INDIAN INSTITUTE OF INFORMATION TECHNOLOGY BHAGALPUR

Dept. of Electronics and Communication Engineering (ECE)

M. Tech in Microwave and Communication System

(For Regular Students)

Curriculum

Code	Course Name	L	T	P	C
	1st Semester				
MA503	Probability and Stochastic Processes	3	0	0	3
EC521	Advance Electromagnetics and Antenna	3	0	2	4
EC522	Computational Electromagnetics	3	0	2	4
EC523	Microwave Circuits & Measurements	3	0	0	3
EC5XX	Elective-I	3	0	0	3
EC541	Microwave Simulation and Measurement Lab	0	0	3	2
EC583	Seminar	0	0	0	1
	Total Credits				20
	2nd Semester				
EC556	MIMO Wireless Communication	3	0	0	3
EC524	Monolithic Microwave Integrated Circuit	3	0	2	4
EC525	Microwave Communication System	3	0	2	4
EC5XX	Elective-II	3	0	0	3
EC5XX	Elective-III	3	0	0	3
EC542	Advance Communication Engineering Lab	0	0	3	2
EC582	Capstone Project	0	0	0	1
	Total Credits				20
	3rd Semester				
EC591	Major Project-I	0	0	0	10
	4th Semester				
EC592	Major Project-II	0	0	0	14
	Total Credits				64

Elective Courses

Code	Course Name	L-T-P-C
Code	Course Name	L-T-P-C
EC561	Semiconductor Microwave Devices and Applications	3-0-0-3
EC557	Microwave Imaging and Radar Signal Processing	3-0-0-3
EC563	RF Integrated Circuit Design	3-0-0-3
EC571	Advanced Antenna & Array Design	3-0-0-3
EC572	THz Communication System	3-0-0-3
EC573	Wireless Sensor Network	3-0-0-3
C574	Principles and Techniques for Modern Radar System	3-0-0-3
EC575	Advance Mobile Communication System	3-0-0-3
EC576	Electromagnetic Interference & Electromagnetic Compatibility	3-0-0-3
EC577	Advance Optical Communication	3-0-0-3
EC503	Computational Intelligence	3-0-0-3

Course Syllabus

Course Code	Course name	L	T	P	C	Semester
MA503	Probability and Stochastic Processes	3	0	0	3	1st

Topic	Contents	No. of Lectures
Module-I	Axiomatic definitions of probability; conditional probability, independence and Bayes theorem, continuity property of probabilities.	**08**
Module-II	Random variable: probability, density and mass functions, functions of a random variable; expectation, characteristic, and moment-generating functions; Chebyshev, Markov and Chernoff bounds;	**08**
Module-III	Jointly distributed random variables: joint distribution and density functions, joint moments, conditional distributions and expectations, functions of random variables; random vector-mean vector and covariance matrix, Gaussian random vectors; Sequence of random variables: almost sure and mean-square convergences, convergences in probability and in distribution, laws of large numbers, central limit theorem;	**08**
Module-IV	Random process: probabilistic structure of a random process; mean, autocorrelation and autocovariance functions; stationarity - strict- sense stationary and wide-sense stationary (WSS) processes: time averages and ergodicity; spectral representation of a real WSS process-power spectral density, cross-power spectral density,	**08**
Module-V	Linear time-invariant systems with WSS process as an input-time and frequency domain analyses; examples of random processes: white noise, Gaussian, Poisson and Markov processes.	**08**
	Total	**40**
Text	1. H. Stark and J. W. Woods, Probability and Random Processes with Applications to Signal Processing, Pearson, 3rd Edition, 2002. 2. A. Papoulis and S. U. Pillai, Probability, Random Variables and Stochastic Processes, McGraw-Hill, 4th Edition, 2017..	
Reference	1. B. Hajek, An Exploration of Random Processes for Engineers, Cambridge University Press , 2015. 2. Sheldon M Ross, Stochastic Processes, Wiley , 2nd Ed, 2016.	

Course Code	Course name	L	T	P	C	Semester
EC521	Advance Electromagnetics and Antenna	3	0	2	4	1st

