Scheme of

POSTGRADUATE DEGREE COURSE

M.Tech. I to IV Semester

Digital Communication

(Effective from academic session: 2020-21)

Rajasthan Technical University, Kota

Akelgarh, Rawatbhata Road, Kota-324010

RAJASTHAN TECHNICAL UNIVERSITY

M.Tech. (Digital Communication)

Teaching & Examination Scheme (Full Time) w.e.f. 2020-21

Semester I

SN	Course Type	Course code	Course Name	Teaching Scheme			Marks			Credit
				L	T	P	I	E	T	
1.	PCC	1MDC1-01	Digital Communication system	3	0	0	30	70	100	3
2.	PCC	1MDC1-02	Advanced Digital Signal Processing	3	0	0	30	70	100	3
3.	PEC-1	1MDC2-11	High Frequency Electronics	3	0	0	30	70	100	3
		1MDC2-12	Optimization Techniques							
		1MDC2-13	Detection & Estimation Theory							
4.	PEC-2	1MDC2-14	Advanced Computer Networks	3	0	0	30	70	100	3
		1MDC2-15	Statistical signal processing							
		1MDC2-16	Satellite Communication							
5.	MCC	1MCC3-21	Research Methodology and IPR	2	0	0	30	70	100	2
6.	PCC	1MDC1-06	Digital Communication System Lab	0	0	4	60	40	100`	2
7.	PCC	1MDC1-07	Modelling & Simulation Lab	0	0	4	60	40	100	2
8.	SODECA	1MDC5-00	Social Outreach Discipline & Extra Curriculum Activities				50		50	1
			Total						**750**	**19**

Semester II

SN	Course Type	Course code	Course Name	Teaching Scheme L	T	P	Marks I	E	T	Cr
1.	PCC	2MDC1-01	Wireless and Mobile Communication	3	0	0	30	70	100	3
2.	PCC	2MDC1-02	Antenna Theory & Techniques	3	0	0	30	70	100	3
3.	PEC-1	2MDC2-11	Micro-Electro-Mechanical-Systems	3	0	0	30	70	100	3
		2MDC2-12	Advanced Optical Communication							
		2MDC2-13	Artificial Neural Networks							
4.	PEC-2	2MDC2-14	Information Theory & Coding	3	0	0	30	70	100	3
		2MDC2-15	Digital Image Processing							
		2MDC2-16	Telecommunication Switching & Networks							
5.	MCC	2MCC3-XX	Audit course 1	2	0	0				P
6.	PCC	2MDC1-06	Antennas and Radiating Systems lab	0	0	4	60	40	100`	2
7.	PCC	2MDC1-07	Wireless and Mobile Communication Lab	0	0	4	60	40	100	2
8.	REW	2MDC4-50	Mini Project with seminar	2	0	0	60	40	100	2
9.	SODECA	1MDC5-00	DECA(ANANDAM)				50		50	1
			Total						**750**	**19**

Semester III

SN	Type	Course code	Course Name	Teaching Scheme			Marks			Credit
				L	T	P	I	E	T	
1.	PEC	3MDC2-11	MIMO Systems	3	0	0	30	70	100	3
		3MDC2-12	RF and Microwave Circuit Design	3	0	0	30	70	100	3
		3MDC2-13	Pattern Recognition and Machine Learning	3	0	0	30	70	100	3
2.	MCC	3MCC3-XX	Open elective	3	0	0	30	70	100	3
3.	MCC	3MCC3-XX	Audit course 2	2	0	0				P
4.	REW	3MDC4-60	Dissertation phase I:Industrial Project	2	0	20	180	120	300	10
			Total						**500**	**16**

Semester IV

SN	Course code	Course Name	Teaching Scheme			Marks			Credit
			L	T	P	I	E	T	
1.	4MDC4-70	Dissertation phase II	2	0	32	300	200	500	16
		Total							16

RAJASTHAN TECHNICAL UNIVERSITY
M.Tech. (Digital Communication)
Syllabus (Full Time) w.e.f. 2020-21

SEMESTER I

1MDC1-01: DIGITAL COMMUNICATION SYSTEM

Course Objective:

- The course would be beneficial particularly to students who are interested in doing research in fields related to communications
- The course gives an overview of the designs of digital communication systems with the mathematical foundation
- Cover basics of digital communication system, different techniques and spread spectrum modulation

Topics	Hours
Deterministic and Random Signal Analysis: band pass and low pass signal representation, signal space representation, representation of random processes (via sampling, K-L expansion and narrow band representations)	8
Baseband Pulse Transmission: Nyquist criterion, matched filter, optimum receivers for channels with ISI and AWGN, equalization.	8
Pass band Digital Transmission: binary and M-ary modulation techniques, optimum receivers for AWGN channels, coherent detection, detection of signals with unknown phase, non-coherent orthogonal modulation techniques, power spectrum of digitally modulated signals, bandwidth efficiency, carrier and symbol synchronization.	14
Spread-Spectrum Modulation: Pseudo-Noise sequences, direct sequence spread spectrum, signal-space dimensionality and processing gain, error rate performance, frequency-hopped spread spectrum.	10
Total	**40**

Course Outcomes:

- Design and model the digital communication systems.
- Evaluate the performance of various digital modulation schemes over AWGN and fading channels
- Demonstrate different spread spectrum techniques.

Reference books:

1. John G. Proakis and MasoudSalehi, "Digital Communications", 5th Edition, Mc-Graw Hill Education, 2007.
2. Simon Haykin, "Digital Communication Systems", 2nd Edition, Wiley, 2006.
3. Sklar and Ray, "Digital Communications", 2nd Edition, Pearson, 2008.
4. Glover and Grant, "Digital Communications", 3rd Edition, Pearson, 2010.
5. B. P. Lathi, "Modern Digital and Analog Communication Systems", 4th Edition, Oxford, 2011.
6. Taub and Schilling, "Taub's Principles of Communication Systems", 4th Edition, TMH, 2013.

1MDC1-02: ADVANCE DIGITAL SIGNAL PROCESSING

Course Objective:

- To provide an understanding of the fundamentals of digital signal processing and its wide range of applications.
- To apply digital signal processing concepts to other field of interest andunderstanding of the technical literature on digital signal processing.
- To provide the background for the study of more advanced topics and applications.

