	2/0	0	0/4	20/0	0/40	30/0	50/0	0/60	

Semester-II

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	MOC502	Digital Microwave Engineering	Core	4	3	0	2	15	25	20	40	-	**17**
	2	MOC504	Optical Networks	Core	4	3	0	2	15	25	20	40	-	
Group D	3	MOC5402/5404/…………	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	MOC5302/5304/…………	Elective 5	Elective	3	3	0	0	20	-	30	50	-	

S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
5	MOC5202/5204/…………/ UEC5202/5204/…………	Elective 6/University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Track 1														**12**
Group E	1	MOC651	Research Project	Core	12	0	0	12	0	-	0	100	-	
	Track 2													
	1	MOC601	Major Project I	Core	3						40	60		
	2	MOC6401/6403/…………	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	MOC6301/6303/…………	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	MOC6201/6203/…………	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	**Track 1**													**12**
	1	MOC652	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	MOC602	Major Project II	Core	12						40	60		

List of Elective Courses

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	MOC5401	Advanced Microwave Devices & Circuits	Elective	4	3	0	2	15	25	20	40	-
	2	MOC5403	Photonic switching & Networks		4	3	0	2	15	25	20	40	-
	3	MOC5405	Wireless Communications		4	3	0	2	15	25	20	40	-
	4	MOC5407	Optics & Lasers		4	3	0	2	15	25	20	40	-
	5	MOC5409	Quantum Computing		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	MOC5301	Communication Networks	Elective	3	3	0	0	20	-	30	50	-
	2	MOC5303	RF Microwave & Millimeter circuits		3	3	0	0	20	-	30	50	-
	3	MOC5305	Nano photonics &Plasmonics		3	3	0	0	20	-	30	50	-
	4	MOC5307	Optical Electronics		3	3	0	0	20	-	30	50	-
	5	MOC5309	Soft Computing in Microwave Engineering		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	MOC5201	SEMINAR	Elective	2	0	0	2	-	100	-	-	-
	2	MOC5203	Optical Interconnects		2	2	0	0	20	-	30	50	-
	3	MOC5205	Radar Engineering		2	2	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	4	MOC5207	Information Theory		2	2	0	0	20	-	30	50	-
	5	MOC5209	Language Lab		2	0	0	4	-	40	-	-	60

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	MOC5402	Antenna Design	Elective	4	3	0	2	15	25	20	40	-
	2	MOC5404	Communication Protocol Design		4	3	0	2	15	25	20	40	-
	3	MOC5406	Optoelectronic Devices and Circuits		4	3	0	2	15	25	20	40	-
	4	MOC5408	Optical Sensors		4	3	0	2	15	25	20	40	-
	5	MOC5410	Satellite Communications		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	MOC5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60
	2	MOC5304	Numerical Techniques in Electromagnetics		3	3	0	0	20	-	30	50	-
	3	MOC5306	EMI/EMC		3	3	0	0	20	-	30	50	-
	4	MOC5308	Radar Signal Processing		3	3	0	0	20	-	30	50	-
	5	MOC5310	Radiating Systems in RF Communications		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	MOC5202	Photo voltaics	Elective	2	2	0	0	20	-	30	50	-
	2	MOC5204	Bio-Photonics		2	2	0	0	20	-	30	50	-
	3	MOC5206	MIMO Wireless Communication		2	2	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	MOC6401	Smart Antenna	Elective	4	3	0	2	15	25	20	40	-
	2	MOC6403	Fiber optic Components		4	3	0	2	15	25	20	40	-
	3	MOC6405	Wireless Optical Communication		4	3	0	2	15	25	20	40	-
	4	MOC6407	Biological Effects of Electromagnetic Fields		4	3	0	2	15	25	20	40	-
	5	MOC6409	Broadband Communication Systems		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	1	MOC6301	Statistical Mathematics		**3**	3	0	0	20	-	30	50	-
Elective 8	2	MOC6303	Integrated Optics	Elective	3	3	0	0	20	-	30	50	-
	3	MOC6305	Quantum Electronics		3	3	0	0	20	-	30	50	-
	4	MOC6307	Optical Computing		3	3	0	0	20	-	30	50	-
	5	MOC6309	Optical Signal Processing		3	3	0	0	20	-	30	50	-
	6	MOC6311	Spread Spectrum Communication		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	MOC6201	Wireless Sensor Networks	Elective	2	2	0	0	20	-	30	50	-
	2	MOC6203	Special Topics on Optical Communications		2	2	0	0	20	-	30	50	-
	3	MOC6205	Special Topics on Microwave communication		2	2	0	0	20	-	30	50	-
	4	MOC6207	Neuromorphic Engineering		2	2	0	0	20	-	30	50	-

Semester I
Courses

MOC501   Advanced Electromagnetic Theory
 	
Review of Maxwell equations; Concepts of Source, Duality, Uniqueness & Image theorem, Equivalence principle, Induction Theorem, Green's Function; Green's reciprocity theorem; Radiation from simple sources and apertures, Antenna Theory, Receiving antennas and various types of Antennas, Antenna pattern synthesis; Tensor, Diadic, Integral Equation, Cylindrical and Spherical Wave Function; Inhomogeneous Field Waveguides, Discontinuity and Excitation of waveguides, Periodic structure, Floquet's Theorem, Integral Transform.
 	