Topic	Contents	No. of Lectures
Module-I	**Introduction to Preliminary topics in EM**: Vector Calculus, Review of Maxwell's Equation and boundary conditions, time harmonic electromagnetic fields, vector potentials, electromagnetic theorems and concepts: uniqueness, image theory, field equivalence principle, reciprocity.	**10**
Module-II	**Waves and Antenna:** Helmholtz equation, Plane, cylindrical and spherical waves, Elementary wave functions in cylindrical	**08**

	coordinates; radiation and scattering, Antenna and its parameters, Radiation pattern, near- and far-field regions, dipole antennas, Antenna and arrays, aperture antennas: radiation from open ended rectangular and circular waveguides, horn antennas, parabolic antennas, slot antennas, antenna and its arrays, microstrip antenna.	
Module-III	**Anisotropic materials:** Lorentz and Drude models, Isotropic materials, Nonlinear and anisotropic materials, Transmission lines in anisotropic media, Coupled-mode theory, Coupled-mode devices.	**09**
Module-IV	**Periodic structures:** Theory of periodic structures, Calculation examples of periodic structures, Diffraction gratings, Subwavelength gratings, Guided mode resonance, Introduction to engineered materials, Metamaterials, Photonic crystals, Homogenization and parameter retrieval.	**08**
Module-V	**Frequency selective surfaces:** Spatial transforms, Holographic lithography, Spatially variant lattices, Frequency selective surfaces, Surface waves, Slow waves, Simulation using CAD, Interfacing MATLAB with CAD.	**07**
	Total	**42**
Text	1. C.A. Balanis, "Advanced Engineering Electromagnetics", Wiley India Pvt. Ltd., 2012. 2. R. J. Marhefka, A. S. Khan and J. D. Kraus, "Antennas and Wave Propagation", Tata McGraw - Hill Education 2010.	
Reference	1. Ben A. Munk, "Frequency Selective Surfaces: Theory and Design", Wiley, 2000. 2. Harrington, R.F., "Time-harmonic Electromagnetic Fields", Wiley-IEEE Press. 2001. 3. C. A. Balanis, "Antenna Theory: Analysis and Design," John Wiley & Sons, 2009.	

Course Code	Course name	L	T	P	C	Semester
EC522	Computational Electromagnetics	3	0	2	4	1st
Topic	**Contents**					**No. of Lectures**
Module-I	Fundamental Concepts: Review of Maxwell's equations and boundary conditions, integral equations versus differential equations, radiation and edge conditions, modal representation of fields in bounded and unbounded media.					**06**
Module-II	Green's Functions: Green's function technique for the solution of partial differential equations, classification of Green's functions, various methods for the determination of Green's functions including Fourier transform technique and Ohm-Rayleigh technique, dyadic Green's functions, determination of Green's functions for free space, transmission lines, waveguides, and microstrips.					**12**

Module-III	Integral Equations: Formulation of typical problems in terms of integral equations: wire antennas, scattering, apertures in conducting screens and waveguides, discontinuities in waveguides and microstriplines; Solution of Integral equations: General Method of Moments (MoM) for the solution of integro-differential equations, choice of expansion and weighting functions, application of MoM to typical electromagnetic problems.	**12**
Module-IV	Finite Element Method: Typical finite elements, Solution of two dimensional Laplace and Poisson's equations, solution of scalar Helmholtz equation	**06**
Module-V	Finite-difference Time-domain Method: Finite differences, finite difference representation of Maxwell's equations and wave equation, numerical dispersion, Yee's finite difference algorithm, stability conditions, programming aspects, absorbing boundary conditions.	**06**
	Total	**42**
Text	1. Jin, Jian-Ming, Theory and computation of electromagnetic fields. John Wiley & Sons, 2011. 2. David B Davidson, Computational electromagnetics for RF and microwave engineering. Cambridge University Press, 2010.	
Reference	1. Peterson, A.F, Ray, S.L. and Mittra, R., "Computational Methods for Electromagnetics", Wiley-IEEE Press. 1998. 2. Volakis, J.L., Chatterjee, A. and Kempel, L.C., "Finite Method for Electromagnetics", Wiley-IEEE Press. 1998.	

Course Code	Course Name	L	T	P	C	Semester
EC523	Microwave Circuit and Measurement	3	0	0	3	1^{st}
Topic	Contents					No. of Lectures
Module-I	Introduction to Printed Transmission Line: Transmission Line, Smith Chart, Impedance Transformation, Problem based on Single and Double Stub, Concept of 2 port network, S parameters, Passive Devices and matching. Measurement of Q factor, Impendence, Power, Noise figure, S-parameters, dielectric constant and permeability. Swept frequency measurement. Network analyzers. Spectrum analyzers and TDR.					10
Module-II	Power Dividers and Couplers: Basic Properties of power dividers and couplers, T junction, Wilkinson type, quadrature hybrid power dividers, coupled line directional coupler, Hybrid Brach Line Couplers, Circulator.					09
Module-III	Filter and Isolator: Basic Filter design technique, Insertion loss, Filter transformations and implementation, low pass filters, coupled line filters, coupled resonator based filters, Metamaterial Filters.					08