Topics	Hours
The DFT: properties and efficient computation of DFT using FFT Algorithms.	4
Digital filter design and structures: design of FIR filters using windows and frequency sampling method, IIR filter design by impulse invariance, bilinear transformation, structures for FIR and IIR systems.	16
Finite word length effects in FIR and IIR digital filters: coefficient quantization and round-off noise.	4
Multirate DSP: Decimators and Interpolators, Sampling rate conversion, multistage decimator and interpolator, poly phase representation, poly phase structures for Decimation and Interpolation filters, digital filter banks, quadrature mirror filter bank (QMF), perfect reconstruction (PR) systems. Application of multirate DSP in design of phase shifters and sub band coding of speech signals.	10
Introduction to wavelets: the wavelet transform and its relation to multirate filter banks, overview of wavelet applications.	6
Total	**40**

Course Outcome:

- Interpret and process discrete/digital signal and systems.
- Analyze and provide solutions to practical implementation issues of DSP systems.
- Apply multi rate signal processing and wavelets.
- Design digital filters for particular application.

Reference books:

1. A.V.Oppenheim, R.W.Schafer and J.R.Buck, "Discrete-Time Signal Processing", 2nd Edition, Pearson, 1999.
2. J.G.Proakis and D.G.Manolakis, "Digital signal processing: Principles, Algorithm andApplications", 4th Edition, Pearson, 2009.
3. P.P.Vaidyanathan, "Multirate Systems and Filter Banks", Pearson, 1992.
4. V.M.Gadre and A.S.Abhyankar ,"Multiresolution and Multirate Signal Processing", McGraw Hill Education, 2017.
5. Andreas Antoniou, "Digital Signal Processing: Signals, Systems, and Filters", 1st Edition, McGraw-Hill Education, 2005.
6. Andreas Antoniou, "Digital filters:, 2ndt Edition, McGraw-Hill Education, 2000.

1MDC2-11: HIGH FREQUENCYELECTRONICS

Course Objective:

- The course would be beneficial particularly to students who are interested in doing research in fields of High frequency electronics.
- To provide an understanding of the fundamental underlying principles of high frequency electronics operating up to microwave frequencies
- To provide the ability to design high frequency RF and microwave circuits and systems using amplifiers, oscillators, mixers, resonators and filters

Topics	Hours
Analysis of planar transmission lines: Variational method. losses in microstrip lines, analysis & design of devices; passive circuits, impedance transformers, couplers, power dividers, filters, oscillators, mixers, switches, amplifiers (narrow band /broad band) oscillators, active & passive phase shifters.	18
Microstrip lines on ferrite and garnet substrate; Isolators and circulators; lumped elements in MICs Analysis of basic transmission lines for millimeter wave frequencies. Integrated finline, image guide and its variants, non-radiative guide, H-guide and groove guide. Millimetre wave devices for generation and detection. Transitions, bends anddiscontinuities.	18
Monolithic circuit components planar transmission lines, lumped and distributed passive elements.	4
Total	**40**

Course Outcome:

- Specify high frequency systems including RF and Microwave systems
- Design high frequency amplifiers, oscillators, mixers, resonators and filters and printed circuit boards
- Build and test high frequency circuits operating up to microwave frequencies
- Understand the complete design process.

Reference books:

1. D.M.Pozar, " Microwave engineering" ,Wiley, 4th edition, 2011.
2. Bahl, I. and Bhartia, P., "Microwave Solid State Circuit Design", 2nd Ed., John Wiley & Sons. 2003
3. Chang, K., Bahl, I. and Nair, V., "RF and Microwave Circuit and Component Design for Wireless Systems", Wiley Interscience. 2002
4. Bhat, B. and Koul, S.K., "Stripline Like Transmission Lines", John Wiley & Sons. 1989
5. Edwards, T.C. and Steer M.B., "Foundations for Interconnects and Microstrip Design", 3rd Ed., John Wiley & Sons. 2001
6. Koul, S.K., "Millimeter Wave and Optical Dielectric Integrated Guides and Circuits", John Wiley & Sons. 1997
7. Bhat, B. and Koul, S. K., "Analysis, Design and Applications of Finlines", Artech House. 1987
8. Koul, S.K., "Millimeter Wave and Optical Dielectric Integrated Guides and Circuits", John Wiley & Sons. 1997
9. Gonzalez, G., "Microwave Transistor Amplifiers: Analysis and Design", 2nd Ed., Prentice-Hall. 1997
10. Chang, K., Bahl, I. and Nair, V., "RF and Microwave Circuit and Component Design for Wireless Systems", Wiley Interscience. 2002

1MDC2-12: OPTIMIZATION TECHNIQUES

Course Objective:

- This course introduces the principal algorithms for linear, network, discrete, nonlinear,dynamic optimization and optimal control.
- Emphasis is on methodology and the underlying mathematical structures.
- Modeling of the real-world problem and simulate it.

Topics	Hours
Introduction: Historical development, application to engineering problems, statement of optimization, classification of optimization, examples of optimization problems.	5
Linear Programming: Graphical method, simplex method, revised simplex method, Big-M method, 2- phase method, alternate optimal solutions, unbounded LPs, degeneracy and convergence, duality in linear programming, sensitivity analysis, dual simplex method, Transportation, assignment and other applications.	10
Non-Linear Programming: Unconstrained optimization techniques, direct search methods (Fibonacci method, golden section, quadrature and cubic interpolation) descent methods, constrained optimization, direct and indirect methods, optimization with calculm, kuhn-tucker conditions.	10
Dynamic Programming: Multistage decision process, principles of optimality, computational procedures in dynamic programming.	5
PID parameters optimization by using these techniques: Particle Swarm Optimization (PSO), Bacteria Foraging Algorithm (BFA), Genetic Algorithm (GA), and Ant colony optimization (ACO), Swarm Optimization Method (SMO), Artificial bee colony (ABC), grey wolf optimization (GWO), whale optimization algorithm (WOA), Sine Cosine algorithm (SCA)	10
Total	**40**

Course Outcomes:

- Understand importance of optimization
- Apply basic concepts of mathematics to formulate an optimization problem
- Analyze and appreciate variety of performance measures for various optimizationproblems

Reference books:

1. Hiller and Lieberman, "Introduction to Operation Research" 7th Edition, Tata McGrawHill, 2000.
2. Ravindran Philips and Solberg, "Operation Research Principles and Practice"2nd Edition, Wiley India, 2007.
3. Research Papers in PID Parameter Optimization.

1MDC2-13: DETECTION AND ESTIMATION THEORY

Course Objective:

- Introduction to the fundamentals of detection and estimation theory involving signal and system models.
- Students should have enough understanding of the main concepts and algorithms of detection and estimation theory for practical applications as well as for their research.