Reference Books:
  1. Electromagnetic wave theory for boundary-value problems: an advanced course on analytical methods by Hyo J. Eom, 1 ed, Springer 2004
  2. Electromagnetic Wave Theory for Boundary-Value Problems: An Advanced Course on Analytical Methods [1 ed.]
    By Professor Hyo J. Eom, Springer-Verlag Berlin Heidelberg 2004

MOC503   Optical Communication Systems
 	
Introduction to communication; review of optical sources, fibers and Detectors; Optical signaling scheme viz. IM, PL, PCM, PCM/PL, digital PPM, PRM etc. video signal; Electro-optic modulator; Various receive configurations-direct detection, Homodyne and heterodyne; Noise source in optical communication-model noise, speckle noise, shot noise, phase noise thermal noise etc. ; Direct detection receiver- analog and digital; optimum gain in APD; Signal-to-noise ratio (SNR) calculation; optimization of SNR; MDP and NEP; photon counter, receiver limits; Optical pre -amplifier design; digital hierarchy; optical line coding schemes; Performance evaluation of optical receiver for various modulation and demodulation schemes and their comparative study; Review of various optical amplifiers and SNR calculation for different applications of optical amplifier in the system; Optical fiber link design – power budget, time budget and maximum link length calculation; hybrid fiber co-axial/microwave links; fiber-in-the loop (FITL) FTTH.
 	
Reference Books:
  1. Keiser, G. (2003). Optical fiber communications. *Wiley Encyclopedia of Telecommunications*.
  2. Senior, J. M. (2004). Optical fiber communications: principles and practice.
  3. Agrawal, G. P. (2012). *Fiber-optic communication systems*. John Wiley & Sons.
  4. Ghatak, A., & Thyagarajan, K. (1998). *An introduction to fiber optics*. Cambridge university press.

MOC5401   Advanced Microwave Devices & Circuits

Impedance Matching with Reactive Elements and Lumped Elements, Design of Complex Impedance Terminations, Transformers :Quarter-Wave, Binomial, Chebyshev, Tapered Transmission Lines : Exponential Taper, Taper with Triangular Distribution, Power Dividers and Couplers with odd-even mode analysis, Modelling of MEMS devices (Static and Dynamic analysis), MEMS switch circuits (Design, Reliability, Power Handling), MEMS varactors, tunable oscillators and reconfigurable subsystems, Phase Noise Analysis EBG structures: Introduction and numerical methods, Hypothesis and Floquet Bloch Transform with Decomposition of Initial Problem, Theory Analysis and Application of artificial ground plane, Metamaterials such as ENG, MNG, DNG, Homogenization of structured materials and modeling, Transmission lines media with negative refractive index, CRLH transmission, Metamaterials Couplers and Resonators, Designing of electromagnetic compatibility, Cabling, Grounding, Balancing and Filtering, Passive and Active devices noise, Digital Circuit Radiation, Pre-compliance Measurements' Test procedures and cautions.

Reference Books:

1. Liao, S.Y. / Microwave Devices & Circuits; PHI, 2003
2. Collin, R.E. Foundations for Microwave Engineering; TMH, 2000
3. Advance Microwave Circuits and systems, Edited by Vitaliy Zhuerbanko, Technical University of Denmark, Denmark
4. Advanced Microwave and Millimeter Wave Technologies, Edited By Moumita Mukherjee, University of Calcutta, India

MOC5403   Photonic Switching & Networks

Photonic Switching: Switching architectures, Single and Multistage switching, Space switching, Time switching, Combinations of space and Time switching; Interconnection networks: Crossbar, shuffle/Omega, Benes, Close networks and their realizations, Multi wavelength switching systems, free space interconnections; Photonic networks: Introduction to computer data networks, Fiber optic LAN architecture and protocols, Ring, Star and Bus architectures, Fiber distributed data interface (FDDI): I & II, Distributed queen dual bus (DQDB); High speed bus protocol- RATO Net, Wavelength Division Multiplexed Networks

Reference Books:

1. Mukherjee, B. (2006). *Optical WDM networks*. Springer Science & Business Media.
2. Ramaswami, R., Sivarajan, K., & Sasaki, G. (2009). *Optical networks: a practical perspective*. Morgan Kaufmann.