Module-IV	Microwave Amplifiers: Single stage amplifiers, Power gain equation, Stability circles, Broad-band amplifier design, Solid State Power Amplifiers.	08
Module-V	Microwave diodes, transistor and Oscillator: BJT, GaAs FET and applications, IMPATT, TRAPATT, Gunn Diode, Microwave Oscillator using Transistors, Dielectric Resonators, Active and Passive Phase shifters.	09
	Total	42
Text	1. Pozar, David M, Microwave engineering, 4th ed. 2012, Wiley 2. Samuel Y. Liao, Microwave Device and Circuits, Pearson Prentice Hall, 2008.	
Reference	1. Pierre Jarry, Jacques N. Beneat, RF and Microwave Electromagnetism, Wiley, 2014. 2. Nuno Borges Carvalho and Dominique Schreurs. Microwave and wireless measurement techniques. Cambridge University Press, 2013.	

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Semester**
EC556	MIMO Wireless Communication	3	0	0	3	2nd
Topic	**Contents**					**No. of Lectures**
Module-I	**Introduction**: Diversity-multiplexing trade-off, transmit diversity schemes, advantages, and applications of MIMO systems.					**10**
Module-II	**Analytical MIMO channel models**: Uncorrelated, fully correlated, separately correlated and keyhole MIMO fading models, parallel decomposition of MIMO channel.					**08**
Module-III	**Power allocation in MIMO systems**: Uniform, adaptive and near optimal power allocation. **MIMO channel capacity**: Capacity for deterministic and random MIMO channels, Capacity of i.i.d., separately correlated and keyhole Rayleigh fading MIMO channels.					**09**
Module-IV	**Space-Time codes**: Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel, Space-time turbo codes. **MIMO detection**: ML, ZF, MMSE, ZF-SIC, MMSE-SIC, LR based detection.					**08**
Module-V	**Advances in MIMO wireless communications**: Spatial modulation, MIMO based cooperative communication and cognitive radio, multiuser MIMO, cognitive-femtocells, and large MIMO systems for 5G wireless.					**07**
	Total					**42**
Text	1. Rakhesh Singh Kshetrimayum, Fundamentals of MIMO wireless communications. Cambridge University Press, 2017.T. M. Duman and A.					

	Ghrayeb, Coding for MIMO communication systems, John Wiley and Sons, 2007. 2. N. Costa and S. Haykin, Multiple-input multiple-output channel models, John Wiley & Sons, 2010.
Reference	1. J. Choi, Optimal Combining & Detection, Cambridge University Press, 2010. 2. A. Chokhalingam and B. S. Rajan, Large MIMO systems, Cambridge University Press, 2014.

Course Code	Course name	L	T	P	C	Semester
EC524	Monolithic Microwave Integrated Circuits Technology (MMIC)	3	0	2	4	2^{nd}

Topic	Contents	No. of Lectures
Module-I	**Introduction**: Brief History, Advantages, and disadvantages of MMICs, Applications, Active device Technology, Design Approaches, Multi-chip module Technology. **Devices and fabrication Technology**: Substrate and Technologies, Passive lumped elements, BJTs, FETs, Comparison of BJTs and FETs.	**10**
Module-II	**Passive Components**: Inductors, Capacitors, Resistors, via-holes and Grounding, Micro strip and Co-planar components, Multi-layer Techniques, Micro mechanical Passive components.	**08**
Module-III	**CAD Techniques**: Integrated CAD Design Environment, CAD package features, Circuit simulation Engines, Commercial CAD packages, Commercial Modelling Software. EM simulation Tools.	**09**
Module-IV	**Transceivers**: Conventional UP/Down conversion architectures, Direct Conversion architectures, Modulators, demodulators, and Frequency Translators. **Integrated Antennas**: Basic Integrated Antenna Requirements, Integrated Antenna selection and examples, Photonic Band gap antennas.	**08**
Module-V	**Monolithic amplifiers**: Monolithic IC technology, MMIC design and examples, CMOS fabrication. **Amplifier packages**: Amplifier packaging overview, materials for packages, ceramic package design, and plastic package design, package assembly, thermal considerations, CAD Tools for packages, power amplifier modules.	**07**
	Total	**42**
Text	1. I. D. Robertson, S. Lucyszyn, RFIC and MMIC design Technology, IEEE Publications, 2001. 2. Inder J Bahl Fundamentals of RF and Microwave Transistor Amplifiers, John Wiley & sons Inc, 2009.	

Reference	1. Sorab. K. Ghandhi, VLSI Fabrication principles – Silicon and Gallium Arsenide, 2nd Edition, Wiley India, 2009. 2. Matthew M. Radmanesh, RF and Microwave Electronics Illustrated, , 1 st edition, Pearson Education, 2004.

