# Course Structure & Syllabus
# of
# M. Tech. Programme
# in
## Electronics & Telecommunication Engineering
## with Specialisation
## RF & MICROWAVE ENGINEERING
## Academic Year –2019- 20


**VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, ODISHA**
**Burla, Sambalpur-768018, Odisha**
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## DEPARTMENT VISION:

Developing new ideas in the field of communication to enable students to learn new technologies, assimilate appropriate skills and deliver meaningful services to the global society and improve the quality of life by training them with strength of character, leadership and self-attainment.

## DEPARTMENT MISSION:

- Imparting futuristic technical education to the students.
- Promoting active role of Industry in student curriculum, projects, R&D and placements. Organizing collaborative academic and non-academic programmes with institutions of national and international repute for all round development of students.
- Organizing National and International seminars and symposium for exchange of innovation, technology and information.
- Expanding curricula to cater to demands of higher studies in internationally acclaimed institutes. Preparing students for promoting self-employment.
- Develop the department as a centre of excellence in the field of VLSI and communication technology by promoting research, consultancy and innovation.

Semester I

| Sl. No. | Core/ Elective | Subject Code | Subject Name | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1 | Core-1 | | RF IC | 3 | 0 | 0 | 3 |
| 2 | Core-2 | | Radio Wave Engineering | 3 | 0 | 0 | 3 |
| 3 | PE-1 | | | 3 | 0 | 0 | 3 |
| 4 | PE-2 | | | 3 | 0 | 0 | 3 |
| 5 | Common | | Research Methodology & IPR | 2 | 0 | 0 | 3 |
| 6 | Lab-1 | | Microwave Engg. Lab I | 0 | 0 | 3 | 2 |
| 7 | Lab-2 | | Computational Electromagnetic Lab | 0 | 0 | 3 | 2 |
| 8 | Audit -1 | | English for Research Paper Writing | | | | |
| Total Credits | | | | | | | 19 |

Semester II

| Sl. No. | Core/ Elective | Subject Code | Subject Name | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1 | Core-3 | | RF & Microwave Solid State Device | 3 | 0 | 0 | 3 |
| 2 | Core-4 | | Microstrip Components & Circuits | 3 | 0 | 0 | 3 |
| 3 | PE-3 | | | 3 | 0 | 0 | 3 |
| 4 | PE-4 | | | 3 | 0 | 0 | 3 |
| 5 | Common | | Term Paper | 0 | 0 | 4 | 2 |
| 6 | Lab-3 | | Antenna & Simulation Lab | 0 | 0 | 3 | 2 |
| 7 | Lab-4 | | Microwave Engg. Lab II | 0 | 0 | 3 | 2 |
| 8 | Audit -2 | | Pedagogy Studies | | | | |
| Total Credits | | | | | | | 18 |

Semester III

| Sl. No. | Core/ Elective | Subject Code | Subject Name | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1 | PE-5 | | | 3 | 0 | 0 | 3 |
| 2 | OE-1 | | | 3 | 0 | 0 | 3 |
| 3 | Minor Project | | Project Progress Report | 0 | 0 | 20 | 10 |
| Total Credits | | | | | | | 16 |

Semester IV

| Sl. No. | Core/ Elective | Subject Code | Subject Name | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1 | Major Project | | Project & Thesis | 0 | 0 | 32 | 16 |
| Total Credits | | | | | | | 16 |

| List of Professional Elective | | |
|---|---|---|
| Sl. No. | Category | Subject Name |
| 1 | PE-I | Computational Electromagnetics |
| 2 | | Advanced Signal Processing |
| 3 | | Advanced Electromagnetics |
| 1 | PE-II | Microwave Circuits & Measurements |
| 2 | | MIC & MMIC |
| 3 | | Advanced Communication Technique |
| 1 | PE-III | Advanced Antenna Technology |
| 2 | | Smart Antenna System |
| 3 | | Microwave Remote Sensing |
| 1 | PE-IV | Metamaterials |
| 2 | | RADAR Technology & Counter Measure |
| 3 | | Radio Navigational Aids |
| 1 | PE-V | EMI &EMC |
| 2 | | Cognitive Radio |
| 3 | | RF MEMS |

| List of Open Elective |
|---|
| Basics of RF & Microwave Engineering |
| Basics of Antenna & Propagation |

## RF IC (3-1-0)

COURSE OBJECTIVE:

1. To educate students fundamental RF circuit and system design skills.
2. To introduce students, the basic RF electronics utilized in the industry and how to build up a complex RF system from basics.
3. To offer students experience on designing and simulating RF circuits in computer.

| MODULE | CONTENTS | HOURS |
|---|---|---|
| MODULE 1 | Introduction, Basic Concepts in RF Design, Passive RLC Networks, Passive IC Components and Their Characteristics. | 6 |
| MODULE 2 | Voltage references & biasing, Feedback Systems, Noise, Phase Noise. | 8 |
| MODULE 3 | High frequency amplifier design, LNA design, RF power amplifier | 10 |
| MODULE 4 | Oscillators, PLL, Synthesizers, Mixers. | 12 |
| MODULE 5 | Transceiver Architecture and Practical Design Example | 4 |
| TEXT BOOKS | 1. T. H. Lee, "*The Design of CMOS RF Integrated Circuits*", Cambridge University Press.<br>2. B. Razavi, "RF *Microelectronics*", Pearson Education. | |
| REFERENCE BOOKS | 1. B. Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw-Hill, 2002.<br>2. Sorin Voinigescu, "*High Frequency Integrated Circuits*", Cambridge University Press.<br>3. Reinhold Ludwig, Gene Bogdanov, "RF Circuit Design Theory and Applications", Pearson Education. | |

COURSE OUTCOME: After completion of course, student should be able to

1. Be conversant with RF design concepts, passive on-chip elements.
2. Understand biasing, feedback and noise.
3. Design a RF amplifier, Power amplifier, LNA.
4. Be proficient with frequency conversion and signal generation.
5. 5. Present the different transceiver architecture.

## RADIO WAVE ENGINEERING (3-1-0)

COURSE OBJECTIVE:

1. Understand the concepts of Maxwell's Equation and propagation of plane Electromagnetic wave through conductors & wave guides.
2. Familiar with different Polarization of Electromagnetic Waves
3. Methods and limitation of different propagation of waves
4. Understanding of Propagation of Radar Waves

| MODULE | CONTENTS | HOURS |
|---|---|---|
| MODULE 1 | Introduction, Maxwell's Equation, Wave Equation: Derivation & Solution, Propagation of plane EM wave through conductors & wave guide | 8 |
| MODULE 2 | Dispersion, Scattering, Diffraction & Polarization of EM Waves, | 8 |
| MODULE 3 | Radiating System, Multi-pole Fields & Radiation | 8 |

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|---|---|---|
| MODULE 4 | Basics of Wave Propagation, Ground Wave propagation, Space Wave Propagation | 8 |
| MODULE 5 | Sky Wave Propagation, Propagation of Radar Waves | 8 |
| TEXT BOOKS | 1. Electromagnetic Waves & Radiating Systems,By Jordan &Balmain, PHI (Chapters: 4, 5, 10, 16, 17)<br>2. Classical Electrodynamics, By J. D. Jackson, Wiley (Chapters: 7, 9, 10)<br>3. Antennas & Waves Propagation,By J. D. Kraus, McGraw Hill (Chapters: 4, 22, 23, 24, 25)<br>4. Introduction to Radar Systems, By M. L. Skolnik, McGraw Hill (Chapter: 8) | |

COURSE OUTCOME: After completion of course, student should be able to

1. Familiar with Maxwell's Equation
2. Able to design antennas based on various propagation such as ground wave propagation, Space Wave Propagation Sky Wave Propagation.
3. Understand concepts and relation of maximum and lowest useable frequency for all types of propagation.
4. Gain design ideas of propagation of Radar Waves.
5. Analyse Sky Wave & Radar Waves Propagation

## COMPUTATIONAL ELECTROMAGNETICS (3-1-0)

COURSE OBJECTIVE:

1.Toimpart knowledge on advance level of electromagnetic field theory.