Topics	Hours
Hypothesis testing: bayes, minimax and Neyman-Pearson criteria. Types of estimates and error bounds.	12
Parameter Estimation: Least square, generalized and recursive least square, Estimator properties including error bounds and convergence, MES, ML and MAP estimators. General Gaussian problem.	14
Detection and estimation in colored noise. Elements of sequential and non-parametric detection.	8
Applications to communication, radar and sonar systems.	6
Total	**40**

Course Outcomes:

- Understand the mathematical background of signal detection and estimation
- Formulate and solve problems for signaldetection and parameter estimation from noisy signals.
- Derive and apply filtering methods for parameter estimation.

Reference books:

1. S. M. Kay, "Fundamentals of statistical signal processing: Estimation theory," 2nd Edition, Englewood Cliffs, NJ: Prentice-Hall, 1993.
2. H.V. Poor, "An Introduction to Signal Detection and Estimation", 2nd Edition, Springer-Verlag, 1994.
3. Gelman, J.B. Carlin, H.S. Stern, and D.B. Rubin, "Bayesian Data Analysis", 2nd Edition, Chapman &Hall, 2004.
4. L. Wasserman, "All of Statistics" New York:Wiley, 2004.

1MDC2-14: Advanced Computer Network

Course Objective:

- This course aims to provide advanced background on relevant computer networking topics to have a comprehensive and deep knowledge in computer networks
- Build an understanding of the fundamental concepts of data communication.
- Familiarize the student with the basic taxonomy and terminology of the networking area.

Topics	Hours
Overview of Internet-Concepts, challenges and history. Overview of -ATM. TCP/IP Congestion and Flow Control in Internet-Throughput analysis of TCP congestion control. TCP for high bandwidth delay networks. Fairness issues in TCP.	8
Real Time Communications over Internet. Adaptive applications. Latency and throughput issues. Integrated Services Model (intServ). Resource reservation in Internet. RSVP.;Characterization of Traffic by Linearly Bounded Arrival Processes (LBAP). Leaky bucket algorithm and its properties.	8
Packet Scheduling Algorithms-requirements and choices. Scheduling guaranteed service connections. GPS, WFQ and Rate proportional algorithms. High speed scheduler design. Theory of Latency Rate servers and delay bounds in packet switched networks for LBAP traffic.;Active Queue Management - RED, WRED and Virtual clock. Control theoretic analysis of active queue management.	8
IP address lookup-challenges. Packet classification algorithms and Flow Identification-Grid of Tries, Cross producting and controlled prefix expansion algorithms.	4
Admission control in Internet. Concept of Effective bandwidth. Measurement based admission control. Differentiated Services in Internet (DiffServ). DiffServ architecture and framework.	8
IPV4, IPV6, IP tunneling, IP switching and MPLS, Overview of IP over ATM and its evolution to IP switching. MPLS architecture and framework. MPLS Protocols. Traffic engineering issues in MPLS.	4
Total	**40**

Course Outcome:

- Explain different component of computer networks, various protocols,modern technologies and their application.
- Demonstrate and understand internetworking principles and how the Internet protocols IP, IPv6 operate.
- Design and implement network protocol for different application

Reference books:

1. Jean Wairand and PravinVaraiya, "High Performance Communications Networks", 2nd edition, 2000.
2. Jean Le Boudec and Patrick Thiran, "Network Calculus A Theory of Deterministic Queueing Systems for the Internet", Springer Veriag, 2001.
3. Zhang Wang, "Internet QoS", Morgan Kaufman, 2001.
4. Anurag Kumar, D. Manjunath and Joy Kuri, "Communication Networking: An Analytical Approach", Morgan Kaufman Publishers, 2004.
5. George Kesidis, "ATM Network Performance", Kluwer Academic, Research Papers, 2005

1MDC2-15: STATISTICAL SIGNAL PROCESSING

Course Objective:

- Introduce advanced techniques in statistical signal processing with applications in the different domain
- Introduction to the statistical approaches in signal processing and adaptive filters
- Introduction to the different spectrum estimation method.

Topics	Hours
Linear Algebra: vectors, matrices, eigenvalues and eigenvectors. \	4
Discrete-time Random Processes: Gaussian processes, filtering, types-MA, AR, ARMA processes.	6
Linear prediction and optimum linear filters: forward and backward linear prediction, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction.	10
Adaptive Filters: FIR adaptive filters, LMS algorithm, and Recursive Least Square algorithm, frequency domain & sub-band adaptive filters, applications.	10
Spectrum Estimation: Nonparametric Methods, Parametric Methods, Minimum-Variance Spectrum Estimation, Eigen analysis Algorithms for Spectrum Estimation.	10
Total	**40**

Course Outcomes:

- Characterize and apply probabilistic techniques in modern decision systems, such asinformation systems, receivers, filtering and statistical operations.
- Demonstrate mathematical modelling and problem solving using such models.
- Comparatively evolve key results developed in this course for applications to signalprocessing, communications systems.
- Develop frameworks based in probabilistic and stochastic themes for modelling andanalysis of various systems involving functionalities in decision making, statisticalinference, estimation and detection.

Reference books:

1. M.H.Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons Inc., 2002.
2. S.Haykin, "Adaptive Filter Theory", 4th Edition, Prentice Hall, 2001.
3. D.G.Manolakis, V.K.Ingle and S.M.Kogon,"Statistical and AdaptiveSignal Processing", McGraw Hill, 2000.

1MDC2-16: SATELLITE COMMUNICAITON

Course Objective:

- To provide an in-depth understanding of different concepts used in a satellite communication system.
- To explain the tools necessary for the calculation of basic parameters in a satellite communication system.
- To get knowledge of every aspects of satellite communication like orbital mechanics, launching techniques, satellite link design, earth station technology and different access system towards a satellite.

Topics	Hours
Architecture of Satellite Communication System: Principles and architecture of satellite Communication, Brief history of Satellite systems, advantages, disadvantages, applications, and frequency bands used for satellite communication and their advantages/drawbacks.	8
Orbital Analysis: Orbital equations, Kepler's laws of planetary motion, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc. of a satellite, concepts of Solar day and Sidereal day.	8
Satellite sub-systems: Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Attitude and orbit control system (AOCS), Communication sub-system, power sub-systems, antenna sub-system.	8
Typical Phenomena in Satellite Communication: Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift.	4
Satellite link budget: Flux density and received signal power equations, Calculation of System noise temperature for satellite receiver, noise power calculation, drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions, Case study of Personal Communication system (satellite telephony) using LEO.	8
Modulation and Multiple Access Schemes used in satellite communication. Typical case studies of VSAT, DBS-TV satellites and few recent communication satellites launched by NASA/ ISRO. GPS.	4
Total	**40**

Course Outcomes:

- Visualize the architecture of satellite systems as a means of high speed, high range communication system.
- State various aspects related to satellite systems such as orbital equations, sub-systems in asatellite, link budget, modulation and multiple access schemes.
- Solve numerical problems related to orbital motion and design of link budget for the givenparameters and conditions.