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Semester**
EC525	Microwave Communication System	3	0	2	4	2nd
Topic	**Contents**					**No. of Lectures**
Module-I	Line-of-sight Propagation and System performance, Active and passive repeater design.					**10**
Module-II	Troposcatter propagation. FM/Digital. AM/FDM and AM/TDM systems.					**08**
Module-III	Satellite Communication Systems, Earth Station design criteria and direct reception system.					**09**
Module-IV	Multiple access Time division multiple access, Frequency division multiple access, and Spatial division multiple access.					**08**
Module-V	Noise consideration: Unilateral Design, Unilateral Figure of Merit, Bilateral Design, Operating and Available Power Gain Circles, Noise Figure Circles, Constant VSWR Circles					**07**
	Total					**42**
Text	1. Bruce R Elbert. Introduction to satellite communication. Artech house, 2008. 2. George Kizer. Digital microwave communication: engineering point-to-point microwave systems. John Wiley & Sons, 2013.					
Reference	1. P. V. Sreekanth. Digital microwave communication systems: with selected topics in mobile communications. Universities Press, 2003. 2. Jonathan Wells. Multi-gigabit microwave and millimeter-wave wireless communications. Artech House, 2010. 3. Timothy Pratt and Jeremy E. Allnutt. Satellite communications. John Wiley & Sons, 2019.					

Course Code	Course name	L	T	P	C	Semester
EC561	Semiconductor Microwave Devices and Applications	3	0	0	3	
Topic	Contents					No. of Lectures
Module-I	Introduction to radio frequency engineering; advantages; various frequency bands; propagation; transmission lines; microwave waveguides and components; their characterizations; s-parameters and their use					08

Module-II	Microwave transistor; FETs, Gunn diode, IMPATT diodes; microwave tubes; Klystron; two cavity Klystron amplifier analysis; reflex Klystron; TWTs; high power tubes; cross field tubes; micro-strip lines; MMICs	08
Module-III	Microwave measurements; microwave antennas and microwave communication system; microwave applications; ISM applications	08
Module-IV	Introduction to EMI and EMC; microwave hazards., refraction and diffraction; transmission lines and resonators	08
Module-V	Microwave Attenuators: Fixed and Variable Attenuators, Microwave RF Switches: Series and Shunt SPST, Series and Shunt SPDT Switches and Introduction to Phase Shifters, Microwave Phase Shifters: Switched and Loaded Line	08
	Total	40
Text	1. D. M. Pozar, Microwave Engineering, John Wiley & Sons, 2nd edition, 1998. 2. A. R. Harish and M. Sachidananda, "Antennas and Wave Propagation", Oxford University Press, 2013	
Ref	1. Samuel Y. Liao, Microwave Devices and Circuits, Pearson education, 3rd edition, 2017.	

Course Code	Course name	L	T	P	C	Semester
EC557	Microwave Imaging and Radar Signal Processing	3	0	0	3	
Topic	**Contents**					**No. of Lectures**
Module-I	Electromagnetic Scattering, Wave Equations and Their Solutions, Volume Scattering by Dielectric Targets, Volume Equivalence Principle, Integral Equations, Surface Scattering by Perfectly Electric Conducting Targets. Electromagnetic Inverse Scattering Problem: Two-Dimensional Inverse Scattering.					**08**
Module-II	Imaging Configurations and Model Approximations: Objectives of the Reconstruction, Tomographic configurations, Configurations for Buried Object Detection, Born-Type Approximations, Extended Born Approximation, Rytov Approximation.					**08**
Module-III	Qualitative Reconstruction Methods: Generalized Solution of Linear IllPosed Problems, Regularization Methods, Singular Value De-composition, Regularized Solution of a Linear System Using Singular Value Decomposition, Qualitative Methods for Object Localization and Shaping, Back projection, w-k, beamforming, Civil and Industrial Applications, Medical Applications of Microwave Imaging, Shallow Subsurface Imaging.					**08**
Module-IV	Basic radar definitions: radar range equation, receiver noise, probability of detection and signal-to-noise ratio, RCS, CW, FMCW and multiple frequency CW radars, delay line canceler, error signal of conical-scan radar, monopulse radars, clutter, jamming, doppler shift, Radar waveforms, waveform matched					**08**

	filter, pulse burst waveform, frequency-modulated pulse compression waveforms.	
Module-V	Phase array working and feed systems; Synthetic aperture radars (SAR), pulse compression techniques, Doppler processing, Alternate forms of the Doppler spectrum, Moving target indication (MTI), Pulse Doppler processing, Dwell-to-dwell stagger, Clutter mapping and the moving target detector, Detection of radar signals in noise.	**08**
	Total	**40**
Text	1. M. Pastorino, Microwave Imaging, Wiley & Sons, 1st edition, 2010. 2. Mark A. Richards, Fundamentals of Radar Signal Processing, McGraw-Hill, 2nd edition, 2014. 3. S. Haykins, Adaptive Radar Signal Processing, John Wiley & Sons, Inc. 1 st edition, 2007.	
Reference	1. V. C. Chen and H. Ling, Time-Frequency Transforms for Radar Imaging and Signal Analysis, Artech House,1st edition, 2002. 2. 2. Bernard D. Steinberg, H. M. Subbaram, Microwave Imaging Techniques, Wiley & Sons.,1st edition, 1991.	