2.Toimpart knowledge on various computational techniques such as FDM, FDTD, FEM, MoM.

3.To impart knowledge on the application of computational techniques to different electromagnetic problems.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Introduction to Numerical Methods:<br><br>Electromagnetic Problems, Basic Numerical Methods, Solution of Algebraic Equations, Accuracy Consideration and Richardson Extrapolation, Examples | 06 |
| MODULE 2 | Finite-Difference Method:<br>Finite-Differencein One Dimension, A One Dimensional Differential Equation, Finite-DifferenceinTwo Dimensions, Two Dimensional Capacitance Problem, Open Regions, Generalizations, Determination of Eigen values in One Dimension, Waveguide Mode Example, Numerical Evaluation of the Determinant, Iterative Solution Methods | 08 |
| MODULE 3 | Finite-Difference Time-Domain Method:<br>Wave Equation in One Spatial Dimension, Time Quantization, Initial Conditions, Waves in Two and Three Spatial Dimensions, Maxwell's Equations. | 08 |
| MODULE 4 | Finite Element Method:<br>Basic Concept of Finite Elements, Finite Elements in One Dimension, Linear Interpolation for Isosceles Right Triangles, Square Elements, General Triangular Elements, High Order Interpolation with Triangles, Nodal Expansions and the weak Formulation, Time Dependent Variables. | 10 |
| MODULE 5 | Method of Moments:<br>Linear Operators, Approximation by Expansion in Basis Functions, Determination of the parameters, Differential Operators, Integral Operators, Pulse Functions, Parallel Plate Capacitor in Two Dimensions, Analysis of Wire Dipole Antenna, Comparison of FDM, FDTD, FEM, and MoM. Hybrid Computational Methods | 08 |

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|---|---|
| TEXT BOOK | 1.Analytical and Computational Methods in Electromagnetics, By R.Garg, ArtechHousePublication<br>2. Computational Methods for Electromagnetics and Microwaves, By R.C Booton, Jr, , John Wiley & Sons |
| REFERENCE BOOK | 1.Computational Methods for Electromagnetics, By A. F. Peterson, S. L. Ray, and R. Mittra, IEEE Press<br>2.The Finite Element Method in Electromagnetics, By J. M. Jin, John Wiley & Sons<br>3.The finite difference time domain method for electromagnetics,By K. S. Kunz & R. J. Luebbers, CRC Press<br>4.Field Computation by Moment Methods,By R. F. Harrington, Macmillan |

COURSE OUTCOME: After completion of course student should be able to

1.It provides an impetus for the higher studies in the field of RF and Microwave engineering.

2.It provides exposure to work in the advance R&D labs such as Society for Applied Microwave Electronics Engineering and Research (SAMEER).

3.It develops intellect to work in the leading companies of the globe such as MathWorks, Texas Instruments etc.

## ADVANCED SIGNAL PROCESSING(3-1-0)

COURSE OBJECTIVE

This subject aims to provide the students to

1. Analyze the process of Sampling, aliasing and the relationship between discrete and continuous signals. Review of Fourier transforms, the Z-transform, FIR and IIR filters, and oscillators
2. Implement the Filter design techniques, structures and numerical round-off effects. Understand the Auto-correlation, cross-correlation, power spectrum estimation techniques, forward and backward Linear prediction
3. Analyze Wiener filters, LMS adaptive filters, and applications, Multi-rate signal processing and sub-band transforms. Analyze the Time-frequency analysis, the short time Fourier transform, and wavelet transforms.

| MODULE | CONTENTS | HOURS |
|---|---|---|
| MODULE 1 | ***Multi-Rate Digital Signal Processing***: Introduction, Decimation by A Factor D, Interpolation by A Factor I, Sampling Rate Conversion by Rational Factor I/D, Filter Design and Implementation for Sampling-Rate, Multistage Implementation of Sampling Rate Conversion, Sampling Rate Conversion of Band-Pass Signal, Application of Multi Rate Signal Processing: Design of Phase Shifters, Implementation pf Narrowband Low Pass Filters. Implementation of Digital Filter Banks | 8 |
| MODULE 2 | ***Linear Prediction and Optimum Linear Filters***: Innovations Representation of a Stationary Random Process, Forward and Backward Linear Prediction, Solution of The Normal Equations, Properties of The Linear Prediction Error Filters, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filter For Filtering and Prediction: FIR Wiener Filter, Orthogonality, Principle in Linear Mean-Square Estimation. | 8 |
| MODULE 3 | ***Power Spectrum Estimation***: Estimation of Spectra from Finite-Duration Observation of Signals, Non-Parametric Method for Power Spectrum Estimation: Bartlett Method, Blackman And Turkey | 8 |

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|---|---|---|
| | Method, Parametric Method for Power Estimation: Yuke-Walker Method, Burg Method, MA Model and ARMA Model. Filter Bank and - Filters and Its Applications | |
| MODULE 4 | Adaptive Signal Processing Least Mean Square Algorithm, Recursive Least Square Algorithm, Variants of LMS Algorithm: SK-LMS, N-LMS, FX-LMS. Adaptive FIR & IIR Filters, Application of Adaptive Signal Processing: System Identification, Channel Equalization, Adaptive Noise Cancellation, Adaptive Line Enhancer. | 10 |
| MODULE 5 | HOS- Higher Order Statistics: Definitions and Properties, Moments, Cumulants, Blind Parameters and Order Estimation of MA & ARMA Systems. Application of Higher Order Statistics: Applications to Signal Processing and Image Processing. | 6 |
| TEXT BOOKS | 1. J.G. Proakis and D.G. Manolakis, "Digital Signal Processing", 3rd Edition, PHI. | |
| REFERENCE BOOKS | 1. Oppenheim and Schafer, "Digital Signal Processing", PHI<br>2. B. Widrow and Stern, "Adaptive Signal Processing", PHI,1985 | |

COURSE OUTCOME

After completion of this course, students should be able to

1. Have a more thorough understanding of the relationship between time and frequency domain interpretations.
2. Implementations of signal processing algorithms.
3. Be familiar with some of the most important advanced signal processing techniques, including multi-rate processing and time-frequency analysis techniques
4. Understanding power spectrum estimation techniques.
5. Understand and be able to implement adaptive signal processing algorithms based on second order statistics.