MOC5405   Wireless Communications

Radio Propagation characteristics: models for path loss, shadowing and multipath fading (delay spread, coherence bandwidth , coherence time, Doppler Spread) Jakes channel model ; Spread spectrum Communication and multiple access techniques in mobile wireless communication: FDMA/TDMA, CDMA; The cellular concept : frequency re-use , theory of hexagonal cell layout , Spectrum efficiency, FDMA/TDMA, CDMA, cellular system, soft capacity, Erlang capacity, GSM standards, signaling and call control, mobility management; Wireless data networking, packet array

modeling on fading channels, performance analysis, links and transport layer protocols over wireless channels, mobile data network, wireless data in GSM,IS95 and GPRS.

Reference Books:

1. Wireless Communication Principle and Practices by Rappaport, Pearson
2. Wireless and personal Communication Systems by VK Garg and JE Wilkes; Prentice Hall
3. Wireless Communications by Andrea Goldsmith

MOC5407   Optics & Lasers

Geometric Optics: Refractive Index, Reflection and Refraction, Huygen's Principle, Fermat's Principle, Snell's law, Total Internal Reflection. Polarization. Wave Optics: Fresnel and Fraunhoffer Diffraction. Diffraction Grating, Interference (Double Slit and Multiple Slit), Introduction to Laser Physics: fundamentals and working principles of Gas Lasers, and p-n junction LASERS.

Reference Books:

1. Ghatak, A. *Optics*, Tata McGraw Hill, 4th edition.
2. Hecht, E. (1998). Optics, ed. *MA: Addison-Wesley Publishing Company*.

MOC5409   Quantum Computing

Basis of quantum computing, Quantum bits, Bloch sphere, Representation of a qubit, Hilber Space, Probabilities, entanglement, quantum mechanics, single and multiple Qubit gates, Design and analysis of quantum circuits, Quantum information theory, Quantum cryptography, quantum algorithms, graph states and codes, quantum error correction

Reference Books:

1. Mandel, L., & Wolf, E. (1995). Optical coherence and quantum optics. Cambridge university press.
2. Agarwal, G. S. (2012). Quantum optics. Cambridge University Press.

MOC5301   Communication Networks

OSI model, TCP/IP, UDP/IP, IPv6, and Internet applications, Markov systems, Queueing models, traffic modeling, Little's theorem, Jackson networks, flow control, routing, channel access, and cyclic redundancy checks, Wireless networks, packet radio networks, Bluetooth, GSM, IS-95, 802.11, and HiperLAN. 3G, 4G, 5G, mesh networks, ad hoc networks, sensor networks

Reference Books:

1. Communication Networks: Fundamental Concepts and key Architectures" by Alberto Leon Garcia, Indra Widjaja; TMH, 2007

2. TCP/IP Protocol Suite", 2nd Ed., by B. A. Forouzan; TMH, 2004

MOC5303   RF Microwave & Millimeter Circuits

DC and low frequency Circuit Concepts; RF Electronic Concepts; RF amplifier design and analysis; RF Oscillator design and analysis; RF/Microwave frequency conversion: Rectifier and detector design, Mixer design; Control circuit design; Analysis of planar circuits: Sample and arbitrary, Derivation Circuits characteristics; Equivalence of multi-pole planar circuits; Short boundary planar circuits, Segmentation method, Optimum planar circuits, Different types of planar transmission and their characteristics: Micro structured lines, stripe, slot, coplanar, inverted and suspended micro strip lines; Comparisons of various MIC lines; Discontinuity analysis and Equivalence circuits; Fin lines, Fin guide, H – guide, Arrow guide and surface waveguide.

Reference Books:
1. Microwave and Millimeter Wave Circuits and Systems: Engineering Design, Technologies and Applications by Apostolos Georgiadis, Hendrik Rogier, Luca Roselli, Paolo Arcioni, Wiley
2. RF Circuit Design (English, Paperback, Bowick Christopher)
3. Advanced Microwave and Millimeter Wave Technologies: Semiconductor Devices, Circuits and Systems by Moumita Mukherjee 2010

MOC5305   Nano Photonics & Plasmonics

Ray Optics, Wave Optics, Beam Optics, Review of Electromagnetic (EM) Theory, Ring Resonators, Disc Resonators; Numerical Modelling, Surface Plasmon Resonance, Localized Surface Plasmon Resonance, Photonic waveguides, Coupling conditions: Otto and Kretchmann Configuration, Grating coupling, Nanofabrication

Reference Books:
1. Maier, S. A. (2007). *Plasmonics: fundamentals and applications*. Springer Science & Business Media.
2. Novotny, L., & Hecht, B. (2012). *Principles of nano-optics*. Cambridge university press.

