

**Course Structure & Syllabus  
of  
M. Tech. Programme  
in  
Electronics & Telecommunication Engineering  
with Specialisation  
RF & MICROWAVE ENGINEERING  
Academic Year – 2016-17**



**VEER SURENDRA SAI UNIVERSITY OF  
TECHNOLOGY, ODISHA  
Burla, Sambalpur-68018, Odisha  
[www.vssut.ac.in](http://www.vssut.ac.in)**

## **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.

# **CURRICULUM FOR M.TECH – RF & MICROWAVE ENGINEERING**

## **FIRST SEMESTER**

Course Code	Subject	L	T	P	C
	RF Solid State Devices	3	1	0	4
	Radio Wave Engineering	3	1	0	4
	Computational Electromagnetics	3	1	0	4
	Elective-I	3	1	0	4
	Elective-II	3	1	0	4
	Microwave Engineering Laboratory - I	0	0	3	2
	Computational Electromagnetic Laboratory	0	0	3	2
	Seminar -I	0	0	3	2
	Comprehensive Viva Voce-I				2

Total = 15 5 9 28

## **SECOND SEMESTER**

Course Code	Subject	L	T	P	C
	CMOS RF Circuit Design	3	1	0	4
	Microstrip Components & Circuits	3	1	0	4
	Advanced Antenna Technology	3	1	0	4
	Elective-III	3	1	0	4
	Elective-IV	3	1	0	4
	Microwave Engineering Laboratory - II	0	0	3	2
	Antenna & Simulations Laboratory	0	0	3	2
	Seminar -II	0	0	3	2
	Comprehensive Viva Voce-II				2

Total = 15 5 9 28

**THIRD SEMESTER**

Course Code	Subject	L	T	P	C
	Dissertation Interim Evaluation				10
	Comprehensive Viva -Voce				3
	Seminar on Dissertation				2

Total= 15

**FOURTH SEMESTER**

Course Code	Subject	L	T	P	C
	Dissertation Open Defense				5
	Dissertation Final Evaluation				20

Total= 25

Grand Total = 96

<b><u>ELECTIVE-I/ ELECTIVE-II</u></b>	<b><u>ELECTIVE-III/ ELECTIVE-IV</u></b>
Microwave Signal Processing	EMI & EMC
Microwave Circuits & Measurements	Software Defined Radio
Vacuum Tube Technology for Microwave MIC & MMIC	Microwave Remote Sensing
RADAR Technology & Counter Measure	Advanced Wireless Communications
Modern DCT	Adaptive & Smart Antenna
Optical & Satellite Communication	Fast Wave Devices
Advanced Electromagnetics	Computational Intelligence
	Radio Navigational Aids

## **MEC RF SOLID STATE DEVICE (3-1-0)**

### **Course Objectives:**

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

### **Module-I**

**08hours**

Energy Bands & Current Carriers in Semiconductors, Intrinsic & Extrinsic Semiconductor, Junctions, Carrier Process, Drift-Diffusion, Generation-Recombination

### **Module-II**

**12hours**

Microwave Transistor, Tunnel Diode, Microwave Field Effect Transistor

### **Module-III**

**12hours**

Transferred Electron Devices, Avalanche Transit Time Devices

### **Module-IV**

**08hours**

Optoelectronics, LED, Laser, Photo-detector, Solar Cell

### **Text Books:**

1. Semiconductor Devices, By Kanaan Kano, Pearson (Chapters: 2, 3, 4, 14)
2. Solid State Electronic Devices, By B G Streetman & S Banerjee, Pearson (Chapters: 3, 4, 5, 8)
3. Semiconductor Physics & Devices, By D A Neamen, Tata McGraw Hill (Chapters: 4, 5, 6, 14)
4. Microwave Devices & Circuits, By S Y Liao, Pearson (Chapter: 5, 6, 7, 8)
5. Microwave Semiconductor Devices and their applications, By Watson, McGraw Hill
6. Microwave Semiconductors, By H.V Shurmer, Wien Oldenbourg

### **Course Outcomes :**

- Understanding working concepts of RF active components.
- Designing of various Microwave Solid State Devices.
- Analysis of various microwave devices.

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

### **Course objectives:**

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-I**

**08 hours**

Introduction, Maxwell's Equation, Wave Equation: Derivation & Solution, Propagation of plane EM wave through conductors & wave guide

### **Module-II**

**12hours**

Dispersion, Scattering, Diffraction & Polarization of EM Waves, Radiating System, Multi-pole Fields & Radiation

### **Module-III**

**10hours**

Basics of Wave Propagation, Ground Wave propagation, Space Wave Propagation

### **Module-IV**

**10hours**

Sky Wave Propagation, Propagation of Radar Waves

### **Text Books:**

1. Electromagnetic Waves & Radiating Systems, By Jordan & Balmain, PHI (Chapters: 4, 5, 10, 16, 17)
2. Classical Electrodynamics, By J. D. Jackson, Wiley (Chapters: 7, 9, 10)
3. Antennas & Waves Propagation, By J. D. Kraus, McGraw Hill (Chapters: 4, 22, 23, 24, 25)
4. Introduction to Radar Systems, By M. L. Skolnik, McGraw Hill (Chapter: 8)

### **Course outcomes:**

1. Familiarity with Maxwell's Equation
2. Ability to design antennas based on various propagation such as ground wave propagation, Space Wave Propagation Sky Wave Propagation.
3. Familiarity with the concepts and relation of maximum and lowest useable frequency for all types of propagation.