Reference books:

1. Timothy Pratt and Others, "Satellite Communications", 2nd edition Wiley India, 2010.
2. S. K. Raman, "Fundamentals of Satellite Communication", PearsonEducation India,2011.
3. Tri T. Ha, "Digital Satellite Communications", Tata McGraw Hill, 2009.
4. Dennis Roddy, "Satellite Communication", 4th Edition, McGraw Hill, 2008.

1MCC3-21: Research Methodology and IPR

Course Objective:

- To give an overview of the research methodology and explain the technique of defining a researchproblem.
- To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
- To explain the art of interpretation and the art of writing research reports.
- To explain various forms of the intellectual property, its relevance and business impact in thechanging global business environment.

Topics	Hours
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.	5
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	4
Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	5
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	5
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	4
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	5
Total	28

Course Outcomes:

- Understand research problem formulation.
- Analyze research related information.
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Reference books:

1. Stuart Melville and, WayneGoddard,"Researchmethodology: An introductionfor science & engineering students" 2nd Edition, Juta & Company, 2004
2. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners" 5th edition, AGE Publications Ltd, 2019.
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

4. Mayall, “Industrial Design”, McGraw Hill, 1992.
5. Niebel, “Product Design”, McGraw Hill, 1974.
6. Asimov, “Introduction to Design”, Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in NewTechnologicalAge”, 2016.
8. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

1MDC1-06: DIGITAL COMMUNICAITON SYSTEM LAB

1. PCM AND LINK ANALYSIS: Link establishment, Noise on PCM link, Error detection, BER calculation, Error correction.
2. TDM. DIGITAL MODULATION TECHNIQUES: ASK, FSK, PSK, QPSK Modulation and Demodulation.
3. CDMA – DSSS: Modulation, Demodulation & BER measurement.

REAL TIME SIGNAL ANALYSIS ON DSP KITS:

4. FIR Digital Filter Design
5. IIR Digital Filter Design
6. FFT of a given signal
7. Plot PSD/Power Spectrum of a signal
8. Adaptive Filter Design using Standard LMS Algorithm
9. Speech analysis using L.P.C.

1MDC1-07: MODELING & SIMULATION LAB

SIMULATION IN MATLAB ENVIRONMENT

1. Perform simulation to estimate the performance of the following Digital Communication Systems in the presence of noise (AWGN) using coherent detection of signals in noise. (Maximum Likelihood Decoding). Plot the bit error rate (BER) as a function of signal energy per bit-to-noise spectral density ratio, E_b/N_o.
   (i). Binary Phase Shift Keying (BPSK)
   (ii). Binary Frequency Shift Keying (BFSK)
   (iii). Quadrature Phase Shift Keying (QPSK)
   (iv).16-Quadrature Amplitude Modulation (16-QAM)
2. Design FIR filters (low pass, high pass, band pass and band stop), using window techniques.
3. Design IIR filters (low pass, high pass, band pass and band stop), using bilinear transformation.
4. Investigate the effect of coefficient quantization on the following aspects of filter behavior for the filters designed in 2 and 3.
   (i). pole-zero movement
   (ii). frequency response
   (iii). impulse response
5. Perform simulation to estimate the performance of Direct-Sequence Spread Spectrum with coherent Binary Phase-Shift Keying in the presence of noise and interference.
6. Implement the LMS algorithm for coefficient adjustment of the adaptive FIR filter for a given input signal and a desired response.
7. Decomposition & denoising of signal using Wavelet Transform.

SEMESTER II

2MDC1-01: WIRELESS AND MOBILE COMMUNICATION

Course objective:

- To expose the students to understand mobile radio communication principles and to study the recent trends adopted in cellular systems and wireless standards.
- Introduce concept of cellular communication, mobile radio propagation and generation of cellular standard

Topics	Hours
Cellular Communication Fundamentals: Cellular system design, Frequency reuse, cell splitting, handover concepts, Co channel and adjacent channel interference, interference reduction techniques and methods to improve cell coverage, Frequency management and channel assignment.	4
GSM architecture and interfaces, GSM architecture details, GSM subsystems, GSM Logical Channels, Data Encryption in GSM, Mobility Management, Call Flows in GSM.2.5 G Standards: High speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS), 2.75 G Standards: EDGE,	6
Spectral efficiency analysis based on calculations for Multiple access technologies: TDMA, FDMA and CDMA, Comparison of these technologies based on their signal separation techniques, advantages, disadvantages and application areas. Wireless network planning (Link budget and power spectrum calculations).	6
Mobile Radio Propagation: Large Scale Path Loss, Free Space Propagation Model, Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering, Practical Link Budget Design using Path Loss Models, Outdoor Propagation Models, Indoor Propagation Models, Signal Penetration into Buildings. Small Scale Fading and Multipath Propagation, Impulse Response Model, Multipath Measurements, Parameters of Multipath channels, Types of Small-Scale Fading: Time Delay Spread; Flat, Frequency selective, Doppler Spread; Fast and Slow fading.	10
Equalization, Diversity: Equalizers in a communications receiver, Algorithms for adaptive equalization, diversity techniques, space, polarization, frequency diversity, Interleaving.	4
Code Division Multiple Access: Introduction to CDMA technology, IS 95 system Architecture, Air Interface, Physical and logical channels of IS 95, Forward Link and Reverse link operation, Physical and Logical channels of IS 95 CDMA, IS 95 CDMA Call Processing, soft Handoff, Evolution of IS 95 (CDMA One) to CDMA 2000, CDMA 2000 layering structure and channels.	6
Higher Generation Cellular Standards:3G Standards: evolved EDGE, enhancements in 4G standard, Architecture and representative protocols, call flow for LTE, VoLTE, UMTS, introduction to 5G	4
Total	**40**

Course Outcomes:
At the end of this course, students will be able to

- Design appropriate mobile communication systems.
- Apply frequency-reuse concept in mobile communications, and to analyze its effects on

interference, system capacity, handoff techniques

- Distinguish various multiple-access techniques for mobile communications e.g. FDMA, TDMA, CDMA, and their advantages and disadvantages.
- Analyze path loss and interference for wireless telephony and their influences on a mobilecommunication
  system's performance.
- Understanding upcoming technologies like 3G, 4G etc.