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Semester**
EC563	RF Integrated Circuit Design	3	0	0	3	

Topic	**Contents**	**No. of Lectures**
Module-I	Introduction & Passive RLC Networks: RF systems – basic architectures Transmission media and reflections Maximum power transfer, Parallel RLC tank, Series RLC networks, matching, Pi match, T match, Review of MOS Device Physics.	**09**
Module-II	Distributed Systems: Transmission lines, reflection coefficient, the wave equation, examples, Lossy transmission lines, Smith charts – plotting gamma, Bandwidth estimation using open-circuit & short-circuit time constants, Zeros to enhance bandwidth, Shunt-series amplifiers, tuned amplifiers, Cascaded amplifiers.	**09**
Module-III	LNA Design: Intrinsic MOS noise parameters, Power match versus noise match, large signal performance, design examples & Multiplier based mixers, Mixer Design, Subsampling mixers.	**08**
Module-IV	RF Power Amplifiers: Class A, AB, B, C, D, E, F amplifiers, Voltage controlled oscillators, Resonators, Negative resistance oscillators, Phase locked loops, Linearized PLL models, Phase detectors, charge pumps, Loop filters, PLL design examples.	**08**
Module-V	Frequency synthesis and oscillators: Frequency division, integer-N synthesis, Fractional frequency synthesis, Phase noise General considerations, Radio architectures, GSM radio architectures, CDMA, UMTS radio architectures.	**08**
	Total No. of Lectures	**42**

Text	1. T. H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits, Cambridge University Press; 2nd edition, 2004. 2. C. Coleman, An Introduction to Radio Frequency Engineering, Cambridge University Press, Reissue edition, 2004.

Course Code	Course name	L	T	P	C	Semester
EC571	Advanced Antenna and Array Design	3	0	0	3	

Topic	Contents	No. of Lectures
Module-I	Introduction: Radiation mechanism, Poynting vector, Steradian concept, Power intensity, Parameters, Radiation pattern, Field regions, Radiation integrals and Auxiliary Potential Functions	08
Module-II	Aperture Antennas: Introduction, Field equivalence principle, Love's equivalence principle, Electrical and magnetic conductor equivalence principle, Computation of field quantities of aperture antenna, Relation between wire and aperture antennas, Horn antenna design principle Broadband Antennas: Introduction, Principle of frequency-independent antenna, Examples of frequency-independent antennas, Log-periodic antenna concept and examples	09
Module-III	Antenna Arrays: Introduction, Two-element array, Example problems, Pattern multiplication concept, N-element array, Uniform array, Array factor, Broad-side and end-fire arrays, Phased array, Directivity and pattern characteristic of linear uniform array, Non-uniform array, Binomial array, Dolph-Chebyshev array concept, Design principle of Chebyshev array and examples, Planar arrays	09
Module-IV	Microstrip Antennas: Introduction, Advantages and disadvantages, Microstrip antenna configurations, Excitation techniques, Radiation mechanism, Design methodology, Methods of analysis, Transmission line model, Cavity model Basic Concepts of Smart Antennas: Introduction, Need of smart antenna system, Overview of smart antenna system, Types of smart antennas, Switched beam system, Adaptive system, Beam forming	09
Module-V	Antennas for millimeter wave systems: mm wave design consideration, printed mm wave antennas, On-chip and In package mm wave antennas, Techniques to improve gain of on-chip antennas, Implementation for mm wave in adaptive antenna arrays	07
	Total	42
Text	1. C.A.Balanis,"Antenna Theory and Design", 3 rd Ed., John Wiley & Sons., 2005. 2. W. L.Stutzman, and G.A. Thiele,"Antenna Theory and Design", 2 nd Ed., John Wiley & Sons., 1998. 3. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.	
Reference	4. R.S.Elliot,"Antenna Theory and Design", Revised edition, Wiley-IEEE Press., 2003. 5. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014.	