## Advanced Electromagnetics(3-1-0)

COURSE OBJECTIVE:

1. To acquire the knowledge of Advanced Electromagnetic field theory that allows the student to have a solid theoretical foundation to be able in the future to design emission, propagation and reception of electromagnetic wave systems.
2. To identify, formulate and solve fields and electromagnetic waves propagation problems in a multidisciplinary frame individually or as a member of a group.
3. To provide the students with a solid foundation in engineering fundamentals required to solve problems and also to pursue higher studies.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | The Dirac Delta & its representation for infinitesimal dipole, magnetic current & magnetic current density, inadequacies in Maxwell's equations, impossibility of TEM in waveguide. | 8 |

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|---|---|---|
| MODULE 2 | Huygens's principle, Babinet's principle, holography, correlation between circuit theory & field theory, derivation of circuit relations from field theory, bridging the gap between electricity & magnetism using relativity, interaction of fields & matter. | 8 |
| MODULE 3 | Dielectric slab waveguide & its application to optical communication, plasma oscillations & wave propagation in plasma, dielectric resonator, Faraday rotation, Schumann resonance, tropo-scatter propagation, earth as a cavity resonator, scattering & diffraction. | 8 |
| MODULE 4 | Bio-electromagnetics: Introduction, the axon, retinal optical fibers, heart dipole field, defibrillators & pacemakers, biological fields, electromagnetic hazards & environment | 8 |
| MODULE 5 | Introduction of tensors, Special theory of relativity & its applications in electromagnetics | 8 |
| TEXT BOOK | 1. Electromagnetic Waves & Radiating Systems, By Jordan & Balmain, PHI.<br>2. Maxwell's Equations & The Principles of Electromagnetism, By R. Fitzpatric, Infinity Science Press LLC. | |
| REFERENCE BOOK | 1. Classical Electrodynamics, By J D Jackson, Wiley.<br>2. Introduction to Electromagnetic Fields, By C. R. Paul, K. W. Whites, Syed A. Nasar, McGraw Hill.<br>3. Concepts of Modern Physics, By A. Beiser, Mc Graw Hill | |

COURSE OUTCOME: After completion of course student should be able to

1. Solve inadequacies in Maxwell's equations and correlating between circuit theory and field theory.
2. Understand and explain Huygens's, Babinet's, and holographic principles.
3. Correlate and derive the circuits relations from field theories and vice versa.
4. Demonstrate knowledge of dielectric slab waveguides, Schumann resonance, and tropo-scatter propagation.
5. Understand and explain bio-electromagnetics, such as retinal optical fibers, defibrillators and pacemakers, electromagnetic hazards and environment.

## MICROWAVE CIRCUITS AND MEASUREMENT (3-1-0)

COURSE OBJECTIVE:

1. Understand the concepts of microwave network analysis
2. Familiarity with different microwave measurement techniques
3. Methods and limitation of different microwave parameter measurement

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Introduction to microwave circuit concepts, Relation between [s], [z], [y] parameter | 6 |
| MODULE 2 | Microwave circuits & theorems, Impedance matching, Passive microwave components | 8 |
| MODULE 3 | Measurement of Wavelength, Frequency and Impedance-Introduction, Equivalent circuit of Cavity wave meters, Typical wave meters, resonant cavities, Methods of frequency measurements | 10 |
| MODULE 4 | Standard wave reflectors, Measurement of reflection coefficient, Low, Medium, High VSWR measurements, Standing wave pattern, Slotted Line | 8 |

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|---|---|---|
| | section and its limitation, Impedance measurement techniques, Reflectometer | |
| MODULE 5 | Vector Network analyzer, Concept and description, Reflection and Transmission measurements, magnitude and Phase, measurement of S-Parameters, SWR and Impedances measurements, errors and corrections. | 8 |
| TEXT BOOK | 1. Microwave circuit, By J.L. Altmen, Van Nostrand Co.<br>2. Foundations for microwave engineering, By R. E. Collins., John Wiley & Sons | |
| REFERENCE BOOK | 1. Microwave Circuit Theory and Analysis, By R. N. Ghosh, McGraw Hill<br>2. RF & Microwave circuits, Measurements and modelling, M. Golio & J. Golio, CRC Press<br>3. An introduction to Microwave Measurements, Ananjan Basu, CRC Press | |

COURSE OUTCOME:

1. Gain proficiency regarding microwave circuit concepts and relation between different parameters.
2. Design impedance matching networks and familiarity with passive microwave components.
3. Design of basic microwave laboratory set up along with measurement of parameters.
4. Knowledge of VNA will help in the measurement of S parameters of different microwave devices.
5. Familiarity with VNA concept can be used for finding gain, phase, reflection and transmission coefficient etc.

## MIC & MMIC (3-1-0)

COURSE OBJECTIVE: This course will enable:

1. To learn about the concept of Microwave Integrated Circuits, stripline and microstripline.
2. To get familiar aboutthe MIC's Design and fabrication of lumped elements.
3. To learn the Nonreciprocal components for MIC's on Ferrimagnetic substrateswithMMICS Technology.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Review of fundamentals of electronic conduction in compound semiconductors. Study of semiconductors like GaAs, InP. Fundamentals of band gap engineering. MIC Technology – Thick film and Thin film technology, Hybrid MIC's, Monolithic MIC technology. | 8 |
| MODULE 2 | Analysis of stripline and microstripline, Method of conformal Transformation, Characteristic parameters of strip, Microstrip lines, Microstrip circuit Design, Impedance transformers, Filters, Lumped components, Microstrip circuits. | 8 |
| MODULE 3 | Coupled Microstrips and Directional couplers, Even and odd mode analysis, Theory of coupled microstrip Directional couplers, Calculations for a coupled pair of Microstrips, Branch line couplers. Lumped Elements for MIC's Design and fabrication of lumped elements, circuits using lumped elements. | 8 |
| MODULE 4 | Nonreciprocal components for MIC's Microstrip on Ferrimagnetic substrates, Microstrip circulators. Isolators and phase shifters, Design of microstrip circuits – high power and low power circuits. | 8 |

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| MODULE 5 | Monolithic Microwave Integrated Circuits (MMICS) Technology: Fabrication process of MMIC, Hybrid MMICs, Dielectric substances, Thick film and thin film technology and materials, testing methods, Encapsulation and mounting of devices. | 8 |
| TEXT BOOK | 1. Microwave Devices & Circuits, By S Y Liao, Third Edition, Pearson hall, 2003.<br>2. Microwave Integrated circuits, By Gupta KC and Amarjit Singh - Wiley Easterrn. | |
| REFERENCE BOOK | 1. Hoffman R.K "Hand Book of Microwave Integrated Ciruits", Artech House, Boston, 1987.<br>2. Stripline-like Transmission Lines for Microwave Integrated Circuits, By Bharathi, Bhat, and S.K. Koul New Age International 2007. | |

COURSE OUTCOME: After completion of course student should be able:

1. To Identify about theMicrowave Integrated Circuits for different types of RF applications.
2. To designand analyze the stripline and microstripline using conformal Transformation method.
3. To describeaboutthe Design and fabrication of Directional couplers using lumped elements.
4. To state the design and concept of circulators, Isolators and phase shifters.
5. To Analyzethe MMICS Technology with their various fabrication and testing methods.