4. Gain design ideas of propagation of Radar Waves.

## **MEC COMPUTATIONAL ELECTROMAGNETICS(3-1-0)**

### **Course Objectives:**

- To provide advance level of understanding of electromagnetic field theory.
- To provide comprehensive knowledge on various computational techniques such as FDM, FDTD, FEM, MoM.
- To provide the application of computational techniques to solve Maxwell's equations, wave propagation in bounded and unbounded media, radiation, scattering and other fundamental electromagnetic problems.

### **Module-I 06hours**

Introduction to Numerical Methods:

Electromagnetic Problems, Basic Numerical Methods, Solution of Algebraic Equations, Accuracy Consideration and Richardson Extrapolation, Examples

### **Module-II 10hours**

Finite-Difference Method:

Finite-Difference in One Dimension, A One Dimensional Differential Equation, Finite-Difference in Two 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

### **Module-III 12hours**

Finite-Difference Time-Domain Method:

Wave Equation in One Spatial Dimension, Time Quantization, Initial Conditions, Waves in Two and Three Spatial Dimensions, Maxwell's Equations.

Finite Element Method:

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.

### **Module-IV 12hours**

Method of Moments:

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

### **Text Books:**

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

### **Course Outcomes:**

- It provides an impetus for the higher studies in the field of RF and Microwave engineering.
- It provides exposure to work in the advance R&D labs such as Society for Applied Microwave Electronics Engineering and Research (SAMEER).
- It develops intellect to work in the leading companies of the globe such as MathWorks, Texas Instruments etc.

## **MEC MICROWAVE SIGNAL PROCESSING(3-1-0)**

### **Course Objectives:**

- To provide various understandings related to analog signals and its digitization process.
- To provide the basics of various power spectrum estimation.
- To learn the adaptive signal processing.

### **UNIT-I 08hours**

Multirate 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 of Narrowband Low Pass Filters. Implementation of Digital Filter Banks. Filter Bank and Sub band Filter Applications.

### **UNIT-II**

**08hours**

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.

### **UNIT-III**

**12hours**

Power Spectrum Estimation: Estimation of Spectra from Finite-Duration Observation of Signals, Non Parametric Method for Power Spectrum Estimation: Bartlett Method, Blackman and Turkey Method, Parametric Method for Power Estimation: Yuke-Walker Method, Burg Method, MA Model and ARMA Model.

Higher Order Statics (HOS): Moments, Cumulants, Blind Parameters and Order Estimation of MA & ARMA Systems-Application of Higher Order Statistics.

### **UNIT-IV**

**12hours**

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.

### **Text Books:**

1. Digital Signal Processing, By J.G. Proakis and D.G. Manolakis, Pearson
2. Adaptive Signal Processing, By B. Widrow and Stern, PHI
3. Adaptive Filter, By Simon Haykins, PHI

### **Course Outcomes :**

- Understanding of Multirate Digital Signal Processing & its concepts.
- Understanding of the power spectrum estimation and error prediction.
- Understanding of Adaptive Signal Processing through Least Mean Square Algorithm, Recursive Least Square Algorithm, etc.

## **MEC MICROWAVE CIRCUITS & MEASUREMENT (3-1-0)**

### **Course objectives:**

- Understand the concepts of microwave network analysis
- Familiar with different microwave measurement techniques
- Methods and limitation of different microwave parameter measurement
- Understanding of Vector network analyzer
- Design various impedance matching devices and knowledge of passive microwave components

### **Module-I**

**08hours**

Introduction to microwave circuit concepts, Relation between [s], [z], [y] parameter

### **Module-II**

**08hours**

Microwave circuits & theorems, Impedance matching, Passive microwave components

### **Module-III**

**14hours**

Measurement of Wavelength, Frequency and Impedance-Introduction, Equivalent circuit of Cavity wave meters, Typical wave meters, resonant cavities, Methods of frequency measurements direct method - Interpolation method, Standard wave reflectors, Measurement of reflection coefficient, Low, Medium, High VSWR measurements, Standing wave pattern, Slotted Line section and its limitation, Impedance measurement techniques, Reflectometer

### **Module-IV**

**10hours**

Vector Network analyzer, Concept and description, Reflection and Transmission measurements, magnitude and Phase, measurement of S- Parameters, SWR and Impedances measurements, errors and corrections

### **Text Books:**

1. Microwave circuit, By J.L. Altman, D van Nostrand Co., Inc.
2. Foundations for microwave engineering, By R. E. Collins., John Wiley & Sons
3. Microwave Circuit Theory and Analysis, By R. N. Ghosh, McGraw Hill

### **Course outcomes:**

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

## **MEC VACUUM TUBE TECHNOLOGY FOR MICROWAVE(3-1-0)**

### **Course Objectives:**

- To provide understanding of vacuum tube technology.
- To provide the basics of RF-wave and beam interaction.
- To understand the concepts of various microwave tube based sources.

### **Module-I**

**08hours**

High Frequency limitations in conventional tubes, UHF miniature tubes.

Classification of Microwave tubes, O-type and M-type Tubes, Slow wave and Fast-wave devices.

Sub-assemblies of Microwave Tubes: Electron Gun (Parallel flow and convergent beam guns, MIG guns),

RF Input/Output Couplers, RF Interaction Structures, Magnetic Focusing structures and Collectors.

### **Module-II**

**12hours**

RF-wave and beam interaction: localized and continuous.

Transit time O-type Microwave Tubes: reflex klystrons, Klystrodes, multi-cavity klystrons, traveling wave tube amplifiers, Backward Wave Oscillators, Device operation, gain and efficiency calculations, operational characteristics, design criteria, and future trends. Efficiency enhancement and Broadbanding techniques.

### **Module-III**

**10hours**

Electron beam wave interactions. Performance and design principle of amplifiers and oscillators.