MOC5307   Optical Electronics

Wave propagation in Anisotropic media; Electro-Optic Effect: Phase and Amplitude modulators; Electro-Optic Effect: A.O. modulators, detectors and tunable filters; Nonlinear Optics: SHG, sum & Difference frequency generation, phase conjugation, SRS & SBS, SPM, Solitons; Non-linear effects in Optical fibers.

Reference Books:
1. Yariv, A. (1991). *Optical electronics*. Saunders College Publications
2. Ghatak, A. K., & Thyagarajan, K. (1989). *Optical electronics*. Cambridge University Press.

MOC5309   Soft Computing in Microwave Engineering

Neural Networks: History, overview of biological Neuro-system, Mathematical Models of Neurons, ANN architecture, Learning rules, Learning Paradigms- Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms-perceptions, Training rules, Adaptive Resonance Theory: Architecture, classifications, Implementation and training. Associative Memory, Introduction to Fuzzy Logic, Classical and Fuzzy Sets, Operations on Fuzzy Sets, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations, Classical Logic, Multi valued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges. Uncertainty based Information, Non-specificity of Fuzzy & Crisp Sets, Fuzziness of Fuzzy Sets. Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks, Rough Fuzzy Sets. Application of Fuzzy Logic: Medicine, Economics. Genetic Algorithm Implementation of GA Neuro-Genetic training of Backpropagation, Design and development of certain scientific and commercial application using computational neural network models, fuzzy models, fuzzy clustering applications and genetic algorithms in specified applications

Reference Books:

1. S. Rajasekaran and G.A.Vijaylakshmi Pai.. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India, 2004
2. K.H.Lee.. First Course on Fuzzy Theory and Applications, Springer Verlag, 2004.
3. S.N.Sivanandam, S.N.Deepa "Principles of Soft Computing" Second Edition, Wiley Publication.

MOC5209   Language Lab

Organs of Speech, Speech Sounds, Phonetic symbols, Place of Articulation, Manner of Articulation, Stress, Syllable, Transcription of words and, short Sentences, Voiced and Voiceless Sounds Dialogues- Principles and Characteristics, Mock Interviews - Do's and Don'ts, Group Discussion - Truth Taking Strategy, Presentations and Debates - Essentials of Oral Presentations, Nature of Basic Topics, Rules.

Reference Books:

1. J.D O'Connor, Better English Pronunciation, Cambridge University
2. Peter Roach, English Phonetivs and Phonology: A Practical Course, Cambridge University
3. Meenakshi Raman and Sangeeta Sharma, Technical Communication: Principles and Practice, OUP: Delhi

MOC5203   Optical Interconnects

State-of-the-art progress in optical interconnects, Incorporation of optical communication links into computing systems, Components for optical transmitters and receivers (VCSELs, DFB Lasers, etc.), electronic techniques to boost bandwidths, approaches to electronic-photonic integration, link budgets and impediments, single-mode vs. multi-mode fibre links, and optically-enabled system architectures, challenges and opportunities of optical interconnect

technologies.

Reference Books:

1. Kawai, S. (2005). *Handbook of optical interconnects*. CRC Press.
2. Pavesi, L., & Guillot, G. (2006). Optical interconnects. *Springer series in optical sciences*, *119*.

MOC5205   Radar Engineering

Introduction to Radar, Radar Band Designations, Detection of Signals in Noise, SNR< Probabilities of Detection and False Alarms, Antenna Parameters and Signal Losses, Types of Radars, Pulse and CW Radars, Doppler Radar and MTI, Monopulse Tracking, Radar Signals and Clutter, Statistical Model for Surface Clutter, Detection of targets in Clutter, Devices and Radar Systems, Applications such as ESM, ECM, ECCM, IFM, and system design examples

Reference Books:

1. Introduction to Radar Systems, by Merrill I. Skolnik; Tata McGraw-Hill (3rd Edition) 2003
2. Radar Principles, by Peyton Z Peeble; John Wiley 2004

MOC5207   Information Theory

Review of Probability Theory, Information Measures such as entropy, divergence and mutual information, Szego's Theorem, lossless data compression, Slepian-Wolf Problem, Ergodic Sources, Birkhoff-Khintchine Theorem, Lempel-Ziv Optimality, Binary hypothesis testing, Channel Coding, Asymptotics, Gaussian channels, coding with feedback, Huffman coding, block codes and convolutional codes, Asymptotic equi-partition property, Scalar quantization and Panter-Dite approximation, vector quantization and rate distortion , Multi-user information theory

Reference Books:

1. Digital and Analog communication systems, K. Sam Shanmugam, John Wiley, 1996
2. Digital communication, Simon Haykin, John Wiley, 2003

Seminar

Courses
MOC502   Digital Microwave Engineering
Transmission systems environment; Statistical method in digital transmission systems; Digital modulation methods;

Microwave amplifier; System gain, M-array, PSK and QAM microwave system; Correlative techniques & application to Digital Radio system design; Diversity and Protection techniques, fading techniques, digital microwave communication equipments, Digital microwave networks and its applications, Microwave propagation and its anti-fading technologies, Designing Microwave Transmission Links.