## Advanced Communication Techniques(3-1-0)

COURSE OBJECTIVE:

1. Understanding the band pass modulation and demodulation.
2. Understanding of multiple access and spread spectrum concepts.
3. To understand the advance concepts of Fading and Synchronization.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Baseband Demodulation: Signals and Noise, Detection of Binary Signals in Gaussian Noise, Intersymbol Interference, Equalization Bandpass Modulation and demodulation: Digital Bandpass Modulation Techniques, Detection of Signals in Gaussian Noise, Coherent Detection, Noncoherent Detection, Complex Envelope, Error Performance for Binary Systems, M-ary Signaling and Performance, Symbol Error Performance for M-ary Systems. | |
| MODULE 2 | Multiplexing and Multiple Access: Allocation of the Communications Resources, Multiple Access, Communications System and Architecture, Access Algorithms, Multiple Access Techniques Employed with INTELSAT, Multiple Access Techniques for Local Area Network. | |
| MODULE 3 | Spread Spectrum Techniques: Spread-Spectrum Overviews, Pseudo noise Sequences, Direct Sequence, Spread-Spectrum Systems, Frequency Hopping Systems, Synchronization, Jamming Considerations, Commercial Applications, Cellular Systems, Introduction to OFDM. | |

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|---|---|---|
| MODULE 4 | Synchronization: Introduction, Receiver Synchronization, Network Synchronization Communications Link Analysis: Channel and sources of signal loss, Received Signal Power and Noise Power, Link Budget Analysis, Noise Figure, Noise Temperature, and System Temperature, Sample Link Analysis, Satellite Repeaters. | |
| MODULE 5 | Fading Channels: The Challenge of Communicating over Fading Channels, Characterizing, Mobile-Radio Propagation, Signal Time-Spreading, Time Variance of the Channel Caused by Motion Mitigating the Degradation Effects of Fading, Summary of the Key Parameters Characterizing Fading Channels, Applications: Mitigating the Effects of Frequency Selective Fading. | |
| TEXT BOOK | 1. Digital Communications - Fundamentals and applications by Bernard Sklar, 2nd Edition of Pearson education Publication<br>2. Digital Communications - J. G. Proakis, 3rd edition, McGraw Hill Publication. | |
| REFERENCE BOOK | 1. J.G. Proakis, M. Salehi, Communication Systems Engineering, Pearson Education International, 2002.<br>2. Lee & Moseschmitt, Digital Communication, Springer, 2004.<br>3. R. Prasad, OFDM for Wireless Communications Systems, Artech House, 2004. | |

COURSE OUTCOME: After completion of course student should be able to

1. Understand various formatting & modulation process in digital communication.
2. Understand the concepts communication link analysis.
3. Understanding of Spread Spectrum Techniques, Fading Channels, etc.
4. Understand the effects of mitigating Fading.
5. Understand the commercial applications of recent Cellular Systems.

## MICROWAVE ENGINEERING LAB I (3-0-0)

SESSIONAL OBJECTIVE:

1. To be familiar with microwave components and to find the frequency of a wave
2. To calculate the wave parameters.
3. To understand fixed and variable attenuator characteristics

| Experiment No. | CONTENT |
|---|---|
| 1 | Study of microwave components |
| 2 | Measurement of VSWR in waveguide |
| 3 | Measurement of frequency of microwave source |
| 4 | Study of attenuator characteristics |
| 5 | Measurement of microwave source characteristics: Klystron, Gunn Diode |
| 6 | Measurement of dielectric constant |
| 7 | Measurement of Main Line and Auxiliary Line VSWR, Coupling Factor, Insertion Loss and Directivity of a Directional coupler. |
| 8 | Study of power division in E-plane and H-plane TEE. |
| 9 | Radiation pattern and Gain of Waveguide Horn antenna. |

| | |
|---|---|
| 10 | Design and Study of H-plane TEE (using HFSS). |

SESSIONAL OUTCOME:
1. Familiarity with microwave components and their applications for high frequency signals.
2. Calculate wave parameters (Frequency, VSWR, Reflection coefficients)
3. Understanding the concept and use of attenuators..
4. Understanding the concept and characteristics of reflex klystron tube.
5. Understanding the characteristics of Gunn diode.

## COMPUTATIONAL ELECTROMAGNETICS LAB (0-0-3)

**SESSIONAL OBJECTIVE**:
1. To impart knowledge on some extrapolation techniques.
2. To impart knowledge on different engineering problems.
3. To impart knowledge on application of four computation methods to different engineering problems.

| Experiment No. | CONTENT |
|---|---|
| 1 | Application of Richardson extrapolation method to find the exact value from the calculated value. |
| 2 | Application of Richardson extrapolation to evaluate potential integral |
| 3 | Evaluation of solution to Poisson's equation using finite difference method |
| 4 | Application of finite difference method to calculate the characteristic impedance of a transmission line. |
| 5 | Calculation of TM modes of a rectangular wave guide using finite difference method. |
| 6 | Determination of potential distribution of an earthed cylinder partially filled with a charge liquid using finite difference method. |
| 7 | Evaluate the solution of Laplace's equation using finite element method. |
| 8 | Evaluate the characteristic impedance of a strip transmission line using method of moments. |
| 9 | Evaluation of the self-impedance of a dipole using method of moments. |
| 10 | Evaluation of the mutual-impedance between two dipoles using method of moments. |
| **SUPPLEMENTARY BOOK** | **1.**Analytical and Computational Methods in Electromagnetics, By R. Garg, Artech House Publication |

**SESSIONAL OUTCOME:**After completion of the sessional student should be able to
**1.**Understand the application of finite difference method to different engineering problems.
**2.**Understand the application of finite difference time domain method to different engineering problems.
**3.**Understand the application of finite element method to different engineering problems.
**4.**Understand the application of method of moments to different engineering problems.
**5.**Understand unique numerical methods to find the exact value instead of approximated value.

