# POST GRADUATE SYLLABUS

# FOR

# COMMUNICATION SYSTEMS & SIGNAL PROCESSING

राष्ट्रीय प्रौद्योगिकी संस्थान अगरतला

NATIONAL INSTITUTE OF TECHNOLOGY AGARTALA

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

BARJALA, AGARTALA - 799046

# FOREWORD

Electronics & Communication Engineering Department of NIT Agartala awards the degree of Master of Technology (M.Tech) in two different specializations, i.e. i)Communication Systems & Signal Processing and ii) VLSI Design.

The course structures of all post graduate degree programmes are carrying a total of 80 credits and 2000 marks. Semester wise distribution of course and credits are as follows. First semester 25 credits and 800 marks for five theory subjects, two laboratory subjects and seminar, second semester 25 credits and 800 marks for four theory subjects, two laboratory subjects, comprehensive viva-voce and project preliminaries; Third Semester 10 credits and 100 marks, fourth semester 20 credits and 300 marks. Third and fourth semester of PG courses will be fully devoted ton project works. Minimum requirement of number of class hours for each theory course is 40 hours per semester.

There will be continuous assessment of the performance of students throughout the semester. Each theory subject in a semester is evaluated for 100 marks, with the following weightage sub-component weightage. Continuous evaluation 30 marks (Attendance: 5 marks, Quiz: 5 marks, Class test 10 marks, Assignment 10 marks); Mid-Semester Examination 20 marks; and End-Semester Examination 50 marks.

The course curriculum of all post-graduate programmes are designed considering the Programme Outcomes as formulated by National Board of accreditation (NBA)

Expert opinions are being taken on a regular basis in order to improve the quality of teaching learning process and to attain the programme outcomes efficiently.

In the final year of M.Tech Programmes (third and fourth semesters) students may also opt industrial research. If any student desire to pursue his/her research in reputed industries, he/she may be allowed to do so, provided:

a. The selected industry is a permanent member of NASSCOM, FICCI and other such industry bodied.
b. The selected industry needs is approved by the DPPC of the concerned department.
c. The student selects one supervisor from industry and another supervisor form the Institute.
d. If any students opt for such industrial research he/she will not receive any scholarship from the institute in this tenure, even if he/she wants to return back. In such cases the student will be allowed to complete his/her project in the institute but without any scholarship.

# Vision and Mission of ECE Department

## Vision

Department is committed to impart high level of Teaching, Conducting up to date research along with technical skill so that the department can excel in the fields of teaching and research at national and international level and to cope with the latest demand of industry, academia and research in Electronics & Communication Engineering.

## Mission

I. To provide high quality undergraduate and graduate education in the field of Electronics and Communication Engineering.
II. To promote research and development.
III. To collect the knowledge and expertise and to cater the people and to work for the development of the society at large.
IV. To develop and promote a smooth and friendly academic industry relationship.
V. To make the department more conductive for professional and personal development so as to attract good professionals and academicians from all over the country and abroad.

# Program Outcomes (POs)

PO1: Ability to independently carry out research/investigation and development to solve practical problems.

PO2: Ability to write and present substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: Ability to identify, formulate, and solve Communication Systems & Signal Processing related problems using advanced level computing techniques.

PO5: Ability to understand the impact of Communication Systems & Signal Processing solutions in a global, economic, environmental and societal context.

PO6: Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to multidisciplinary environment..

# Program Educational Objectives (PEOs)

1. To develop a sound knowledge in the field related to Communication and Signal Processing to serve as a competent engineer.

2. To develop a sound knowledge in theory and practical related to Communication and Signal Processing to prove the ability to work in any interdisciplinary areas.