Reference Books:

1. Digital Microwave Communication by George Kizer, John Wiley and Sons
2. Microwave Transmission Networks: Planning, Design, and Deployment Second Edition by Harvey Lehpamer, McGraw Hill

MOC504   Optical Networks

Need for optical networks, multiplexing techniques, Fundamentals of supporting technology: LASERS, LEDs, Photodiodes, Fiber loss, Dispersion. Types of optical networks, Network components: Multiplexers, Filters, Amplifiers, switches and wavelength converters. Optical Networks: SONET/SDH: Architecture, Network Topologies, Protection schemes, WDM, DWDM, Network Management and Access Networks, Photonic Packet Switching

Reference Books:

1. Mukherjee, B. (2006). *Optical WDM networks*. Springer Science & Business Media.
2. Lam, C. F. (Ed.). (2011). *Passive optical networks: principles and practice*. Elsevier.

MOC5402   Antenna Design

Fundamental parameters of Antennas; Radiation integrals and potential functions; Wire Antennas, loop antennas design and analysis of Arrays; Broadband Dipole and matching techniques; Frequency independent antennas and antenna miniaturization; Aperture antenna, Horn, Micro-strip, Reflector, Lenses, Antenna Measurements.

Reference Books:

1. Antennas: For All Applications - Kraus, John D&, Ronald J Mashefka - Tata McGraw Hill, 3rd Edition,1999
2. Antenna theory: Analysis and Design by Constantine A. Balanis, Wiley, 3rd Edition, 2005
3. Antenna Theory and Design by Stutzman, thiele
4. Antenna Theory and Design by Robert.S Elliott, Wiley IEEE Press, Revised Edition

MOC5404   Communication Protocol Design

Network Models and Architectures, Protocol Design Issues, Transmission, Multiplexing and Switching, Protocol Layering and Protocol Framework, Link Level Protocols, IETF,LAN Protocols, LAN Design and Implementation, Ethernet Switching, Wireless Networks, 802.11, IP Design, Internet Addressing, Internetworking & Routing,

VLANs,IPv6 Protocol Design, IPv6 Addressing, Transport Layer Protocol Design, TCP and UDP,TCP Congestion Control, Connection Management, Network Address Translation (NAT), Application Layer Protocols Domain Name System (DNS)

Reference Books:

1. Principles of Protocol Design by Robin Sharp Springer, 2008th Edition
2. Design and validation of computer protocols by Gerard J. Holzmann
3. Communication Protocol Engineering, Pallapa Venkataram And Sunilkumar S. Manvi

MOC5406   Optoelectronic Devices and Circuits

Laser theory, Rate equations, Gain saturation, threshold; Condition, mode selection, Q-switching, Mode locking; Review of semiconductor physics: energy bands electron and holes, density of states, Fermi level, p-n junction; Homo- and hetero- junctions, Quantum wells, Semiconductor materials; LEDs and LDs: Device structure and characteristics; DFB, DBR and Quantum well lasers; Circuit design for LD transmitters and PIN receivers, OTDR and Optical spectrum analyzer

Reference Books:

1. P. Bhattacharya, *Semiconductor Optoelectronic Devices*, Prentice Hall of India (1997).
2. B. E. A. Saleh and M. C. Teich, *Fundamentals of Photonics*, John Wiley & Sons, Inc., 2nd Ed. (2007)

MOC5408   Optical Sensors

Principles of Optical Sensing, Absorption and Fluorescence spectroscopy, Distributed Scattering based optical sensing, Dielectric waveguides, Micro-cantilevers, Quantum dot sensors, Multifunctional sensor devices: Lab-on-chip, OTDR, LIDAR, and other recent optical sensor systems.

Reference Books:

1. Haus, J. (2010). *Optical sensors: basics and applications*. John Wiley & Sons.
2. Krohn, D. A., MacDougall, T., & Mendez, A. (2014). *Fiber optic sensors: fundamentals and applications*. Bellingham, WA: Spie Press.

MOC5410   Satellite Communication

Introduction to communication using satellites; Keplers laws and Orbital Mechanics; Satellite Launching; Propagation Characteristics, Frequency Spectra and bands; Satellite sub-systems; Design of satellite links and link equations; Earth station technology, Multiple access techniques; Applications of GEO, MEO, LEO and V-SATS, Mobile Satellite Communication.

Reference Books:

1. Satellite Communication, Dennis Roddy, McGraw Hill
2. Satellite Communication Systems, Richharia M. Macmillan Press

MOC5304   Numerical Techniques in Electromagnetics

Finite difference Method; Finite Segment Method; Integral equations; TLM method; Moment method; Ritz Galrkin's method; Method of lines; Spectral domain techniques; Mode matching method; Generalized scattering matrix, Transverse resonance; Practicals on development of programs using above mentioned methods.