## RF & MICROWAVE SOLID STATE DEVICE (3-0-0)

COURSE OBJECTIVE:

1. To learn the basics principles of various microwave solid state devices.
2. To study the operation and device characteristics of RF Active components.
3. To design and analyze various other Solid State Devices.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Energy Bands & Current Carriers in Semiconductors, Intrinsic & Extrinsic Semiconductor | 6 |
| MODULE 2 | Junctions Carrier Process, Drift-Diffusion, Generation-Recombination | 8 |
| MODULE 3 | Microwave Transistor, Tunnel Diode, Microwave Field Effect Transistor | 10 |
| MODULE 4 | Transferred Electron Devices, Avalanche Transit Time Devices | 8 |
| MODULE 5 | Optoelectronics, LED, Laser, Photo-detector, Solar Cell | 8 |
| TEXT BOOK | 1. Semiconductor Devices,By Kanaan Kano, Pearson (Chapters: 2, 3, 4, 14)<br>2. Solid State Electronic Devices, By B G Streetman & S Banerjee , Pearson (Chapters: 3, 4, 5, 8)<br>3. Semiconductor Physics & Devices,By D A Neamen, Tata McGraw Hill (Chapters: 4, 5, 6, 14) | |
| REFERENCE BOOK | 1. Microwave Devices & Circuits,By S Y Liao, Pearson (Chapter: 5, 6, 7, 8)<br>2. Microwave Semiconductor Devices and their applications, Watson, McGraw Hill<br>3. Microwave Semiconductors, H.VShurmer, Wien Oldenbourg | |

COURSE OUTCOME:

1. Understanding working concepts of RF active components.
2. Designing of various Microwave Solid State Devices.
3. Analysis of various microwave devices.
4. Knowledge opto-electronic devices.
5. Working transistor and diode at high frequency.

## MICROSTRIP COMPONENTS AND CIRCUITS (3-1-0)

COURSE OBJECTIVE:

1. Understand the concept of Microstrip transmission line
2. Design of Co-planar Waveguide, Coupled Microstrip and Directional Coupler
3. Design of impedance transformer and filter using microstrip technology

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Methods of Microstrip analysis, Losses in Microstrip | 6 |
| MODULE 2 | Slot line and Co-planar Waveguide, Coupled Microstrip and Directional Coupler. | 10 |
| MODULE 3 | Branch line coupler, Impedance transformers | 8 |
| MODULE 4 | Power dividers and combiners, Circulators | 8 |

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|---|---|---|
| MODULE 5 | Filters and Lumped components | 8 |
| TEXT BOOK | 1. Microwave engineering using Microstrip Circuits, Fooks and Zakarevicius, Prentice Hall<br>2. Microstrip lines and slotlines, Gupta,Garg,Bahl and Bhartia, Artech House | |
| REFERENCE BOOK | 1. Foundations for Microstrip Circuit Design, T. C. Edwards, Wiley & Sons<br>2. Microstrip filters for Rf/Microwave applications, Hong & Lancaster, Wiley & Sons<br>3. Microstrip circuits, Fred Gardiol, Wiley & Sons | |

COURSE OUTCOME:

1. Proficiency regarding design and implementation of microstrip transmission line
2. Design of coplanar waveguide and its advantage compared to microstrip line.
3. Gain basic ideas about directional and branch line coupler using microstrip.
4. Gain design ideas of circulators and branch line couplers.
5. Implementation of microstrip technology for various impedance matching network and couplers.

## ADVANCED ANTENNA TECHNOLOGY (3-1-0)

COURSE OBJECTIVE:

1. To impart the knowledge on performance of different types of broadband antennas.
2. To impart the knowledge on different types of antennas for special application.
3. To impart the knowledge on different types of low profile antennas and its feeding.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Biconical antenna, Discone and conical skirt monopole, theory behind frequency independent antenna, equiangular spiral antenna, fractal antenna concept and technology, corrugated horn antenna, multimode horn antenna. | 08 |
| MODULE 2 | Smart antenna systems, benefit, drawbacks of Smart antenna, array design for smart antennas, adaptive beamforming, MANET, array theory, Electrically & Physically small & big antenna | 08 |
| MODULE 3 | Artificial dielectric lens antenna, Luneburg & Einstein lenses, electrically and small antenna, ground plane antenna, sleeve antenna, turnstile antenna, submerged antenna, surface wave and leaky wave antenna, weather-vane antenna, flagpole antenna, chimney antenna, ILS antenna, sugar-scoop antenna, asteroid detection antenna, embedded antenna, plasma antenna | 08 |
| MODULE 4 | Microstrip and other planar antennas, Various types of feeding methods for microstrip antenna (Co-axial, Inset, Aperture/Slot Coupled, Proximity coupled and Corporate feeding for Arrays); Analysis of rectangular Patch Antenna, Cavity/ Modal Expansion Technique, microstrip antenna array | 10 |
| MODULE 5 | Conventional Scanning Techniques, Feed Networks for phased Arrays, Frequency Scanned Array Design, Target indicators, Search Patterns | 06 |
| TEXT BOOK | 1.Antennas Theory – Analysis and Design, By C. Balanis, Wiley India Edition<br>2.Antennas, By J. D. Kraus & others, McGraw Hill-Special Indian Edition | |
| REFERENCE BOOK | 1.Phased Array Antennas, By A. A. Ollinerand G.H. Knittel,Artech House<br>2.Introduction to Radar Systems, By M. L. Skolnik, McGraw Hill | |

COURSE OUTCOME:After completion of course student should be able to

1. Understand different design and operation of broadband antennas including comparison of its associated parameters.
2. Understand different design and operation of Smart antennas including associated networks.
3. Understand several advanced antennas for special application.
4. Understand different design and operation of different types of patch antennas and their feedings.
5. Understand different scanning techniques.

## Smart Antenna System (3-0-0)

COURSE OBJECTIVE:

1. To impart the knowledge on some recent antennas.
2. To impart the knowledge on different Direction of Arrival and beamforming algorithms.
3. To impart the knowledge on working of Smart antennas.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Brief discussion on some recent antennas and its parameters: Wideband, multiband, phased array, adaptive array, highly directional, low profile, low side-lobes, low back-lobe, low beam-width, high SNR, low loss | 06 |
| MODULE 2 | Fundamentals on Smart antennas: Need of Smart antennas, Smart antenna configurations, Space division multiple access (SDMA), Architecture of Smart antenna system, Benefits and drawbacks, Basic principles, Mutual coupling effects<br>System design and requirements:<br>Fixed beam systems, switched beam systems, adaptive antenna system, calibration | 10 |
| MODULE 3 | DOA algorithms and application: Conventional methods, sub-space methods, Integrated methods. Other methods, DOA estimation under coherent signal conditions, DOA estimation under other conditions | 08 |
| MODULE 4 | Beamforming fundamentals: The classical beamformer, Statistically Optimum Beamforming weight vectors, Adaptive algorithms for beamforming | 08 |
| MODULE 5 | Integration and simulation of Smart antennas: Antenna design, mutual coupling, Adaptive signal processing algorithms, Trellis coded modulation for adaptive arrays, smart antenna systems for Mobile Ad-Hoc NETworks | 10 |
| TEXT BOOK | 1. Smart Antennas for Wireless Communications IS-95 and Third Generation CDMA Applications, By J. C. Liberti Jr., T. S Rappaport, PTR – PH publishers<br>2. Smart Antennas, By Lal Chand Godara, CRC Press | |
| REFERENCE BOOK | 1. Introduction to Smart Antennas by C. A. Balanis and P. I. Ioannides, Morgan & Claypool Publishers<br>2. Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location, By T.S. Rappaport , IEEEPress, PTR – PH publishers | |

COURSE OUTCOME: After completion of course student should be able to

1. Understand Basic working principle of recent antennas.
2. Understand foundation of smart antennas.
3. Understand different types of Directional of Arrival algorithms.
4. Understand different types of beamforming techniques.
5. Understand working principle of practical smart antenna.