Magnetrons: device operation, Pi-mode of operation, strapping, mode jumping, frequency pulling and pushing, Performance Chart and Rickie Diagram. Design and Testing of Magnetrons. Crossed field amplifiers: operating principle, device gain and efficiency. Coaxial Magnetrons, Inverted Coaxial Magnetrons, Frequency Agile, Voltage Tunable Magnetrons, Carcinotrons, Amplitrons.

### **Module-IV**

**10hours**

Millimeter wave generation and amplification: Peniotrons, Ubitrons, Gyrotrons and Free Electron Lasers, Application, efficiency and bandwidth enhancements and future trends.

### **Text Books:**

1. Microwave Devices & Circuits, By S Y Liao, Pearson
2. Microwave Tubes, By A. S. Gilmour, Artech House
3. Microwave Active Devices, Vacuum & Solid State, By M. L. Sisodia, New Age International

### **Course Outcomes (CO):**

- Understanding of vacuum tube technology.
- Understanding of the microwave sources and amplifiers.
- Understanding and working of various microwave sources.

## **MEC MIC AND MMIC(3-1-0)**

### **Course Objective:**

- To learn about Hybrid and Monolithic MIC technology.
- To analyse and design microstrip integrated circuit design using lumped elements.
- To analyse and design coupled microstrip and directional couplers.

### **Module-I**

**08hours**

MIC Technology – Thick film and Thin film technology, Hybrid MIC's, Monolithic MIC technology

**Module-II****12hours**

Analysis of stripline and microstripline, Method of conformal Transformation, Characteristic parameters of strip, Microstrip lines, Microstrip Circuit Design, Impedance transformers, Filters, Lumped constant Microstrip circuits

**Module-III****10hours**

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.

**Module-IV****10hours**

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

**Text Books:**

1. Microwave Devices & Circuits, By S Y Liao, Pearson
2. Microwave Integrated circuits, By Gupta KC and Amarjit Singh - Wiley Eastern
3. Stripline-like Transmission Lines for Microwave Integrated Circuits, By Bharathi, Bhat, and S.K. Koul  
New Age International

**Course Outcome:**

- Understand the concept of hybrid and monolithic MIC technology.
- Understand conformal transformation method and its application in characterisation and design of microstrip integrated circuits.
- Understand the concept of coupled microstrip and directional couplers.
- Able to analyse and design MIC using lumped elements- high power and low power circuits.
- Study about microstrip circulator, isolators and phase shifters.

**MEC RADAR TECHNOLOGY & COUNTER MEASURE (3-1-0)****Course Objectives:**

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

**Module-I****08hours**

Radar Range Equation, Theory of target detection, Targets & Interference, MTI Radar

**Module-II****12hours**

Pulse Compression Radar, Detection of Radar signals in noise, Waveform selection

**Module-III****10hours**

General Introduction to Electronics Warfare, Intercept Systems. Signal Detection, Analysis and Environment Study

**Module-IV****10hours**

Dumb and Smart Jammers, Confusion Reflectors, Target Masking and Decoys, Infrared Countermeasures. ECCM system

**Text Books:**

1. Modern Radar System Analysis, By David Barton .K - Artech House
2. Radar Design Principles Signal Processing and The Environment, By Fred Nathanson Mcgraw Hill
3. Introduction to Radar systems, By Skolnik - Mcgraw Hill

**Course Outcomes:**

- Understanding of Radar technology.
- Understanding of the concepts of electronic warfare systems.
- Design and analysis of Dumb and Smart Jammers, Confusion Reflectors.

**MEC MODERN DCT (3-1-0)****Course Objectives:**

- Understanding the base band communication.
- Understanding of band pass modulation and demodulation.
- To understand the advance concepts of Fading & Synchronisation.

<b>Module-I</b> Formatting & modulation of base band, base band demodulation/detection	<b>10hours</b>
<b>Module-II</b> Band-pass Modulation and Demodulation / Detection, Communications Link Analysis	<b>10hours</b>
<b>Module-III</b> Synchronization, Multiplexing & Multiple Access	<b>10hours</b>
<b>Module-IV</b> Spread Spectrum Techniques, Fading Channels	<b>10hours</b>

**Text Books:**

1. Digital Communications, By Fundamentals and applications by Bernard Sklar, Pearson
2. Digital Communications, By J. G. Proakis, McGraw Hill
3. Principles of Communications, By Taub and Scheling, TMH

**Course Outcomes :**

- Understanding various formatting & modulation process.
- Understanding the concepts communication link analysis.
- Understanding of Spread Spectrum Techniques, Fading Channels, etc.

**MEC OPTICAL & SATELLITE COMMUNICATION (3-1-0)**

**Course Objectives:**

- Provide an overview of optical communication, particularly fiber optics, and deals with both the function of related components and with system performance.
- Facilitate the knowledge about optical fiber sources and transmission techniques
- Enrich the idea of optical fiber networks algorithm such as SONET/SDH and optical CDMA, Transceiver, semiconductors optical amplifiers, couplers/splicers, wavelength division multiplexers and demultiplexers, filters, isolators and optical switches
- Understand the basics of orbital mechanics, the types of satellite orbits, the location of ground stations, and the look angles from ground stations to the satellite.
- Understand link budget equations to provide sufficient margin for performance
- Understand the different interferences and attenuation mechanisms affecting the satellite link design.

**Module-I:** Satellite System Technology: (10 hours)

Satellite orbits, Satellite constellation and ISL, orbital parameters, look angle determination, launching procedures. Spacecraft subsystems - Attitude and orbit control, power, TT & C, Communication and antennas. Earth station engineering - Transmitter and receiver, antenna.