Reference books:

1. V.K.Garg, J.E.Wilkes, "Principle and Application of GSM", Pearson Education, 5th edition, 2008.
2. V.K.Garg, "IS-95 CDMA & CDMA 2000", Pearson Education, 4th edition, 2009.
3. T.S.Rappaport, "Wireless Communications Principles and Practice", 2nd edition, PHI,2002.
4. William C.Y.Lee, "Mobile Cellular Telecommunications Analog and Digital Systems", 2nd edition, TMH, 1995.
5. Asha Mehrotra, "A GSM system Engineering" Artech House Publishers Bosten, London,1997.

2MDC1-02: ANTENNA THEORY AND TECHNIQUES

Course Objective:

- Introduce the student to antennas, covering their principles of radiation, their basic parameters, (radiation resistance, radiation pattern, polarization, reciprocity, effective radiated power), their general types, and those commonly used in wireless systems.
- The course reviews Electromagnetic Theory and electromagnetic wave properties. The student also learns the various propagation mechanisms/impairments and the basic models of propagation. Atmospheric and weather effects are also reviewed.
- Introduce different type of antenna and its applications.

Topics	Hours
Review of the theory of electromagnetic radiation. Introduction to various antenna types wire, loop and helical antennas, analysis using assumed current distribution.	8
Aperture antennas: slot, wave guide, horn, and reflector antennas. Analysis using field equivalence principle and Fourier transform methods. Linear arrays. Traveling wave & broadband antennas. Antenna measurements.	12
Printed antennas: Feeding methods, transmission line & cavity models, analysis and design of rectangular & circular microstrip antenna. Arrays: pattern synthesis, planar arrays, phased arrays. Active antennas andarrays.	12
Paraboloidal reflector antenna, different feed configurations, shaped beam antennas, lens antenna. Antennas for biomedical applications. Smart antennas for mobile communications. Antenna for infrared detectors.	8
Total	**40**

Course Outcomes:

- Compute the far field distance, radiation pattern and gain of an antenna for given currentdistribution.
- Estimate the input impedance, efficiency and ease of match for antennas.
- Compute the array factor for an array of identical antennas.
- Design antennas and antenna arrays for various desired radiation pattern characteristics.

Reference books:

1. John D. Kraus, Ronald J. Marhefka, "Antennas", 3rd Edition, McGraw-Hill Science, 2001.
2. ,E.C. Jordan And K.G. Balmain, "Electromagnetic Waves And Radiating Systems",2nd EditionPrentice Hall India, 1964.
3. Constantine A. Balanis, "Antenna Theory: Analysis And Design", 4th Edition, John Wiley &Sons, 2016.
4. Robert S. Elliott, John, "Antenna Theory & Design", Revised Edition, Wiley &Sons, 2003.
5. G. S. N. Raju, "Antennas AndWave Propagation",Pearson, 2004.
6. A.R. Harish, M. Sachidananda, "Antennas AndWave Propagation",Oxford, 2007.
7. Y. T. Lo, S. W. Lee, "Antenna Handbook: Antenna Theory",Springer, 1994.
8. ,Chatterjee, R, "Antenna Theory And Practice", New AgeInternational, 1998.

2MDC2-11: MICRO-ELECTRO-MECHANICAL-SYSTEMS (MEMS)

Course Objective:

- Knowledge of the fabrication of different microelectronics system.
- Able to design a MEMS device with given constraints.
- Familiarize about Integration and Packaging of Microelectromechanical Systems.

Topics	Hours
Micro electro mechanical system (MEMS) origins. MEMS impetus/ motivation. Material for MEMS.	8
The toolbox: processes for micro machining. MEMS fabrication technologies.	10
Fundamentals MEMS device physics: Actuation.	5
Fundamental MEMS devices: The cantilever beam.	5
Microwave MEMS applications: MEM switch design considerations. The micro-machined transmission line. MEMS-based microwave circuit and system.	12
Total	**40**

Course Outcome:

- Understand basic microfabrication techniques used for fabricating MEMS devices.
- Able to identify and model mechanical stress in MEMS devices.
- Understand working principles of MEMS sensors.
- Explore the Integration and Packaging of Microelectromechanical Systems.

Reference books:

1. Max J. Madou: "Fundamentals of Micro Fabrication", The science of miniaturization-, Nanogen corporation, USA, CRCpress, 2002.
2. Sergey Edward Lyshevski, "Nano-And Micro Electro Mechanical Systems", 2nd Edition, CRC press, Boca RatronLondon, 2002.
3. Sherifsedky: "Integrated MEMS"- Artech House, BostonLondon.
4. N. Maluf,"Introduction To Micro Mechanical Systems Engineering", 2nd Edition, ArtechHouse, 2004.
5. Tai – Ran Hsu,"Memsand Micro Systems: Design and Manufacture" Tata Mc GrawHill 2002.

2MDC2-12: ADVANCED OPTICAL COMMUNICATION

Course Objective:

- The fundamentals of optical signals and modern optical devices and systems from a practical point of view.
- Its goal is to help the student develop a thorough understanding of the underlying physical principles such that device and system design and performance can be predicted, analyzed, and understood.

Topics	Hours
Optical fibers: review of fundamentals, Signal distortion and attenuation, Intermodal and intramodal dispersion, dispersion flattened and dispersion compensated fibers, Profile dispersion, study of PMD. Laser diode and photodiode, Photodetector noise analysis, Analog and Digital communication link design.	12
WDM, DWDM, optical couplers, Mach-Zehnder interferometer multiplexer, optical add/drop multiplexers, isolators, circulators, optical filters, tunable sources and tunable filters, arrayed waveguide grating, diffraction grating, optical amplifiers, optical integrated circuits. Characterization of optical fibers,	10
OTDR SONET: frame format, overhead channels, payload pointer, Virtual tributaries, multiplexing hierarchy.	6
SDH: Standards, frame structure and features.Optical switching, WDM networks,	6
Classification of optical sensors. Intensity modulated, phase modulated and spectrally modulated sensors.	6
Total	**40**

Course Outcome:

- Apply the fundamental principles of optics and light wave to design optical fiber communication systems.
- 10Differentiate losses in optical fiber link and state transmission characteristics of optical fiber.
- Design optical fiber communication links using appropriate optical fibers light sources, detectors.
- Explore concept of designing and operating principles of modern optical systems and networks
- Apply different network access schemes and packet switching in OFC systems

Reference books:

1. De, Anuradha, "Optical FiberandLaserPrinciples and Applications", NewAge, 2009.
2. Sarkar,D.C, "Opto Electronics andFiber Optics Communication, New Age publishers, 2001
3. G P Agrawal, Govind P Agrawal, "Optical Fiber Communications: Principles And Practice", 3rd Edition, Wiley, 2007.
4. Johan Gowar, "Optical Communication System", 2nd Edition, Prentice Hall, 1993.
5. R.P. Khare, "Fiber Optics andOptoelectronics",Oxford, 2004.
6. BiswanathMukherjee, "Optical WdmNetworks - Principles andPractice", 6th Edition, Oxford, 2013.
7. John M Senior , "Optical Fiber Communication: Principles andPractice", 3rd Edition,Pearson, 2009.
8. Joseph C. Palais, "Optical Communication", 5th Edition, Pearson, 2005.
9. Gerd Keiser, "Optical Fiber Communications", 4th Edition, TMH, 2008.
10. Selvarajan A, Kar S, Srinivas T, "Optical Fiber Communication: Principles andSystems",TMH, 2003.

2MDC2-13: ARTIFICIAL NEURAL NETWORKS

Course Objective:

- To provide an introduction to the field of artificial neural networks and its application in different fields
- To teach students how to solve practical problems via implementation of these techniques via simulation;
- To promote further independent learning on the topics of artificial neural networks

Topics	Hours
Introduction: Biological neurons and memory: Structure and function of a single neuron, artificial neural networks (ANN), typical applications of ANNs: classification, clustering, vector quantization, pattern recognition, function approximation, forecasting, control, optimization, basic approach of the working of ANN - training, learning and generalization.	10
Supervised Learning: single-layer networks, perceptron-linear separability, training algorithm, limitations; multi-layer networks-architecture, back propagation algorithm (BTA) and other training algorithms, applications. Adaptive multi-layer networks-architecture, training algorithms, recurrent networks, feed- forward networks, radial-basis-function (RBF) networks.	10
Unsupervised Learning: Winner-takes-all networks, hamming networks, maxnet, simple competitive learning, vector-quantization, counter propagation networks, adaptive resonance theory, Kohonen's Self- organizing Maps, principal component analysis.	10
Associated Models: Hopfield Networks, brain-in-a-box network, Boltzmann machine. Optimization Methods: Hopfield Networks for-TSP, solution of simultaneous linear equations, Iterated gradient descent, simulated annealing, genetic algorithm.	10
Total	**40**

Course Outcome:

- Explain ANN and its applications
- Design single and multi-layer feed-forward neural networks.
- Implement and apply different supervised and unsupervised learning methods
- Formalize the problem, to solve it by using a neural network.

Reference books:

1. S. Shivanandam, S.Sumathi, "Introduction To Neural Network Using Matlab", Tata McGraw-Hill, 2006.
2. Jacek M. Zurada, "Introduction to Artificial Neural Systems", West Group, 1992.
3. B. YEGNANARAYANA, "ARTIFICIAL NEURAL NETWORKS"
4. RobertSchalloff, "Artificial Neural Network", TMH.
5. Laurene V. Fausett, "Fundamental of Neural Network Architecture and Application",Pearson.
6. JamesAFreeman, "Neural Networks: Algorithms, Applications, and Programming Techniques",Pearson, 1991.
7. Cristopher,M.Bhishop, "Neural N/W For Pattern Recognition", Oxford.
8. Raymond S.T. Lee, "Fuzzy Neuro Approach to Agent Application",NewAge, 2006.

2MDC2-14: INFORMATION THEORY & CODING

Course Objective:

- Introduce the principles and applications of information theory.
- To teach study how information is measured in terms of probability and entropy, and the relationships among conditional and joint entropies.
- To teach coding schemes, including error correcting codes.
- Explain how this quantitative measure of information may be used in order to build efficient solutions to multitudinous engineering problems.

Topics	Hours
Shannon's fundamental coding theorems, Differential entropy & mutual information for discrete & continuous ensembles, source coding, Rate distortion theory.	16
Introduction to Algebra: Groups, fields, Binary field arithmetic, Basic properties of Galois field GF(2m)and vector spaces.	12
Channel coding & decoding: Run length limited codes, LBC, cyclic code, BCH code, convolutional code, Trellis coded modulation, Reed-Solomon code.	12
Total	**40**

Course Outcome:

- Apply information theory and linear algebra in source coding and channel coding
- Understand various error control encoding and decoding techniques
- Analyze the performance of error control codes
- Calculate the information content of a random variable from its probability distribution.
- Relate the joint, conditional, and marginal entropies of variables in terms of their coupled probabilities.
- Construct efficient codes for data on imperfect communication channels.

Reference books:

1. Golomb, Solomon W., Peile, Robert E., Scholtz, Robert A, "Basic Concepts In Information Theory And Coding", Springer, 1994.
2. Raymond W. Yeung, "Information Theory And Network Coding",Springer, 2008.
3. by Herbert Taub, Donald Schilling, GoutamSaha, "Taub'sPrinciples Of Communication Systems", 3rd Edition, McGraw Hill Education, 2007.
4. Ian Glover, "Digital Communication", 3rd Edition, Pearson, 2010.
5. B.P. Lathi and Zhi Ding, "Modern Digital And Analog Communication Systems",5th Edition,Oxford, 2018.
6. Digital Communications, Simon Haykin,Wiley
7. Digital And Analog Communication Systems, K.SamShanmugam,Wiley
8. An Introduction To Analog And Digital Communication System, Simon Haykin,Wiley
9. Principle Of Digital Communication, J.Das, NewAge
10. Digital Commnunication, Barry John, Le, Edward, David.G,Springer

2MDC2-15: DIGITAL IMAGE PROCESSING

Course Objective:

- Introduce basic theories and algorithms used to develop tools for acquiring, enhancing, transmitting, and analyzing digital images.
- Introduce fundamental technologies for digital image representation, compression, analysis, and processing.
- Students will gain understanding of algorithm/system design, analytical tools, and practical implementations of various digital image applications.

Topics	Hours
Human visual system and image perception, monochrome &color vision models, color representation; image sampling & quantization; 2-D systems.	10
Image transforms; image coding, stochastic models for image representation, image enhancement, restoration & reconstruction, image analysis using multiresolution techniques.	15
Wavelet Transform for Image Processing: Continuous wavelet transform, discrete wavelet transform, multi-resolution analysis, image compression.	15
Total	**40**

Course Outcomes:

- Demonstrate the image formation model.
- Apply different techniques for image enhancement, restoration.
- Understand the need for image compression and to learn the spatial and frequency domain techniques of image compression.
- Apply different image processing techniques in real time application.