# Microwave Remote Sensing (3-0-0)

COURSE OBJECTIVE:

1. To impart the knowledge on passive and active microwave systems.
2. To impart the knowledge on Microwave imaging.
3. To impart the knowledge on Interferometry and Polarimetry.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | PASSIVE SURVEY SYSTEM: Introduction - History, plane waves, antenna systems, Resolution Concepts, Radiometry - Passive microwave sensing components – Emission laws - Roughness and Dielectric Constant - Radiometers – Components - Brightness temperature - Antenna temperature - Power - temperature correspondence, passive microwave interaction with atmospheric constituents - Emission characteristics of various earth features – Passive missions - Data products and Applications. | 10 |
| MODULE 2 | ACTIVE SURVEY SYSTEM: Basics - RADAR operation and measurements - RADAR equation - RAR - frequency bands - SLAR Imaging Geometry - Geometric Distortions, SAR – Concepts - Doppler principle & Processing System Parameters and fading concepts, Target Parameters. Interaction with Earth surface and vegetation - Physical Scattering Models - Surface and Volume Backscattering. | 10 |
| MODULE 3 | PLATFORMS, SENSORS AND DATA PROCESSING: Airborne, Space borne and Indian missions, Data products and selection procedure, SAR Image Processing software - Measurement and discrimination - Backscatter Extraction - Preprocessing and speckle filtering - Image Interpretation, SAR Image Fusion. | 08 |
| MODULE 4 | APPLICATIONS: Applications in Agriculture, Forestry, Geology, Hydrology, cryospace studies, landuse mapping and ocean related studies, military and surveillance applications, search and rescue operations, ground and air target detection and tracking - case studies. | 08 |
| MODULE 5 | IMAGING AND NON IMAGING METRICS: SAR interferometry - Basics - differential SAR interferometry, SAR polarimetry - Polarization Types – Polarimetricparameters-Information Extraction, Radargrammetry, Altimetry - Principle - Location systems - applications, scatterometer – Types - Calibration- applications. | 08 |
| TEXT BOOK | 1. Microwave remote sensing byF. T. Ulaby, K. R. Moore, and Fung, vol-1, vol-2 and vol- Addison - Wesley Publishing Company, London,1986.<br>2.Introduction to microwave remote sensing, By Iain H.woodhouse | |
| REFERENCE BOOK | 1. Principles and applications of Imaging RADAR, Manual of Remote sensing, vol.2, By F. M.Handersonand A. J.Lewis. ASPRS, Jhumurley and sons, Inc.<br>2. Air and spacebornradar systems-An introduction, By P. L. JeanclandeMarchais, Jean-Philippe Hardarge and Eric Normant, Elsevier publications<br>3. Radar foundations for Imaging and Advanced Concepts, By R. J Sullivan, Knovel, SciTech Pub. | |

COURSE OUTCOME: After completion of course student should be able to

1. Understand conceptsand Basic working principle of passive microwave systems.
2. Understandconceptsand Basic working principle of active microwave systems.
3. Understand the principles of Microwave image analysis and interpretation.
4. Understand the various application domains of microwave satellite data.
5. Understand Interferometry and Polarimetry concepts.

## METAMATERIALS (3-0-0)

COURSE OBJECTIVE:

1. To familiarize with the fundamentals that is essential for the concept of metamaterials
2. To understand design of LHM.
3. Knowledge of application areas of metamaterials.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Introduction, Fundamentals of left handed metamaterials | 6 |
| MODULE 2 | Transmission line theory of metamaterials | 8 |
| MODULE 3 | Two dimensional metamaterials | 8 |
| MODULE 4 | Guided wave applications | 10 |
| MODULE 5 | Radiated wave applications | 8 |
| TEXT BOOK | 1. Electromagnetic metamaterials: Transmission line theory and microwave applications.<br>2. Metamaterials: Physics and Engineering Explorations, Nader Engheta and R.W. Ziolkowski | |
| REFERENCE BOOK | 1. Metamaterials: Theory, Design and applications, J Cui, D. Smith and R. Liu, Springer<br>2. Metamaterials: Classes, properties and applications, E.J. Trembley, Nova Science Pub.<br>3. Metamaterials and plasmonics: Fundamentals, modeling and applications, S. Zouhdi, A. Sihvola, A.P. Vinogradov, Springer science | |

COURSE OUTCOME: After completion of course student should be able to

1. Be aware of the fundamentals related to the left handed materials.
2. Understand its implementation by transmission lines.
3. Obtain the knowledge of two dimensional LHM.
4. Be aware of different application of LHM.
5. Conceptualize of RHM and LHM.

## RADAR TECHNOLOGY & COUNTER MEASURE(3-1-0)

COURSE OBJECTIVE:

1. To provide understanding the basics of Radar technology.
2. To provide the understanding of various types of warfare techniques.
3. To understand the advance concepts of jammer systems.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Radar Range Equation, Theory of target detection, Targets & Interference, MTI Radar | 8 |
| MODULE 2 | Pulse Compression Radar, Detection of Radar signals in noise, Waveform selection | 8 |
| MODULE 3 | General Introduction to Electronics Warfare, Intercept Systems. Signal Detection, Analysis andEnvironment Study | 8 |
| MODULE 4 | Dumb and Smart Jammers, Confusion Reflectors, Target Masking and Decoys, | 8 |
| MODULE 5 | Infrared Countermeasures. ECCM system | 8 |
| TEXT BOOK | 1. Modern Radar System Analysis, By David Barton .K - Artech House<br>2. Radar Design Principles Signal Processing and The Environment, By Fred NathansonMcgraw Hill<br>3. Introduction to Radar systems, By Skolnik - Mcgraw Hill | |

COURSE OUTCOME: After completion of course student should be able to

1. Understand the Radar technology.
2. Understand the concepts of Pulse Compression Radar .
3. Design of Electronics Warfare, and Intercept Systems
4. Design and analyse of Dumb and Smart Jammers, Confusion Reflectors.
5. Analyse Infrared Countermeasures. ECCM system

## RADIO NAVIGATIONAL AIDS (3-0-0)

COURSE OBJECTIVE:

1. To become familiar with fundamentals of Radar.
2. To gain in depth knowledge about the different types of Radar and their operation.
3. Need for signal detection in Radar and various Radar signal detection techniques.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Navigational Systems, Inertial Navigation | 6 |
| MODULE 2 | Global Positioning System (GPS) for Navigation | 10 |
| MODULE 3 | Differential GPS and WAAS | 8 |
| MODULE 4 | GPS Navigational Application | 8 |
| MODULE 5 | Air traffic management | 8 |
| TEXT BOOK | 1. Avionics Navigation Systems, By Myron Kayton and Walter Friend, Wiley<br>2. Global Positioning System Theory and Applications, By Parkinson. BW. Spilker, Progress in Astronautics, Vol. I and II, 1996 | |
| REFERENCE BOOK | 1. Foundations for Microstrip Circuit Design, T. C. Edwards, Wiley & Sons<br>2. Microstrip filters for Rf/Microwave applications, Hong & Lancaster, Wiley & Sons<br>3. Microstrip circuits, Fred Gardiol, Wiley & Sons | |

COURSE OUTCOME: After completion of course student should be able to

1. Acquired knowledge about Radar and Radar Equations.
2. Understand the working principal of MTI and Pulse Doppler Radar.
3. Foster ability to work using Detection of Signals in Noise and Radio Direction Finding.
4. Foster ability to work using Instrument Landing System.
5. Acquired knowledge about Satellite Navigation System.