Link Design:

Digital satellite link analysis and design for FSS and BSS - link budget and Eb/No calculations. Performance impairments - Noise, interference, propagation effects and frequency considerations.

**Module-II:** Access Techniques: (10 hours)

FDMA concept- Inter modulation and back off - SPADE system. TDMA concept - Frame and burst structure - Frame acquisition and synchronization - Satellite Switched TDMA system. CDMA concepts - DS and FH System acquisition and Tracking.

**Module-III:** Digital Transmission Systems:- (10 hours)

Point-to-point Links, coding and error considerations, Noise effects on system performance.

Analog Systems:-

Carrier-to-Noise Ratio, Multichannel Transmission Techniques.

**Module-IV:** Optical amplifiers and Integrated Optical devices: (10 hours)

Optical amplifiers, Amplifier Noise, System Applications, Wavelength Converters. Integrated Optical devices.

Optical Networks:-

Basic Networks, SONET/SDH, Broadcast-and-Select WDM Networks, Wavelength-Routed Networks, Ultrahigh Capacity Networks.

**Text Books:**

1. Tri T. Ha, Digital Satellite Communication Systems Engineering, McGraw Hill, 1990.
2. Wilbur L. Pritchard, Henri G. Suyderhoud, and Robert A. Nelson, Satellite Communication System Engineering, 2nd Edn., Pearson Education, New delhi.
3. G. Keiser, Optical Fibre Communications, Mc-Graw-Hill.
4. J.M.Senior, Optical Fibre Communications Principles and Practice, PHI.

**Reference Books**

1. Pratt and Bostain, Satellite Communication, John Wiley and Sons, 1986.
2. M. Richharia, Mobile Satellite Communications – Principles and Trends, Pearson Education, 2003.
3. Robert.M.Gagliardi, Satellite Communication, CBS Publishers

**Course Outcomes:**

- Describe the design and use of modern optical communication systems with emphasis on components and network architecture.
- Discuss the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber.
- Explain the various optical sources and optical detectors and their use in the optical communication system.
- Identify the fundamentals of orbital mechanics, the characteristics of common orbits used by Communications and other satellites, and be able to discuss launch methods and technologies
- Analyze the performance of satellite communications systems by calculating an accurate link budget for a satellite or other wireless communications link.
- Describe how analog and digital technologies are used for satellite communications networks and the topologies and applications of those networks.

**MEC ADVANCED ELECTROMAGNETICS(3-1-0)**

**Course Objectives:**

- Develop analytical skills in applied electromagnetics with solid theoretical foundation to design emission, propagation and reception of electromagnetic wave systems.
- Identify, formulate and solve fields, radiation, propagation and scattering of electromagnetic wave problems of real-world applications in a multidisciplinary frame individually or as a member of a group
- Develop the numerical techniques by achieving the ability to combine mathematical tools and physical understanding for time-harmonic electromagnetic field and wave computation.
- Examine the phenomena of wave propagation in different media and its interfaces and in applications of microwave engineering.
- Analyze the nature of electromagnetic wave propagation in guided medium used in microwave applications.

**Module-I**

**12hours**

The Dirac Delta & its representation for infinitesimal dipole, magnetic current & magnetic current density, inadequacies in Maxwell's equations, impossibility of TEM in waveguide, dielectric slab waveguide & its application to optical communication, plasma oscillations & wave propagation in plasma, dielectric resonator

**Module-II**

**12hours**

Huygens's principle, Babinet's principle, holography, correlation between circuit theory & field theory, derivation of circuit relations from field theory, Faraday rotation, Schumann resonance, tropo-scatter propagation, earth as a cavity resonator, scattering & diffraction, bridging the gap between electricity & magnetism using relativity, interaction of fields & matter

**Module-III****06hours**

Bioelectromagnetics:

Introduction, the axon, retinal optical fibers, heart dipole field, defibrillators &amp; pacemakers, biological fields, electromagnetic hazards &amp; environment

**Module-IV****10hours**

Concept of tensors, Special theory of relativity &amp; its applications in electromagnetics

**Text Books:**

1. Electromagnetic Waves & Radiating Systems, By Jordan & Balmain, PHI
2. Classical Electrodynamics, By J D Jackson, Wiley
3. Introduction to Electromagnetic Fields, By C. R. Paul, K. W. Whites, Syed A. Nasar, McGraw Hill
4. Maxwell's Equations & The Principles of Electromagnetism, By R. Fitzpatrick, Infinity Science Press LLC
5. Concepts of Modern Physics, By A. Beiser, McGraw Hill

**Course Outcomes:**

- Students can use their conceptual understanding of the electromagnetic laws in order to qualitatively describe the behavior of the solution to the problem.
- Illustrate the most common numerical techniques adopted for the electromagnetic modeling of microwave and millimeter-wave circuits and antennas.
- Use their ability to manage the electromagnetic laws to set up a model and perform the necessary calculations by selecting appropriate methods; making appropriate approximations; implementing computer programs.
- Choose some of the most popular commercial electromagnetic programs and to critically evaluate the numerical results.

**MEC MICROWAVE ENGINEERING LABORATORY-I(0-0-3)****Course Objectives:**

- To be familiar with microwave components and to find the frequency of a wave.
  - To calculate the wave parameters.
  - To understand the function of multihole directional coupler.
  - To understand fixed and variable attenuator characteristics.
  - To observe the power division through magic tee.
  - To understand the characteristics of reflex klystron tube.
  - To understand the characteristics of Gunn diode.
1. Study of microwave components
  2. Measurement of VSWR in waveguide
  3. Measurement of frequency of microwave source
  4. Study of attenuator, directional coupler, and magic tee characteristics
  5. Measurement of microwave source characteristics: Klystron, Gunn Diode

**Course Outcomes:**

- Familiarity with microwave components and their applications for high frequency signals.
- Calculate wave parameters (Frequency, VSWR, Reflection coefficients)
- Implement multihole directional coupler and magic tee in different microwave platforms.
- Understanding the concept and use of attenuators.
- Understanding the concept and characteristics of reflex klystron tube.
- Understanding the characteristics of Gunn diode.