Course Code	Course name	L	T	P	C	Semester
EC572	THz Communication System	3	0	0	3	
Topic	Contents					No. of Lectures
Module-I	Basic THz Terminologies. Physical Principles of THz Interaction with Matter. Electromagnetic Waves in Matter. THz Radiation and Elementary Excitations. Laser Basics.					08
Module-II	THz Detectors and Sources. Ultrafast Optics. THz Emitters and Detectors based on Photoconductive Antennas. Optical Rectification. Free-space Electro-optic Sampling. Ultrabroadband Terahertz Pulses. Terahertz Radiation from Electron Accelerators. Novel Techniques for Generating Terahertz Pulses. Continuous-Wave Terahertz Sources and Detectors.					08
Module-III	Photomixing. Difference Frequency Generation and Parametric Amplification. Far-Infrared Gas Lasers. P-Type Germanium Lasers. Frequency Multiplication of Microwaves. Quantum Cascade Lasers. Backward Wave Oscillators. Free-Electron Lasers. Thermal Detectors: Bolometers, Pyroelectric Detectors, Golay Cells. Heterodyne Receivers.					08
Module-IV	Terahertz Optics. Dielectric Properties of Solids in the Terahertz Region. Materials for Terahertz Optics. Optical Components. Terahertz Waveguides. Artificial Materials at Terahertz Frequencies. Terahertz Phonon-Polaritons Imaging with Broadband THz Pulses. Imaging with Continuous-Wave THz Radiation. Millimeter-Wave Imaging for Security. Medical Applications of T-Ray Imaging. Concealed Objects Real-Time Imaging for Security. Compact wireless technologies. Terahertz ultrafast wireless communications. Short distance ultra-broadband communication. THz communication for space applications.					08
Module-V	THz Energy Harvesting - Rectification concept and technological challenges. Design and development of nano-rectennas. Fabrication and measurement techniques					08
	Total					40
Text	1. Yun-Shik Lee, Principles of Terahertz Science and Technology, Springer 2009. 2. Erik Bründermann, et al., Terahertz Techniques, Springer 2012.					
Reference	3. R. A. Lewis, Terahertz Physics, Cambridge University Press 2012.					

Course Code	Course name	L	T	P	C	Semester
EC573	Wireless Sensor Network	3	0	0	3	
Topic	**Contents**					**No. of Lectures**
Module-I	Introduction: Fundamentals of wireless communication technology, the electromagnetic spectrum radio propagation, characteristics of wireless channels, modulation techniques, multiple access techniques, wireless LANs, PANs, WANs, and MANs, Wireless Internet.					08
Module-II	Introduction to adhoc/sensor networks: Key definitions of adhoc/ sensor networks, unique constraints and challenges, advantages of ad-hoc/sensor network, driving applications, issues in adhoc wireless networks, issues in design of sensor network, sensor network architecture, data dissemination and gathering.					08
Module-III	MAC Protocols: Issues in designing MAC protocols for adhoc wireless networks, design goals, classification of MAC protocols, MAC protocols for sensor network, location discovery, quality, other issues, S-MAC, IEEE 802.15.4.					08
Module-IV	Routing Protocols: Issues in designing a routing protocol, classification of routing protocols, table-driven, on-demand, hybrid, flooding, hierarchical, and power aware routing protocols.					08
Module-V	QoS and Energy Management: Issues and Challenges in providing QoS, classifications, MAC, network layer solutions, QoS frameworks, need for energy management, classification, battery, transmission power, and system power management schemes.					08
	Total					40
Text	1. C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education - 2008. 2. Feng Zhao and Leonides Guibas, "Wireless sensor networks ", Elsevier publication - 2004.					
Reference	3. Jochen Schiller, "Mobile Communications", Pearson Education, 2nd Edition, 2003. 4. William Stallings, "Wireless Communications and Networks ", Pearson Education - 2004					

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Semester**
EC574	Principles and Techniques for Modern Radar System	3	0	0	0	
Topic	**Contents**					**No. of Lectures**
Module-I	Basic Principles: Radar Equation, Radar Cross section, CW Radar, FMCW Radar Week Week, Pulsed Radar Principles					8
Module-II	Clutter Analysis, MTI Improvement Factor, Pulsed Doppler Radar, Week, Tracking Radar, Angular resolution, Monopulse Technique, Detection Theory: Match Filtering, Radar Ambiguity Function					8

Module-III	Imaging Radar: Resolution Concept, Pulse Compression, Synthetic Aperture Processing, ISAR Imaging, Probability of False Alarm and Detection, Modified Radar Range Equation with Swerling Models	8
Module-IV	Ground Penetrating Radar for close sensing, Radar Tomography and Radar based Microwave Imaging	8
Module-V	Emerging and Modern Applications of Radar Principles	8
	Total No. of Lectures	40
Text	1. Introduction to Radar Systems, M.I. Skolnik, 3rdEdition, Tata Mcgraw hill edition, 2001 2. Radar Systems Analysis and Design using MATLAB, B.R.Mahafza, 3rd Edition, CRC Press, 2013	
Reference	1. Monopulse Principles and Techniques, S.M.sherman and D.K.Barton, 2ndEdition,Artech house, 2011 2. Fundamentals of Radar Signal Processing, M.A.Richards, TMH, 2005	