## ANTENNA AND SIMULATION LABORATORY(0-0-3)

**SESSIONAL OBJECTIVE**:
1. To impart knowledge on different types of antennas and its simulation using MATLAB.
2. To impart knowledge on different types of antennas and its simulation using HFSS.
3. To impart knowledge on performance of different types of antennas.

| Experiment No. | CONTENT |
|---|---|
| 1 | Design and Analysis of monopole antenna by using MATLAB. |
| 2 | Design and analysis of Helix antenna using MATLAB. |
| 3 | Design and analysis of Pyramidal Horn Antenna using HFSS operating at 6 GHz. |
| 4 | Design and Analysis of circular loop antenna by using MATLAB. |
| 5 | Design and analysis of edge feed rectangular patch antenna at 2.4 GHz using ANSYS HFSS. |
| 6 | Design and analysis of edge feed circular patch antenna at 2.4 GHz using ANSYS HFSS. |
| 7 | Design and analysis of 5X5 planar antenna array with dipole using MATLAB. |
| 8 | Design and Analysis of 16 element circular array dipole antenna using MATLAB. |
| 9 | Design and analysis of edge feed patch antenna at 10 GHz using ANSYS HFSS. |
| 10 | Design and analysis of patch antenna array for FMCW Radar using MATLAB. |

**SESSIONAL OUTCOME:**After completion of the sessional student should be able to
1. Understand the application of MATLAB and HFSS in antenna designs.
2. Understand different patch antenna designs and its associated performance parameters.
3. Understand different design and types of antenna arrays and its performance parameters.
4. Understand several broadband antennas and its performance parameters.
5. Understand different feeding techniques for antennas.

## MICROWAVE ENGINEERING LAB II (3-0-0)

SESSIONAL OBJECTIVE:
1. Study of Waveguide Discontinuities-Inductive Diaphragms.
2. To determine of S-matrix of Directional Coupler,Circulator andMagic Tee.
3. Measurements with Network Analyzer.

| Experiment No. | CONTENT |
|---|---|
| 1 | Study of Waveguide Discontinuities-Inductive and capacitive Diaphragms |
| 2 | Determination of Slide Screw Tuner-Equivalent circuit |
| 3 | Determination of S-matrix of Directional Coupler, Circulator, Magic Tee |

| | |
|---|---|
| 4 | Characterization of Waveguide Slotted Array |
| 5 | Measurements with Network Analyzer |
| 6 | Design of filter |
| 7 | Design of amplifier |
| 8 | Study of different devices using mirostrip technology |
| 9 | Radiation pattern and Gain of microstrip antenna |
| 10 | Design and Study of microstrip patch antenna (using HFSS). |

SESSIONAL OUTCOME:
1. Acquire knowledge about different discontinuities and finding impedances
2. Acquire knowledge about finding the equivalent circuit.
3. Analyse different microwave components and their S-matrix.
4. Acquire knowledge about measurement of different parameters using Network analyser.
5. Understanding the design of patch antenna.

## EMI & EMC (3-0-0)

COURSE OBJECTIVE:
1. To familiarize with the fundamentals that are essential for electronics industry in the field of EMI / EMC
2. To understand EMI sources and its measurements.
3. To understand the various techniques for electromagnetic compatibility.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Introduction, Natural and Nuclear Sources of EMI / EMC | 6 |
| MODULE 2 | EMI from Apparatus, Circuits and Open Area Test Sites | 8 |
| MODULE 3 | Radiated and Conducted Interference Measurements and ESD | 8 |
| MODULE 4 | Grounding, Shielding, Bonding and EMI filters, Cables, Connectors, Components and EMC Standards | 10 |
| MODULE 5 | EMC requirement for electronic systems | 8 |
| TEXT BOOK | 1. Engineering Electromagnetic Compatibility, By Dr. V.P. Kodali, IEEEPublication, Printed in India by S.Chand & Co. Ltd.<br>2. Electromagnetic Interference and Compatibility IMPACT series, IIT – Delhi, Modules 1 –9 | |
| REFERENCE BOOK | 1. Introduction to Electromagnetic Compatibility, C.R. Paul, John Wiley<br>2. Electromagnetic Compatibility Engineering, H.W. Ott, Wiley<br>3. Principles and Techniques of Electromagnetic compatability, C. Christpoulos, CRC Press | |

COURSE OUTCOME:

1. Real-world EMC design constraints and make appropriate trade-offs to achieve the most cost-effective design that meets all requirements.
2. Designing electronic systems that function without errors or problems related to electromagnetic compatibility.
3. Diagnose and solve basic electromagnetic compatibility problems.
4. Understanding of EMC standards different components.
5. Interference coming from electronic system while conducting Antenna measurement.

## Cognitive Radio (PE-II)

COURSE OBJECTIVE:

1. Know the basics of the software defined radios
2. Learn the design of the wireless networks based on the cognitive radios
3. Evaluate different spectrum sensing mechanisms in cognitive radio.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Essential functions of the SDR, SDR architecture, design principles of SDR, traditional radio implemented in hardware and SDR, transmitter architecture and its issues, A/D & D/A conversion, parameters of practical data converters, techniques to improve data converter performance, complex ADC and DAC architectures, digital radio processing, reconfigurable wireless communication systems.. | 8 |
| MODULE 2 | Cognitive Radio (CR) features and capabilities, CR functions, CR architecture, components of CR, CR cycle, CR and dynamic spectrum access, interference temperature, CR architecture for next generation networks, CR standardization. | 8 |
| MODULE 3 | Spectrum sensing and identification, primary signal detection. Energy detector, cyclo stationary feature detector, matched filter, cooperative sensing, spectrum opportunity, spectrum opportunity detection, fundamental trade-offs: performance versus constraint, sensing accuracy versus sensing overhead. | 8 |
| MODULE 4 | Spectrum management of cognitive radio networks, spectrum decision, spectrum sharing and spectrum mobility, mobility management of heterogeneous wireless networks, research challenges in CR. | 8 |
| MODULE 5 | Cognitive radio networks (CRN) architecture, terminal architecture of CRN, diversity radio access networks, routing in CRN, Control of CRN, Self-organization in mobile communication networks, security in CRN, cooperative communications, cooperative wireless networks, user cooperation and cognitive systems. | 8 |
| TEXT BOOK | 1. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks”, John Wiley & Sons, Ltd, 2009 | |
| REFERENCE BOOK | 1. Alexander M. Wyglinski, Maziar Nekovee, and Y. Thomas Hou, “Cognitive Radio Communications and Networks - Principles and Practice”, Elsevier Inc., 2010.<br>2. Jeffrey H. Reed “Software Radio: A Modern Approach to radio Engg”, Pearson Education Asia.<br>3. Alexander M. Wyglinski, Maziarnekovee, Y. Thomas Hu, “Cognitive Radio Communication and Networks,” Elsevier, 2010. | |

COURSE OUTCOME: After completion of course student should be able to

1. Demonstrate an understanding on software defined radio architecture and design principles.
2. Demonstrate an understanding on cognitive radio components, functions and capabilities.
3. Evaluate different spectrum sensing mechanisms in cognitive radio.