**MEC COMPUTATIONAL ELECTROMAGNETICS LABORATORY(0-0-3)****Course Objectives:**

- To provide an environment to bridge theory and experiment.
  - To provide an insight to convert mathematical equations into coding language.
  - To provide a pictorial representation of mathematical modeling of physical system.
1. Simulation of FEM method
  2. Simulation of FDM method
  3. Simulation of MOM method
  4. Simulation of FDTD method

5. Computational complexity & convergence of results comparison of above four methods

**Course Outcomes:**

- It provides hands on experience on MATLAB coding of numerical methods.
- It provides hands on experience on solving fundamental electromagnetic problems using computational methods.
- It creates an interest to model new high frequency devices.
- It develops awareness for upcoming real world problem and to resolve them.
- It develops the potential to implement the new concepts in the diverse field of interest.

**MEC CMOS RF CIRCUIT DESIGN (3-1-0)**

**Course Objectives:**

- The concepts of design and analysis of modern CMOS RF and wireless communication integrated circuits are introduced.
- Students will have an in-depth knowledge of basic concepts in CMOS RF design, scattering parameters, modern integrated circuit technologies, fundamental limitations of speed of operation of transistors, physics of noise, impedance matching, low-noise amplifiers, mixers, oscillators, phase noise and phase locked loops.
- To teach students the fundamentals of analog/mixed-signal (analog & digital) circuit design.
- To prepare students for higher-level courses in analog & RF circuits, and analog-digital conversion.

**Module-I**

Introduction, Basic concepts in RF Design, Passive RLC networks, Passive IC components

**08 hours**

**Module-II**

High frequency amplifier design, Voltage references & biasing, LNA design, Mixers

**12hours**

**Module-III**

RF power amplifier, PLL, Oscillators, Synthesizers

**12hours**

**Module-IV**

Noise, Phase noise, Feedback systems

**08hours**

**Text Books:**

1. The Design of CMOS RF Integrated Circuits, By T. H. Lee, Cambridge University Press
2. RF Microelectronics, By B. Razavi, Pearson

**Course Outcomes:**

- It is expected that the students be able to apply the concepts and design techniques presented in this course to a wide range of applications including high-speed wireless communications and CMOS RF electronics.
- To discuss design and analysis of filters and amplifiers.
- To understand the working concepts of RF active components.
- To study the operation of mixers and oscillators.

**MEC MICROSTRIP COMPONENTS & CIRCUITS (3-1-0)**

**Course Objectives:**

- Understand the concept of Microstrip transmission line
- Design of Co-planar Waveguide, Coupled Microstrip and Directional Coupler
- Design of impedance transformer and filter using microstrip technology
- Familiarity with power dividers and lumped components
- Implementation of circulators and branch line couplers using microstrip

**Module-I**

Methods of Microstrip analysis, Losses in Microstrip

**08hours**

**Module-II**

Slot line and Co-planar Waveguide, Coupled Microstrip and Directional Coupler

**12hours**

**Module-III**

Branch line coupler Impedance transformers, Filters, Lumped components

**10hours**

**Module-IV**

Power dividers and combiners, Circulators

**10hours**

## Reference Books:

1. Microwave engineering using Microstrip Circuits, By Fooks and Zakarevicius, Prentice Hall
2. Microstrip lines and slotlines, By Gupta, Garg, Bahl and Bhartia, Artech House
3. Foundations for Microstrip Circuit Design, By T. C. Edwards, Wiley & Sons

### Course Outcomes:

- Gain proficiency regarding design and implementation of microstrip transmission line.
- Design of coplanar waveguide and its advantage compared to microstrip line.
- Gain basic ideas about directional and branch line coupler using microstrip.
- Gain design ideas of circulators and branch line couplers.
- Implementation of microstrip technology for various impedance matching network, couplers and antennas etc.

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

### Course Objectives:

- To provide comprehensive knowledge of different design and performance parameters of antenna.
- To provide the overall idea about various existing antennas and different advance antennas presently in practice.
- To provide principle of operation, analysis and application of different antennas such as micro-strip antenna, smart antenna, etc.

### **Module-I**

**08hours**

Biconical antenna, disc and conical skirt monopole, equiangular spiral antenna, fractal antenna concept & technology, corrugated horn antenna, multimode horn antenna, smart antenna- benefit, drawbacks & design, adaptive beamforming, MANET, array theory, Electrically small & big antenna

### **Module-II**

**08hours**

Artificial dielectric lens antenna, Luneburg & Einstein lenses, electrically & physically small antenna, ground plane antenna, sleeve antenna, turnstile antenna, submerged antenna, surface wave & leaky wave antenna, weather-vane antenna, flagpole antenna, chimney antenna, ILS antenna, sugar-scoop antenna, asteroid detection antenna, embedded antenna, plasma antenna

### **Module-III**

**10hours**

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

### **Module-IV**

**14hours**

Conventional Scanning Techniques, Feed Networks for phased Arrays, Frequency Scanned Array Design, Search Patterns

### **Text Books:**

1. Antennas Theory – Analysis and Design, By C. Balanis, Wiley India Edition
2. Antennas, By J. D. Kraus & others, McGraw Hill-Special Indian Edition
3. Phased Array Antennas, By A. A. Oliner and G.H. Knittel, Artech House

### Course Outcomes:

- It provides career path to get into different antenna manufacturing industry such as Linx technology, Wavelin Inc. etc.
- It provides an active participation in the electronics industry where advance antennas are essential equipment such as Samsung, Apple etc.
- It provides an opportunity to serve as a faculty in RF & Microwave Engineering

## **MEC EMI & EMC(3-1-0)**

### Course Objectives:

- To familiarize with the fundamentals that are essential for electronics industry in the field of EMI / EMC
- To understand EMI sources and its measurements.
- To understand the various techniques for electromagnetic compatibility.