Course Code	Course name	L	T	P	C	Semester
EC575	Advance Mobile Communication System	3	0	0	3	
Topic	Contents					No. of Lectures
Module-I	Microwave Radio Communications: Introduction, Advantages and Disadvantages, Analog vs digital microwave, frequency vs amplitude modulation Frequency modulated microwave radio system, FM microwave radio repeaters Diversity, protection switching arrangements, FM microwave radio stations, microwave repeater station, line of sight path characteristics.					08
Module-II	Digital TV: Digitized Video, Source coding of Digitized Video, Compression of Frames, DCT based (JPED), Compression of Moving Pictures (MPEG). Basic blocks of MPEG2 and MPE4, Digital Video Broadcasting (DVB). Modulation: QAM (DVB-S, DVB-C), OFDM for Terrestrial Digital TV (DVB –T). Reception of Digital TV Signals (Cable, Satellite and terrestrial). Digital TV over IP, Digital terrestrial TV for mobile Display Technologies: basic working of Plasma, LCD and LED Displays.					08
Module-III	Satellite Communication systems, introduction, Kepler's laws, orbits, orbital effects, orbital perturbations Satellite sub systems, Antennas, Transponders, earth station technology, Link calculation, Satellite systems- GEO systems, non-GEO communication systems, Satellite Applications- Global Positioning System, Very Small Aperture Terminal system, Direct to Home Satellite Systems.					08
Module-IV	Evolution of mobile radio communications, paging systems, Cordless telephone systems, comparison of various wireless systems. Introduction to Modern Wireless Communication Systems, Second generation cellular networks, third generation wireless networks, fourth generation wireless technologies.					08

	Wireless in local loop, wireless local area networks, Bluetooth and Personal Area networks, Overview of WIMAX Technologies, architecture, spectrum allocation.	
Module-V	Introduction to new data services like High Speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS), Digital Enhanced Cordless Telecommunications (DECT) , Enhanced Data Rate for Global Evolution (EDGE), Ultra-wideband systems (UWB), Push To Talk (PTT) technology, Mobile IP .	08
	Total	40
Text	1. Dennis Roody, Satellite communication, 4/e, McGraw Hill, 2006. 2. Herve Benoit, Digital Television Satellite, Cable, Terrestrial, IPTV, Mobile TV in the DVB Framework, 3/e, Focal Press, Elsevier, 2008 3. Jochen Schiller, Mobile Communications, Pearson, 2008.	
Reference	1. Mishra, Wireless communications and Networks, McGraw Hill, 2/e, 2013. 2. Nathan, Wireless communications,PHI, 2012. 3. Signal, Wireless communications, Mc Graw Hill, 2010.	

Course Code	Course name	L	T	P	C	Semester
EC576	Electromagnetic Interference & Electromagnetic Compatibility	3	0	0	3	
Topic	Contents					No. of Lectures
Module-I	Introduction: A brief history of EMI/EMC, Analysis of EMI, Type of Noise and Interference, Electromagnetic Compatibility, Radiated Emission and susceptibility, Conducted Emission and Susceptibility, Benefits of good EMC Design, Brief description of EMC regulations, Examples of EMC related problems.					09
Module-II	Conducted Emission and Susceptibility: Measurement of Conducted emission: LISN, Common and Differential mode currents, Power supply filters: Basic properties of filters, A generic power supply filter topology, Effect of filter elements on common and differential mode currents, Separation of conducted emissions into common and differential mode components for diagnostic purpose, Power supplies: Linear and SMPS, Effect of Power Supply Components on Conducted emissions, Power Supply and Filter placement, Conducted Susceptibility.					09
Module-III	Radiated Emission and Susceptibility: Simple Emission models for wires and PCB lands: Differential mode versus Common mode currents, Differential mode current emission model, Common mode current emission model, Current probes, Simple susceptibility models for wires and PCB lands: Shielded cables and surface transfer impedance.					08