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| 4. Analyse the spectrum management functions using cognitive radio systems and cognitive radio networks.<br>5. Demonstrate an understanding on cooperative communications |

## RF-MEMS (3-0-0)

COURSE OBJECTIVE: This course will enable to:

1. Familiarize the students with different types of MEMS devices and fabrication methods of passive and active MEMS devices.
2.Design micro machined passive components, Transmission lines and Antennas.
3.Analyze Packaging and reliability issues in MEMS structures.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Introduction: RF MEMS for microwave applications, MEMS technology and fabrication, mechanical modeling of MEMS devices, MEMS materials and fabrication techniques. MEMS Switches: Introduction to MEMS switches; Capacitive shunt and series switches: Physical description, circuit model and electromagnetic modeling; Techniques of MEMS switch fabrication and packaging; Design of MEMS switches | 10 |
| MODULE 2 | MEMS inductors: Micromachined inductor, effect of inductor layout, Modeling and design issues of planar inductor. MEMS capacitors: Gap tuning and area tuning capacitors, dielectric tunable capacitors. | 8 |
| MODULE 3 | RF MEMS Filters: Modeling of mechanical filters,micro machined filters, surface acoustic wave filters, micro machined filters for millimeter wave frequencies. Phase shifter: MEMS phase shifters, Ferroelectric phase shifters, types , limitations. | 8 |
| MODULE 4 | Micromachined Transmission lines and Antennas: Micromachined transmission lines, losses in transmission lines, coplanar transmission lines, micromachined waveguide components;<br>Micromachined antennas: Design parameters, Micromachining techniques to improve antenna performance, reconfigurable antennas. | 8 |
| MODULE 5 | Integration and Packaging: Role of MEMS packages, types of MEMS packages, module packaging, packaging materials and reliability issues. | 6 |
| TEXT BOOK | 1.RF MEMS and their Applications, Vijay K. Varadan, Wiley-India, 2011.<br>2.RF MEMS: Theory, Design, and Technology, Gabriel M. Rebeiz, Wiley, 2003. | |

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|---|---|
| REFERENCE BOOK | 1. An Introduction to Microelectromechanical Systems Engineering, NadimMaluf, Artech House, 2000.<br>2. RF MEMS Circuit Design for Wireless Communications, De Los Santos H J, Artech House, 1999. |

COURSE OUTCOME:After completion of course student should be able to
1.Identify various types of RF MEMS devices, fabrication methods and packaging standards.
2.Design MEMS inductors and tunable capacitors using micromaching techniques.
3.Model MEMS filters and Phase shifters for various types of RF applications.
4.Design and analysis of Micro machined Transmission lines and Antennas for wireless applications.
5.Analyze the reliability and design related issues in MEMS structures.

## BASICS OF RF & MICROWAVE ENGINEERING (3-0-0)

COURSE OBJECTIVE:
1. To familiarize with the fundamentals that is essential for Radio frequency & microwave.
2. To understand basics of different type of transmission lines.
3. Knowledge of basic antenna parameters and mathematical analysis of basic antenna.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Introduction, Electromagnetic fields and waves, Maxwell's equation, skin effect, Transmission line theory | 6 |
| MODULE 2 | Basics of coaxial line, microstrip line, stripline, coplalnar line, Rectangular and circular waveguide | 8 |
| MODULE 3 | S-parameter representation of Network, calculation of S-parameter, S-parameter measurement | 8 |
| MODULE 4 | RF component and circuits: Equivalent circuit of passive components, Impedance matching, Filter, Directional coupler, circulator, power divider, balanced to unbalanced circuits, RF design software | 10 |
| MODULE 5 | Fundamental antenna parameters, mathematical treatment of Hertzian dipole, planar antenna, antenna arrays and radio wave propagation mechanism | 8 |
| TEXT BOOK | 1. RF and Microwave Engineering, Fundamentals of Wireless Communications, F. Gustrau, Wiley<br>2. Microwave Engineering: Concepts and Fundamentals, A. Shahid Khan, CRC Press | |
| REFERENCE BOOK | 1. Foundations for Microwave Engineering, R. E. Collin, Wiley<br>2. Essentials of RF and Microwave Grounding, E. Holzman, Artech House<br>3. Microwave, Radar and & RF engineering, P.K. Chaturvedi, Springer | |

COURSE OUTCOME:
1. To be aware of the fundamentals related to RF and Microwave engineering.
2. Understanding Scattering matrix and related measurement.
3. Knowledge of RF components and circuits.
4. Analysis and design of problem related to basic antennas.
5. Mechanism of radio wave propagation.

# BASICS OF ANTENNA AND PROPAGATION (3-0-0)

COURSE OBJECTIVE:

1. To familiarize with the fundamentals that is essential for antenna & radio wave propagation.
2. To understand basics of different type of antennas.
3. Knowledge of propagation of electromagnetic wave.

| MODULE | CONTENT | HOURS |
|---|---|---|
| MODULE 1 | Introduction, Basic antenna concepts | 6 |
| MODULE 2 | Point source and its array | 8 |
| MODULE 3 | Electric dipole and thin linear antenna, dipole array | 8 |
| MODULE 4 | Slot, horn antenna, broadband and frequency independent antenna | 10 |
| MODULE 5 | Modes of radio wave propagation, Structure of Troposphere, Tropospheric Scattering, Ionosphere, Ionospheric Layers - D, E, F1, F2 regions. Sky wave propagation - propagation of radio waves through Ionosphere, Effect of earth's magnetic field, Virtual height, Skip Distance, MUF, Critical frequency, Space wave propagation. | 8 |
| TEXT BOOK | 1. Antenna Engineering, J. D. Krauss, Mc Graw Hill<br>2. Electromagnetic Waves and Radiating Systems, E.C.Jordan & K.G.Balmain, PHI | |
| REFERENCE BOOK | 1. Antenna & Wave Propagation, R E. Collins, Mc Graw Hill<br>2. Antennas Theory: Analysis and Design, C.A. Balanis, John Willey & Son<br>3. Antennas and Wave Propagation, G. S. N. Raju, Pearson Education | |

COURSE OUTCOME:

1. To be aware of the fundamentals related to various antennas.
2. Understanding point source and its array.
3. Knowledge of frequency independent antennas.
4. To be aware of different parameters related wave propagation.
5. Concept of horn and slot antennas.