### **Module-I**

**08hours**

Introduction, Natural and Nuclear Sources of EMI / EMC

**Module-II** **10hours**

EMI from Apparatus, Circuits and Open Area Test Sites

**Module-III** **10hours**

Radiated and Conducted Interference Measurements and ESD

**Module-IV** **12hours**

Grounding, Shielding, Bonding and EMI filters, Cables, Connectors, Components and EMC Standards

**Text Books:**

1. Engineering Electromagnetic Compatibility, By Dr. V.P. Kodali, IEEE Publication, Printed in India by S. Chand & Co. Ltd.
2. Electromagnetic Interference and Compatibility IMPACT series, IIT – Delhi, Modules 1 –9
3. Introduction to Electromagnetic Compatibility, By C.R. Pal, John Wiley

**Course Outcomes:**

- Real-world EMC design constraints and make appropriate trade-offs to achieve the most cost-effective design that meets all requirements.
- Designing electronic systems that function without errors or problems related to electromagnetic compatibility
- Diagnose and solve basic electromagnetic compatibility problems.

## **MEC SOFTWARE DEFINED RADIO (3-1-0)**

**Course Objectives:**

- To understand “Modern Radio Communication System “that can be reconfigured
- To understand GNU Radio
- To understand how SDR platform provides easy access to wireless network system
- To understand how unlike simulation in Communication Projects, SDR allows easy access to both PHY and MAC layer
- To understand the concept of Cognitive Radio and Spectrum sharing

**Module-I** **06hours**

Introduction, Multi Rate Signal Processing

**Module-II** **09hours**

Digital Generation of Signals

**Module-III** **09hours**

Analog to Digital and Digital to Analog Conversion, Digital Hardware Choices

**Module-IV** **16hours**

Object – Oriented Representation of Radios and Network Resources, Case Studies in Software Radio Design

**Text Books:**

1. Software Radio: A Modern Approach to Radio Engineering, By Jeffrey H. Reed, PEA Publication
2. Software Defined Radio: Enabling Technologies, By Walter Tuttle Bee, Wiley

**Course Outcomes:**

- Compare SDR with traditional Hardware Radio HDR.
- Implement modern wireless system based on OFDM, MIMO & Smart Antenna .
- Build experiment with real wireless waveform and applications, accessing both PHY and MAC, Compare SDR versus MATLAB and Hardware Radio .
- Work on open projects and explore their capability to build their own communication system.

## **MEC MICROWAVE REMOTE SENSING(3-1-0)**

**Course Objectives:**

- To learn about fundamentals and application of radar remote sensing and radiometry.
- To learn about airborne and spaceborne radar systems.

**Module-I** **06hours**

Fundamentals and radiometry

**Module-II** **09hours**

Radar remote sensing

**Module-III****09hours**

Airborne and spaceborne radar systems

**Module-IV****16hours**

Application of radar remote sensing, special topics in radar remote sensing

**Text Books:**

1. Microwave remote sensing, By Ulaby, F.T., Moore, K.R. and Fung, vol-1, vol-2 Addison-Wesley Publishing
2. Principles and applications of Imaging RADAR, Manual of Remote sensing, vol.2, By Floyd.M. Handerson and Anthony, J. Lewis ASPRS, Jhumurley and sons, Inc.
3. Air and spaceborne radar systems-An introduction, By Philippe Lacomme, Jean Claude Marchais, Jean-Philippe Hardarge and Eric Normant, Elsevier publications
4. Introduction to microwave remote sensing, By Iain H. Woodhouse
5. Radar foundations for Imaging and Advanced Concepts, By Roger J Sullivan, Knovel, SciTech Pub.
6. Radar Fundamentals, By Ian Faulconbridge, Argos Press

**Course Outcomes:**

- Understand the fundamentals of radar remote sensing and radiometry.
- Apply the concept of radar remote sensing.
- Study about different airborne and spaceborne radar systems.
- Study about special topics in radar remote sensing.

**MEC ADVANCED WIRELESS COMMUNICATIONS (3-1-0)****Course Objectives:**

- To expose the students to understand mobile radio communication principles
- To study the recent trends adopted in cellular systems and wireless standards.
- To study different diversity techniques.
- To know the effect of fading and Different fading models.

**Module-I****(10hours)**

Introduction to Wireless Communications, Broadband Wireless Channel Models, Diversity, Equalization and Estimation Techniques and Cellular Communications.

**Module-II****(10hours)**

**OFDM:** Basic principle of Orthogonality, Single vs multicarrier system, OFDM Block Diagram and ITS Explanation, OFDM mathematical representation, Selection Parameters for modulation, Pulse shaping in OFDM Signal and spectral efficiency, windowing in OFDM signal and spectral efficiency, Synchronization in OFDM, Pilot Insertion in OFDM, Amplitude limitations in OFDM, CDMA vs OFDM, Hybrid OFDM and Variants of OFDM.