Reference Books:

1. Numerical Techniques in Electromagnetics with MATLAB, Third Edition by Matthew N.O. Sadiku
2. Numerical and Asymptotic Techniques in Electromagnetics by R. Mittra (auth.), Professor Raj Mittra (eds.)

MOC5306   EMI/EMC

Importance of EMI/EMC, EMC rules and regulation: Different regulations, importance of considering EMC at design level of different components and systems; EMC requirement for electronic systems: Radiated emission Conducted emission Radiated susceptibility , conducted susceptibility Electrostatic discharge , Design Constraints, Advantage of EMC design , antennas for EMC; Signal spectra, Non Ideal behavior of components Cross talk there conductor lines and cross talk , Shielded wires , twisted wires , shielding, grounding , System design for EMC, Printed circuit board design including details on LISN, Spectrum Analyzer, Anechoic Chamber etc.

Reference Books:

1. Prasad Kodali.V – Engineering Electromagnetic Compatibility – S.Chand&Co. 2000
2. Clayton R.Paul – Introduction to Electromagnetic compatibility – Wiley & Sons 1992

MOC5308   Radar Signal Processing

Angle-of-Arrival Estimation in the Presence of Multipath, Spectrum Estimation Background, Thomson's Multi-Taper Method, Spectrum Estimation Procedures, Multi-taper Spectrum Estimation, F-Test for the Line Components, Low-

Angle Tracking Radar Study, Non stationary Behaviour and Time–Frequency Analysis, High-Resolution Multi-taper Spectrograms, Statistical Nature of Sea Clutter: Classical Approach, Hybrid AM/FM Model of Sea Clutter, Modelling Sea Clutter, Influence of Long Waves, Statistical Data Analyses, Modulation of Long Waves, Non-stationary AR Model, Parametric Analysis of Texture Process, Bayesian Direct Filtering Procedure, Operational Details, Correlation Anomally Detection Strategy

Reference Books:

1. Adaptive Radar Signal Processing by Haykin, Simon, Wiley- Interscience, 2007\
2. Signal Processing in Radar Systems by Vyacheslav Tuzlukov, CRC Press
3. Fundamentals of Radar Signal Processing, by Mark A. Richards Second Edition McGraw-Hill Education

MOC5310   Radiating Systems in RF Communications

Basics of Radiation, Antenna parameters, radiation mechanism, review of dipole and loop antennas, microstrip antennas, radiation from apertures, field equivalence principle, aperture fields of horn antenna, reflector antennas, yagi-uda and log-periodic antennas, antenna arrays, phased arrays, optimization of array patterns, antenna synthesis techniques, antenna design and measurement of antenna parameters

Reference Books:

1. Foundations of Antenna Theory and Techniques by Vincent Fusco, Prentice Hall 1st edition, 2005
2. Antenna Theory: Analysis and Design by Balanis. C.A., 2nd edition 1996

MOC5302   Minor Project

MOC5202   Photo Voltaics

Solid state device physics, p-n and p-i-n junctions, Homojunctions and heterojunctions. Basics of absorption and recombination process, Photovoltaic efficiency, Thin film fabrication processes for photovoltaics, Silicon-based solar cells, III-V and chalcogenide-based solar cells, Organic and Inorganic solar cells.

Reference Books:
1. Mertens, K. (2018). *Photovoltaics: fundamentals, technology, and practice*. John Wiley & Sons.
2. Green, M. A. (2006). Third generation photovoltaics.

MOC5204   Bio-Photonics

Basics of light interaction with biological material, optical sources and photodetectors in biology, optical spectroscopy and its applications in biology, Photobiology, optical imaging, and other emerging biophotonic technologies

Reference Books:
1. Keiser, G. (2016). *Biophotonics*. Springer, Singapore.
2. Pavesi, L., & Fauchet, P. M. (Eds.). (2008). *Biophotonics*. Springer Science & Business Media.

MOC5206   MIMO Wireless Communication

Introduction to wireless communication systems, wireless fading channel models, channel estimation for MIMO systems, information theory basics for MIMO systems, capacity limit of MIMO systems, diversity performance, multi-user MIMO, space-time coding, introduction to massive MIMO wireless systems, spectral efficiency with imperfect CSI, signal processing for 5G Massive MIMO Wireless systems.