Module-IV	Cross talk: Three conductor transmission lines and crosstalk, Transmission line equations for lossless lines, The per unit length parameters: Homogeneous versus Inhomogeneous media, Wide separation approximation for wires, Numerical methods for other structures, The Inductive-Capacitive Coupling Approximation model: Frequency domain Inductive-Capacitive coupling model, Time domain Inductive-Capacitive coupling model, Lumped circuit approximate models. Shielded Wires: Per unit length parameters, Inductive and Capacitive Coupling, Effect of Shield grounding, Effect of pigtails, Effects of Multiple shields, MTL model predictions, Twisted wires: Per unit length parameters, Inductive and Capacitive Coupling, Effects of Twist, Effects of Balancing.	08
Module-V	Shielding: Shielding Effectiveness, Far field Sources: Exact solution, Approximate solution, Near field sources: Near field versus far field, Electric sources, Magnetic sources, Low frequency, magnetic field shielding, Effect of Apertures. Module-VII: System Design for EMC: Shielding and Grounding, PCB Design, System configuration and design, Electrostatic Discharge, Diagnostic tools.	08
	Total No. of Lectures	42
Text	1. Paul, C., Introduction to Electromagnetic Compatibility, John Wiley & Sons, 1992. 2. Kennedy, G., Electronic Communications Systems, McGraw-Hill, 1970.	
Ref	1. 3. Ott, H. W., Noise Reduction Techniques in Electronic Systems, John Wiley & Sons, second edition, 1988.	

Course Code	Course name	L	T	P	C	Semester
EC577	Advance Optical Communication	3	0	0	3	
Topic	Contents					No. of Lectures
Module-I	Optical fiber introduction, advantages, Ray theory and Mode theory of optical fibers, linearly polarized modes. Fiber- SMF, MMF, Attenuation and Dispersion in fibers; Special fibers.					08
Module-II	Optical source, Detectors, Brief overview of optical transmitter and optical receiver. Receiver Noise processes, BER measurement, Noise measurement for optical communication system, Optical Losses.					09
Module-III	Optical Amplifiers, applications, Mechanisms, Optical Filters, Fiber Nonlinearities: Kerr effects, SPM, XPM, FWM					09
Module-IV	Coherent detection: fundamental concept, comparison of direct and coherent detection, Noises formulations, On-off keying, PSK, DPSK, FSK generation and detection					09
Module-V	Optical transmission Link design, Power budget and rise time budget. WDM Systems.					07
	Total					42

Text	1. Optical Fiber Communication-principles and practice, J. M. Senior (Prentice hall of India),Eight Impression 2014 2. Optical Fiber Communications, Gerd Keiser (TMH publication), 4th edition 2011 3. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
Reference	1. Optoelectronics and Photonics, O S Kasap (Pearson publication), 2013. 2. J. C. Palais, Fiber Optic Communications; Pearson, 5 th edition, 2009.

Course Code	Course name	L	T	P	C	Semester
EC503	Computational Intelligence	3	0	0	3	

Topic	Contents	No. of Lectures
Module-I	Introduction to Computational Intelligence: Intelligence machines, Computational intelligence paradigms, Soft computing constituents and conventional Artificial intelligence, Neuro-Fuzzy and soft computing characteristics	8
Module-II	Rule-Based Expert Systems and Fuzzy Expert Systems: Rule-based expert systems, Uncertainty management, Fuzzy sets and operations of fuzzy sets, Fuzzy rules and fuzzy inference, Fuzzy expert systems, Case study: fuzzy logic controller for various applications	8
Module-III	Artificial Neural Networks: Fundamental neuro-computing concepts: artificial neurons, activation functions, Neural network architectures, learning rules, Supervised learning neural networks: multi-layer feed forward neural networks, simple recurrent neural networks, time delay neural networks, supervised learning algorithms, Back propagation algorithm, Radial basis function networks Unsupervised learning neural networks, self-organizing feature maps, Deep neural networks and learning algorithms	8
Module-IV	Evolutionary techniques: Genetic Algorithm, Evolutionary computation: Chromosomes, fitness functions, and selection mechanisms, Genetic algorithms: crossover and mutation, Genetic programming, Evolution strategies, PSO, ACO, BFO	8
Module-V	Hybrid Intelligent Systems: Neural expert system, neuro-fuzzy systems, Evolutionary neural network, case study of Neuro-fuzzy based systems.	8
	Total No. of Lectures	40
Text	1. S. Rajasekaran, G. A. Vijayalaksmi Pai, Neutral Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications, PHI Learning, 2nd edition, 2017. 2. J. S .R. Jng, C. T. Sun, E. Mizutani, Neuro-Fuzzy and Soft Computing, Pearson Education, 1st edition, 2015. 3. S. N. Deepa, S. N. Sivanandam, Principles of Soft Computing, John Wiley, 3rd edition, 2018.	
Reference	1. Timothy J. Ross, Fuzzy logic with Engineering Applications, McGraw-Hill, 3rd edition,2011. 2. Simon Haykin, Neural Networks: A Comprehensive Foundation, Pearson, 3rd edition, 2009., 2005	