**MIMO:** Space Diversity and systems based on space diversity, Smart antenna system and MIMO, MIMO Based system architecture, MIMO exploits Multipath, Space-Time Processing, Antenna considerations for MIMO, MIMO channel modeling, measurement, and Capacity, Cyclic Delay Diversity (CDD), Space-Time coding, Advances and Applications of MIMO, MIMO-OFDM.

**Module-III****(10hours)**

**Wireless Broadcast Networks:** Digital Audio Broadcasting (DAB), Digital Radio Mondiale (DRM), HD Radio Technology, Digital Video Broadcasting (DVB), Direct to Home (DTH).

**Wireless Cellular Networks:** GSM System, GPRS, EDGE Technology, CDMA-based Digital Cellular Standards, WLL, IMT-2000, Mobile Satellite Communication, 3G, 4G and Beyond.

**Wireless Ad-Hoc Networks:** Bluetooth, Wi-Fi standards, WiMAX standards, Wireless sensor networks, IEEE 802.15.4 and Zigbee, UWB, IEEE 802.20 and beyond.

**Module-IV****(10hours)**

**Simulation of communication Systems and Software Defined Radio (SDR):** Simulation methodology, Multidisciplinary aspects of simulation, Modelling of system, Deterministic simulation, Stochastic simulation, General steps of simulation, SDR, Need for SDR, General structure of the transceiver for SDR, 3G SDR system architecture, Present and future trends in SDR, Cognitive Radio (CR).

**Text Books:**

- (1) Wireless Communication, by Upena Dalal, Oxford University Press.

**Reference Books:**

- (1) Fundamentals of Wireless Communications, By D.Tse and P.Viswanath, Cambridge University Press
- (2) Wireless Communications, By A. Goldsmith, Cambridge University Press

- (3) MIMO Wireless Communications, By E. Biglieri, Cambridge University Press  
 (4) Wireless Communications: Principles and Practice, By T. S. Rappaport, Prentice Hall

**Course Outcomes:**

- Knowledge about of technologies used in wireless comm.
- Knowledge about overall GSM cellular concept.
- Knowledge about multiple access technologies.
- Knowledge about the effect of fading and Different fading models.
- Knowledge different of different spread spectrum techniques

**MEC ADAPTIVE & SMART ANTENNA(3-1-0)**

**Course Objectives:**

- Students will be familiar with the Types of Smart Antenna Systems.
- What are the benefits of smart antenna technology.
- Gain an understanding and experience with smart antenna environments and implementation.

**Module-I** **10hours**

Smart Antennas, DOA Estimation Fundamentals

**Module-II** **10hours**

Beam Forming Fundamentals

**Module-III** **10hours**

Integration and Simulation of Smart Antennas

**Module-IV** **10hours**

Space–Time Processing

**Text Books:**

1. Introduction to Smart Antennas, By C. A. Balanis & P. I. Ioannides, Morgan & Claypool Publication
2. Smart Antennas for Wireless Communications IS-95 and Third Generation CDMA Applications, By J. C. Liberti Jr., T. S Rappaport, PTR – PH publishers
3. Smart Antennas, By Lal Chand Godara, CRC Press
4. Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location, By T.S. Rappaport, IEEE Press, PTR – PH publishers

**Course Outcomes:**

- Compare the performances of digital radio receivers and software radios.
- Study the CDMA spatial processors to analyze the multi-cell systems.
- Analyze the channel models for smart antenna systems.
- Study the environmental parameters for signal processing of smart antenna systems.
- Evaluate the requirements for the design and implementation of smart antenna systems.

**MEC FAST WAVE DEVICES(3-1-0)**

**Course Objectives:**

- Students will be conversant with both slow & fast wave devices.
- They can conceptualise relativistic bunching & associated topics.
- They will study various types of mode excitations.

**Module-I** **08hours**

Limitation of slow-wave devices for high power and high frequency applications, Classification and sub-assemblies of fast wave electron beam devices

**Module-II** **08hours**

Relativistic bunching, waveguide mode and beam-mode dispersion relation, Small-orbit, Large-orbit and quasi-optical configurations

**Module-III** **10hours**

Excitation of desired mode, Mode suppressions, CRM and Weibel instabilities. Principle of operation, Electron beam RF wave interaction mechanism

**Module-IV** **14hours**

Performance evaluation and design principles of fast-wave devices like: Gyrotron, gyro-klystron, gyro-Travelling-wave tubes, Slow Wave Cyclotron Amplifier and CARM. Peniotron effects, Ubitron, Free Electron Laser. Application, efficiency and bandwidth enhancements and future trends

**Text Books:**

1. Klystron, TWT, Magnetron, CFA, Gyrotron, By A. S. Gilmour, Artech House
2. Electromagnetic Theory & Applications in Beam Wave Electronics, By B. N. Basu, World Scientific

**Course Outcomes:**

- Study the performances of high frequency & high power systems.
- Study various types of quasi optical systems..
- Analyze CRM and Weibel instabilities.
- Study different types of fast wave devices.

**MEC COMPUTATIONAL INTELLIGENCE (3-1-0)****Course Objectives:**

- To understand the fundamental theory and concepts of neural networks, neuro-modeling, several neural network paradigms and its applications.
- To understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic control and other machine intelligence applications of fuzzy logic.
- To understand the basics of an evolutionary computing paradigm known as genetic algorithms and its application to engineering optimization problems.

**Module-I****08hours**

Introduction to Soft Computing: Soft computing constituents and conventional Artificial Intelligence, Neuro-Fuzzy and Soft Computing characteristics. Fuzzy Sets, Fuzzy Rules and Fuzzy Reasoning: Introduction, Basic definitions and terminology, Set-theoretic operations, MF formulation and parameterization, More on fuzzy union, Intersection and Complement, Extension principle and fuzzy relations, Fuzzy If-Then rules, Fuzzy reasoning. Fuzzy Inference System: Mamdani fuzzy models, Sugeno fuzzy models, Tsukamoto fuzzy models, other considerations.