Reference Books:

1. MIMO System Technology for Wireless Communications by George Tsoulos, Taylor and Francis
2. Fundamentals of MIMO wireless Communications by Rakesh Singh Kshetrimayum
3. Foundations of MIMO Communication by Robert W.Heath JR. Angel Lozano

Courses
Research Work

MOC6401   Smart Antenna

Review of Antenna Theory and various types of antennas; Basic array theory and pattern synthesis techniques, Electromagnetic vectors Sensors, with forming applications; Spatial diversity for wireless communication direction of arrival estimation in mobile communication; Blind channel identification and source separation in free space division Multiple access techniques, Smart antennas , system architecture; Phased array technology for wireless systems, Adaptive antennas for global systems for mobile Communication and TDMA systems.

Reference Books:

1. Smart Antenna Engineering by Ahmed El-Zooghby, Artech House Publishers 2005
2. Smart Antenna Systems and Wireless LANs by Garret T. Okamoto, W. J. Nicholson

MOC6403   Fiber Optic Components

Fundamentals of Fiber Optics, Transmission characteristics of optical fibers: Attenuation and Dispersion, Modulation and Multiplexing, Fiber Optic Components: Splicers, Couplers, Isolators, Multiplexers, Demultiplexers, Switches, Wavelength Converters, Polarization Controllers. Fiber Bragg Gratings: Fabrication and Application, Long Period Gratings, Optical Fiber Amplifiers, EDFAs

Reference Books:
1. Agrawal, G. P. (2012). *Fiber-optic communication systems*(Vol. 222). John Wiley & Sons.
2. Chang, K. (Ed.). (1991). *Handbook of Microwave and Optical Components, Fiber and Electro-Optical Components* (Vol. 4). Wiley-Interscience.

MOC6405   Wireless Optical Communication

EM Wave Propagation in free space, Fundamentals of Free Space Optics, Transceivers employed for FSO, Factors affecting performance of FSO, Long Distance FSO Communication, Modulation techniques, Optical Components for FSO waveguides, filters, couplers, amplifiers, switches and antennas, Optical signal processing for FSO Systems

Reference Books:
1. Hranilovic, S. (2006). *Wireless optical communication systems*. Springer Science & Business Media.
2. Uysal, M., Capsoni, C., Ghassemlooy, Z., Boucouvalas, A., & Udvary, E. (Eds.). (2016). *Optical wireless communications: an emerging technology*. Springer.

MOC6407   Biological Effects of Electromagnetic Fields

Mechanisms of action of EMFs on Biological systems, Mathematical modeling of EMF energy absorption in biological systems, Field computations and measurements, Biological effects of EMFs, Therapeutic Effects of electromagnetic Fields

Reference Books:
1. biological and medical aspects of electromagnetic fields by Frank S. Barnes, Ben Greenebaum, 3rd edition CRC Press 2006
2. Bioengineering and Biophysical Aspects of Electromagnetic Fields (Handbook of Biological Effects of Electromagnetic Fields by Ben Greenebaum, Frank S. Barnes, 3rd edition CRC Press 2006

MOC6409   Broadband Communication Systems

Characterization of broadband wireline and wireless channels. Intersymbol Interference effects, Equalization methods: single-carrier and multicarrier techniques, Equalization techniques such as linear, decision feedback, precoding, zero-forcing, mean square-error, Challenges such as complexity, channel estimation, error propagation. Broadband ISDN and ATM networks, IP switching and MPLS, Real time communication over internet, packet scheduling algorithms, real world broadband communication networks.

Reference Books:

1. Introduction to Broadband Communication Systems by Cajetan M. Akujuobi, Matthew N.O. Sadiku, Chapman and Hall/CRC 2007
2. Introduction to Broadband Communication Systems 1st Edition, by Cajetan M. AkujuobiMatthew N.O. Sadiku.

MOC6301   Statistical Mathematics

Neyman-Pearson Lemma, Decision Theory; The Sequential Probability Ratio Test; Sequential Decision theory; Sufficient statistics; Estimation and Convexity; Minimal Sufficiency and the Lehmann-Scheffe property; Lower Bounds on Mean-Squared Errors: Information Inequalities, Exponential Families; Stein's Phenomenon and James-Stein's Estimators, Robustness, Breakdown points and 1-D Location M-estimates Asymptotic Normality of M-Estimates; Efficiency of estimators.

Reference Books:

1. Statistical Mathematics by Aitken A. Interscience 1947
2. Numerical Methods of Statisitcs by John F. Monahan 3rd edition Cambridge University Press 2011

MOC6303   Integrated Optics

Principles of optical Integrated circuits; Theory of optical waveguides: Planer, Rectangular-core and Rib waveguide, homogeneous and inhomogeneous waveguide; Coupled mode theory: optical waveguide couplers, tapers, bends; Passive and active waveguides- polarizer, printer ,optical amplifier, modulators and switches; Opto-electronic integrated circuits-Simulation Tools and CAD packages for optical integrated circuits; Technology: Materials and Device process, patterning and Lithography, Deposition and Diffusion techniques, Lithium Niobate based integrated optics technology- Process and Characterization; Application: Integrated optic devices and circuits for High speed long distance telecommunication, Optical processing and Optical computing.