Reference books:

1. Digital Image Processing Using MATLAB, Gonzalez, Woods and Eddins, GatesmarkPublishing
2. Digital Image Restoration, Andrews, H.C. Hunt, B.R., Prentice Hall, EnglewoodCliffs.
3. Applications of Digital Signal Processing, Oppenheim, A.V.,Prentice Hall EnglewoodCliffs.
4. Digital Image Processing, Gonzalez, R.C. and Wintz, P.A., Reading,Addison-Wesley.
5. Digital Image Processing, Pratt, W.K., New York:Wiley
6. Digital Image Processing of Remotely Sensed Data, Hord, R.M., AcademicPress.
7. Fundamentals of Digital Image Processing, Jain, A.K., PrenticeHall
8. Algorithms for Graphics and Image Processing, Pavlidis, T., Computer SciencePress
9. Selected Papers on Digital Image Processing, Trivedi, M.M., Optical EngineeringPress.
10. The Image Processing Handbook, Ross, J.C., CRC Press, BocaRaton

2MDC2-16: TELECOMMUNICATION SWITCHING & NETWORKS

Course Objective:

- This subject aims at introducing different circuit switching and signaling schemes, access control protocols and internetworking.

Topics	Hours
Principles of circuit switching &signaling schemes, space time & space time division switching, single stage & multi stage switching network. Traffic engineering and teletraffic theory.	10
Markov processes representing traffic, calculation of blocking probability.	6
Modeling and analysis of important media access control protocols:ALOHA, slotted ALOHA, CSMA, CSMA/CD.	8
LAN: Ethernet, token ring, FDDI.	4
B-ISDN architecture, B-ISDN protocols, ATM traffic & congestion control, signaling, routing and addressing, Internetworking: switches, bridges, routers, gateways. ATM switching.	12
Total	**40**

Course Outcomes:

- Understand the principles of the internal design and operation of telecommunication switches, and the essence of the key signaling systems that are used in telecommunication networks.
- Explain and demonstrate different media access control protocols
- Analyze basic telecommunication traffic theory

Reference books:

1. John C. Bellamy, "Digital Telephony",3rd Edition,Wiley, 2002.
2. Simon Ramo, John R. Whinnery, Theodore Van Duzer, "Fields and Waves inCommunication Electronics", 3rd Edition, Wiley, 1994.

2MDC1-06: Antennas and Radiating Systems Lab.

List of Experiments:

1. Study of antenna parameters i.e., S-parameters, VSWR, Gain, Directivity, Radiation Mechanism, Field Zones, Axial ratio, Polarization, HPBW, Impedance matching, antenna modeling.
2. Design and Simulation of half wave dipole antenna.
3. Design and Simulation of quarter wave, full wave antenna and comparison of their parameters.
4. Design and Simulation of a half wave dipole antenna array (Broadside and End fire array).
5. Design and simulation of various types of Horn antenna.
6. Design & simulation of Pyramidal Horn antenna.
7. Study of different types of Reflector antenna. Design and Simulation of Parabolic reflector antenna.
8. Design and Development of Rectangular Microstrip antenna with microstrip inset feed. Compare the simulated and measured parameters (Return loss, VSWR, E- and H-plane radiation Pattern, Directivity, Gain, HPBW, etc.).
9. Design and Development of Circular Microstrip antenna with probe feed. Compare the simulated and measured parameters (Return loss, VSWR, E- and H-plane radiation Pattern, Directivity, Gain, HPBW, etc.).
10. Design and Simulation of 4-element microstrip antenna array using power divider.
11. Study the recent developments in antennas for wireless technologies and submit a report.

2MDC1-07: Wireless and Mobile Communication Lab.

List of Experiments:

1. Understanding Cellular Fundamentals like Frequency Reuse, Interference, cell splitting, multi path environment, Coverage and Capacity issues using communication software.
2. Knowing GSM and CDMA architecture, network concepts, call management, call setup, call release, Security and Power Control, Handoff Process and types, Rake Receiver etc.
3. Study of GSM handset for various signaling and fault insertion techniques (Major GSM handset sections: clock, SIM card, charging, LCD module, Keyboard, User interface).
4. To study transmitters and receiver section in mobile handset and measure frequency band signal and GMSK modulating signal.
5. To study various GSM AT Commands their use and developing new application using it. Understating of 3G Communication System with features like; transmission of voice and
6. videocalls, SMS, MMS, TCP/IP, HTTP, GPS and File system by AT Commands in 3G
7. network.
8. Study of DSSS technique for CDMA, observe effect of variation of types of PN codes, chip rate, spreading factor, processing gain on performance.
9. To learn and develop concepts of Software Radio in real time environment by studying the building blocks like Base band and RF section, convolution encoder, Interleaver and De-Interleaver.
10. To study and analyze different modulation techniques in time and frequency domain using SDR kit.

SEMESTER III

3MDC2-11: MIMO Systems

Course objective:

- Introduce fundamental of wireless communication syatem and diversity and spatial multiplexing phenomenon in MIMO systems.
- Introduce OFDM and MIMO-OFDM and different channel estimation technique.
- Introduce challenges involved in developing and incorporating MIMO design in practical wireless systems.

Topics	Hours
Introduction to Multi-antenna Systems, Motivation, Types of multi-antenna systems, MIMO vs. multi-antenna systems.	4
Diversity, exploiting multipath diversity, transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing, Spectral efficiency and capacity, Transmitting independent streams in parallel, Mathematical notation.	8
The generic MIMO problem, Singular Value Decomposition, Eigenvalues and eigenvectors, Equalizing MIMO systems, Disadvantages of equalizing MIMO systems, Pre- distortion in MIMO systems, Disadvantages of pre-distortion in MIMO systems, Pre-coding and combining in MIMO systems, Advantages of pre-coding and combining, Disadvantages of pre- coding and combining, Channel state information.	8
Codebooks for MIMO, Beamforming, Beamforming principles, Increased spectrum efficiency, Interference cancellation, Switched beamformer, Adaptive beamformer, Narrowband beamformer, Wideband beamformer.	6
Case study: MIMO in LTE, Codewords to layers mapping, Pre-coding for spatial multiplexing, Pre-coding for transmit diversity, Beamforming in LTE, Cyclic delay diversity based pre-coding, Pre-coding codebooks, Propagation Channels, Time & frequency channel dispersion, AWGN and multipath propagation channels, Delay spread values and time variations, Fast and slow fading environments, Complex baseband multipath channels, Narrowband and wideband channels, MIMO channel models.	8
Channel Estimation, Channel estimation techniques, Estimation and tracking, Training based channel estimation, Blind channel estimation, Channel estimation architectures, Iterative channel estimation, MMSE channel estimation, Correlative channel sounding, Channel estimation in single carrier systems, Channel estimation for CDMA, Channel estimation for OFDM.	6
Total	**40**

Course Outcome:

- Explain and demonstrate basic MIMO communication system.
- Compute performance parameters of MIMO wireless systems.
- Understand generic MIMO problems, different codes, and channel estimation techniques.