**Module-II****13hours**

Least Square Method for System Identification: System Identification, Basic of matrix manipulations and calculus, Least-square estimator, Geometric interpretation of LSE, Recursive least-square estimator, Recursive LSE for time varying systems, Statistical properties and maximum likelihood estimator, LSE for nonlinear models. Derivative based Optimization: Descent methods, Method of Steepest Descent, Newton's method, Step size determination, Conjugate gradient methods, Analysis of quadratic case, Nonlinear least-square problems, Incorporation of stochastic mechanism. Derivative-free Optimization: Genetic algorithm simulated annealing, Random search, Downhill simplex search.

**Module-III****07hours**

Adaptive Networks: Architecture, Back-propagation for feed forward networks, Extended backpropagation for recurrent networks, Hybrid learning rule: combining steepest descent and LSE. Supervised Learning Neural Networks: Perceptrons, Adaline, Back propagation multi layer perceptrons, Radial basis function networks. Learning from Reinforcement: Failure is the surest path to success, Temporal difference learning, The art of dynamic programming, Adaptive heuristic critic, Q-learning, A cost path problem, World modeling, Other network configurations, Reinforcement learning by evolutionary computations.

**Module-IV****15hours**

Unsupervised Learning and other Neural Networks: Competitive learning networks, Kohonen self-organizing networks, Learning vector quantization, Hebbian learning, Principal component networks, Hopfield network. Adaptive Neuro-Fuzzy Inference Systems: ANFIS architecture, Hybrid learning algorithms, Learning methods that cross-fertilize ANFIS and RBNF, ANFIS as universal approximator, Simulation examples, Extensions and advance topics. Coactive Neuro-Fuzzy Modeling towards generalized ANFIS: Framework, Neuro functions for adaptive networks, Neuro-Fuzzy spectrum, Analysis of adaptive learning capability.

**Text Books:**

1. Neuro-Fuzzy and Soft Computing, By J.S.R. Jng, C.T. Sun and E. Mizutani, PHI
2. Neural Networks, Fuzzy Logic and Genetic Algorithms, S. Rajasekaran, G.A. Vijayalaksmi, PHI.

**Course Outcomes:**

- An understanding of fundamental computational intelligence and machine learning models.
- Implemented neural networks, genetic algorithms, and other computational intelligence and machine learning algorithms.
- Applied computational intelligence and machine learning techniques to classification, prediction, pattern recognition, and optimization problems.

## **MEC RADIO NAVIGATIONAL AIDS(3-1-0)**

### **Course Objective:**

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

**Module-I** **10hours**

Navigational Systems, Inertial Navigation

**Module-II** **10hours**

Global Positioning System (GPS) for Navigation

**Module-III** **10hours**

Differential GPS and WAAS

**Module-IV** **10hours**

GPS Navigational Application

### **Text Books:**

1. Avionics Navigation Systems, By Myron Kavton and Walter Friend, Wiley
2. Global Positioning System Theory and Applications, By Parkinson. BW. Spilker, Progress in Astronautics, Vol. I and II, 1996

### **Course Outcomes:**

- Acquired knowledge about Radar and Radar Equations.
- Understanding the working principal of MTI and Pulse Doppler Radar.
- Foster ability to work using Detection of Signals in Noise and Radio Direction Finding.
- Foster ability to work using Instrument Landing System.
- Acquired knowledge about Satellite Navigation System.

## **MEC MICROWAVEENGINEERING LABORATORY-II (0-0-3)**

### **Course Objective:**

- Study of Waveguide Discontinuities-Inductive Diaphragms.
- Study of Waveguide discontinuities capacitive Diaphragms.
- To determine Slide Screw Tuner-Equivalent circuit.
- To determine of S-matrix of Directional Coupler,Circulator and Magic Tee.
- To Characterize of Waveguide Slotted Array.
- Measurements with Network Analyzer.

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

### **Course Outcomes:**

- Acquire knowledge about different discontinuities and finding impedances
- Acquire knowledge about finding the equivalent circuit.
- Analyse different microwave components and their S-matrix.
- Analyse waveguide slotted array.
- Acquire knowledge about measurement of different parameters using Network analyser.

## **MEC ANTENNA & SIMULATIONS LABORATORY (0-0-3)**

### **Course Objective:**

- To provide the practical experience of theoretical information of different antennas.
- To provide a virtual environment to design antenna using MATLAB code.  
To provide the visual representation of electromagnetic radiation of different antennas.

1. Gain measurement of 1) Pyramidal Horn, 2) Conical Horn antennas.
2. Pattern Measurement of 1) Pyramidal Horn, 2) Conical Horn antennas
3. Frequency Scanned Array Characteristics
4. Measurement of Input Impedance of an Antenna
5. Software Simulation and Testing of:
  1. Rectangular Microstrip Antenna, Circular Microstrip antenna.
  2. Micro strip Monopole
  3. Microstrip Tee
  4. Cylindrical Horn antenna, Pyramidal Horn antenna
  5. Microstrip Filters
  6. Microstrip power Dividers, Passive Components
  7. Radar Signals

**Course Outcomes:**

- It provides the hands on experience on design and simulation of low and high frequency devices.
- It provides the hands on experience on MATLAB coding to design and analyze various antennas.
- It develops an idea to compare the performance of different types of antennas.
- It develops an insight to optimize different performance parameters of antenna to have more advance performance.
- It creates an interest to design a new form of antenna which can be implemented in specific wireless applications.