Reference Books:
1. Chuang, S. L. (2012). *Physics of photonic devices* (Vol. 80). John Wiley & Sons.
2. Hunsperger, R. G. (1995). *Integrated optics* (Vol. 4). Springer Verlag.

MOC6305   Quantum Electronics

Propagation of light through anisotropic media, non-linear optical effects, second harmonic generation (SHG), parametric amplification, quasi phase matching, self phase modulation (SPM), cross phase modulation, four wave mixing, quantization of EM field, numbered states, coherent states, squeezed states, entangled states, application areas of quantum electronics.

Reference Books:
1. Quantum Electronics , A Yariv, John Wiley, NY, 1989
2. Scully, M. O., & Zubairy, M. S. (1997). Quantum optics cambridge university press. *Cambridge, CB2 2RU, UK*.

MOC6307   Optical Computing

Need of Optical Computing; Basic of Fourier Optics; Devices for optoelectronic interface: Spatial Light Modulators, Liquid crystal devices, Self-electro-optical effect Devices; Optical Transistors; Real time holograms; Optical Logic Circuits; Optical Interconnections: Crossbars Switch interconnections, Multistage interconnection Networks; Optical Memory: Hierarchies, cache and virtual memory, Optical word pattern matching, holographic memory; Logic Elements and Operations: Combinational and

sequential logic, Optical matrix processing.

Reference Books:
1. Karim, M. A., & Awwal, A. A. (1992). *Optical computing: an introduction*. John Wiley & Sons, Inc..
2. Arsenault, H. (Ed.). (2012). *Optical processing and computing*. Elsevier.

MOC6309   Optical Signal Processing

Geometrical Optics; Physical Optics; Fundamentals of digital signal processing; Spectrum Analysis; Spatial Filtering Systems; Acousto-Optic Devices, Acousto-Optic Power Spectrum Analysers; Heterodyne System; Heterodyne Spectrum Analysis, Decimated Arrays and Cross Spectrum Analysis; Space Integrating Correlators; Time Integrating Systems; Two Dimensional Processing.

Reference Books:
1. Yu, F. T., & Jutamulia, S. (1992). *Optical signal processing, computing, and neural networks*. John Wiley & Sons, Inc..
2. Arsenault, H. (Ed.). (2012). *Optical processing and computing*. Elsevier.

MOC6311   Spectrum Communication

Introduction to spreading techniques, generation of spreading sequences and waveforms, properties of spreading sequences, code properties, code generator polynomials and characteristic equation, interference rejection techniques, code acquisition and tracking mechanism, fading channels and diversity, CDMA, Interference limitation in CDMA, performance analysis of CDMA and WCDMA.

Reference Books:

1. Principles of Spread Spectrum Communication Systems by Torrieri D. 2005

2.Principles of Spread-Spectrum Communication Systems by J. Scott Armstrong, Springer 2005

3. CDMA: Principles of Spread-Spectrum Communication Systems by Andrew J. Viterbi, Addison Wesley1995

MOC6201   Wireless Sensor Networks

Requirements and challanges for Wireless Sensor Networks, Comparison with Adhoc Networks, Sensor node architectures, Transceiver Design Considerations, Energy usage, Modulation schemes, Antenna Considerations, MAC Protocols, Routing and Data Gathering Protocols, Data Centric Routing, Energy aware routing, Rumor Routing, Real Time Routing Protocols, Data Aggregation Protocols, Applications of Wireless Sensor Networks.

Reference Books:

1. Wireless Sensor Networks by Nirupama Bulusu, Sanjay Jha, Artech House 2005.
2. Wireless Sensor Networks: Technology, Protocols, and Applications by Kazem Sohraby, Daniel Minoli, Taieb Znati, Wiley Interscience 2007

MOC6203   Special Topics on Optical Communications

Recent advances in the area of fiber optic or wireless optical communication based on recent papers published in the area.

MOC6205   Special Topics on Microwave Communications

Recent advances in the area of microwave communication based on recent papers published in the area.

MOC6207   Neuromorphic Engineering

Signalling and working of biological neurons, neuron models, signal encoding and statistics, Synapses, biological neural circuits, Neuromorphic design principles; FETs - device physics and sub-threshold circuits, Non-volatile memristive semiconductor devices, Electronic synapse design, Interconnection schemes for large neural networks, neuromorphic VLSI.

Reference Books:

1. Kozma, R., Pino, R. E., & Pazienza, G. E. (Eds.). (2012). *Advances in neuromorphic memristor science and applications* (Vol. 4). Springer Science & Business Media.
2. Lande, T. S. (Ed.). (1998). *Neuromorphic systems engineering: neural networks in silicon* (Vol. 447). Springer Science & Business Media.

Project-1

Research Work