Reference books:

1. Claude Oestges, Bruno Clerckx, "MIMO Wireless Communications: From Real-world Propagation to Space-time Code Design",Academic Press, 1st edition, 2010.
2. MohinderJanakiraman, “Space - Time Codes and MIMO Systems”, Artech House Publishers, 2004.

3MDC2-12: RF and Microwave Circuit Design

Course objective:

- To explain radio frequency design concept and impart knowledge on design and implementation of RF and microwave circuit.
- To develop an ability to analyze various component of radio frequency communication system architecture.

Topics	Hours
Review of basics of Passive and Active Circuits.	2
Microwave Amplifier Design: Comparison of active devices such as BJT, MOSFET, MESFET, HEMT, and HBT; Circuit models for FETs and BJTs; Two-port power gains; Stability of transistor amplifier circuits; Amplifier design using S-parameters: Design for maximum gain, maximum stable gain, design for specified gain.	6
RF power amplifiers: Introduction, class A, AB, B, and C power amplifiers, class D amplifiers, class E amplifiers, Class F amplifiers, summery of PA characteristics, RF PA design examples LNA design: Introduction, LNA topologies- power match vs. noise match, Power constrained noise optimization, Design examples, Linearity and large-signal performance, Spurious free dynamic range	8
Mixers: Mixer characteristics: Image frequency, conversion loss, noise figure; Devices for mixers: p-n junctions, Schottky barrier diode, FETs; Diode mixers: Small-signal characteristics of diode, single-ended mixer, large-signal model, switching model; FET Mixers: Single-ended mixer, other FET mixers; Balanced mixers; Image reject mixers, Analysis of microwave mixers.	8
Mixers: Introductions, Mixer fundamentals, Nonlinear systems as linear mixers, Multiplier-based mixers, Sub sampling mixers.	6
Oscillators and Frequency Synthesizers: General analysis of RF oscillators, transistor oscillators, voltage-controlled oscillators, dielectric resonator oscillators, frequency synthesis methods, analysis of first and second order phase-locked loop, oscillator noise and its effect on receiver performance	6
Switches: Devices for microwave switches: PIN diode, BJT, FET; Device models; Types of switches; Switch configurations; Basic theory of switches; Multi-port, broad-band and isolation switches.	4
Total	**40**

Course Outcomes:

- Understand the behavior of RF passive components and model active components.
- Perform transmission line analysis.
- Demonstrate use of Smith Chart for high frequency circuit design.
- Justify the choice/selection of components from the design aspects.
- Contribute in the areas of RF circuit design.

Reference books:

1. Pozar, D.M. “Microwave and RF Design of Wireless Systems”, John Wiley & Sons. 2001
2. Gonzalez, G., “Microwave Transistor Amplifiers: Analysis and Design”, 2nd Ed., Prentice-Hall. 1997
3. Bahl, I. and Bhartia, P., “Microwave Solid State Circuit Design”, 2nd Ed., John Wiley & Sons. 2003
4. Chang, K., Bahl, I. and Nair, V., “RF and Microwave Circuit and Component Design for Wireless Systems”, Wiley Interscience. 2002
5. Rohde, U.L. and Newkirk, D.P., “RF/Microwave Circuit Design for Wireless Applications”, John Wiley & Sons. 2000
6. Larson, L.E., “RF and Microwave Circuit Design for Wireless Applications”, Artech House. 1996
7. Egan, W. F., “Practical RF Circuit Design”, John Wiley & Sons. 1998

3MDC2-13 Pattern Recognition and Machine Learning

Course Objective:

- To equip students with basic mathematical and statistical techniques commonly used in pattern recognition.
- To introduce students to a variety of pattern recognition and Machine Learning algorithms.
- Enable students to apply machine learning concepts in real life problems.

Topics	Hours
Introduction to Pattern Recognition: Problems, applications, design cycle, learning and adaptation, examples, Probability Distributions, Parametric Learning - Maximum likelihood and Bayesian Decision Theory- Bayes rule, discriminant functions, loss functions and Bayesian error analysis Linear models: Linear Models for Regression, linear regression, logistic regression Linear Models for Classification	10
Neural Network: perceptron, multi-layer perceptron, backpropagation algorithm, error surfaces, practical techniques for improving backpropagation, additional networks and training methods, Adaboost, Deep Learning	8
Linear discriminant functions - decision surfaces, two-category, multi-category, minimum- squared error procedures, the Ho-Kashyap procedures, linear programming algorithms, Support vector machine	8
Algorithm independent machine learning – lack of inherent superiority of any classifier, bias and variance, re-sampling for classifier design, combining classifiers	6
Unsupervised learning and clustering – k-means clustering, fuzzy k-means clustering, hierarchical clustering	8
Total	**40**

Course Outcomes:

- Study the parametric and linear models for classification
- Design neural network and SVM for classification
- Develop machine independent and unsupervised learning techniques.

Reference books:

- Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", 2nd Edition John Wiley & Sons, 2001.
- Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, "The Elements of Statistical Learning", 2nd Edition, 2009.

(Dissertation)
3MDC4-60: Dissertation Phase – I
3MDC4-70: Dissertation Phase – II

Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have thefollowing

- Relevance to social needs ofsociety
- Relevance to value addition to existing technologies & advancement in theinstitute
- Relevance to industry.
- Problems of nationalimportance
- Research and development in variousdomain The student should complete thefollowing:
  - Literature survey ProblemDefinition
  - Motivation for study and Objectives
  - Preliminary design / feasibility / modularapproaches
  - Implementation andVerification
  - Report andpresentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:

- Experimental verification / Proof ofconcept.
- Design, fabrication, testing of CommunicationSystem.
- The viva-voce examination will be based on the above report andwork.

Guidelines for Dissertation Phase – I and II

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January toJune.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in research lab/ industry allotted through department's/T & Pcoordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. Thereferred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization

shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.

- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with the university appointed examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work.