3. To acquire the proper skill and techniques to apply in the industrial fields.

4. To be acquainted with the latest technology so as to be placed in the best industries in the country and abroad.

5. To acquire a strong sound knowledge in the mathematical theory and related computation using recent software.

# Program Specific Objectives (PSOs)

1. To create powerful competent engineers acceptable to any relevant industry all over the world.

2. To acquire sound knowledge in more than one sub-areas of Communication and Signal Processing to pursue research.

# Course structure for M. Tech in Communication Systems & Signal Processing

### Semester-I

| Sl.No. | Subject | L | T | P | Hours/Week | Credit |
|---|---|---|---|---|---|---|
| 1 | Linear Algebra &Stochastic Processes | 3 | 1 | 0 | 4 | 4 |
| 2 | Advanced Digital Signal Processing | 3 | 1 | 0 | 4 | 4 |
| 3 | Advanced Digital Communication | 3 | 1 | 0 | 4 | 4 |
| 4 | Elective-I | 3 | 1 | 0 | 4 | 4 |
| 5 | Elective-II | 3 | 1 | 0 | 4 | 4 |
| 6 | Laboratory–I(Advanced Digital Communication Laboratory) | 0 | 0 | 3 | 3 | 2 |
| 7 | Laboratory –II(Advanced DSP Laboratory) | 0 | 0 | 3 | 3 | 2 |
| 8 | Seminar | 0 | 0 | 2 | 2 | 1 |
| **Total** | | | | | **28** | **25** |

### Semester-II

| Sl.No. | Subject | L | T | P | Hours/Week | Credit |
|---|---|---|---|---|---|---|
| 1 | Estimation and Detection Theory | 3 | 1 | 0 | 4 | 4 |
| 2 | Mobile Communication | 3 | 1 | 0 | 4 | 4 |
| 3 | Switching & Communication Networks | 3 | 1 | 0 | 4 | 4 |
| 4 | Elective-III | 3 | 1 | 0 | 4 | 4 |
| 5 | Laboratory –III (Optical Fibre Communication /Wireless Communication Laboratory) | 0 | 0 | 3 | 3 | 2 |
| 6 | Laboratory –IV(Advanced RF Laboratory) | 0 | 0 | 3 | 3 | 2 |
| 7 | Project Preliminary | 0 | 0 | 6 | 6 | 3 |
| 8 | Comprehensive Viva-Voce | - | - | - | - | 2 |
| **Total** | | | | | **28** | **25** |

### Semester-III

| Sl.No. | Subject | L | T | P | Hours/Week | Credit |
|---|---|---|---|---|---|---|
| 1 | Project & Thesis-I | - | - | - | - | **10** |

### Semester-IV

| Sl.No. | Subject | L | T | P | Hours/Week | Credit |
|---|---|---|---|---|---|---|
| 1 | Project & Thesis-II | - | - | - | - | **20** |
| **Total Credit** | | | | | | **80** |

## List of Electives

| Sl.No. | Elective | Name of the Course |
|---|---|---|
| 1. | Elective-I | Antenna Theory and Design |
| 2. | | Smart Antenna |
| 3. | | Microwave & Millimeter Wave Devices |
| 4. | | Radar Signal Processing |
| 5. | | Microwave Circuits, Systems and Application |
| 6. | | Cryptography & Network Security |
| 7. | Elective-II | Light Wave Technology |
| 8. | | MIMO Communication Systems |
| 9. | | Optical Communication Systems |
| 10. | | Electromagnetic Metamaterials |
| 11. | | Advanced Control System |
| 12. | | Digital Control System |
| 13. | Elective-III | Advanced Microwave Circuits |
| 14. | | Fundamentals of Antenna and Design |
| 15. | | Remote Sensing and Navigational Systems |
| 16. | | Optoelectronic Devices & Circuits |
| 17. | | Laser Science & Technology |
| 18. | | Metaheuristic Algorithms & their applications |
| 19. | | Electromagnetic Interference & Compatibility |

## Semester-I

| Linear Algebra & Stochastic Processes | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- Introduction to Probability , Random Process and Linear Algebra
- Application of linear algebra in theoretical analysis of the communication systems.
- Application of the concepts of Probability & Random Process to solve problems in Communication Systems and Signal Processing.

**COURSE CONTENT:**

**Module-1**

Vector spaces, Vector sub spaces of a matrix, Rank-Nullity Theorem, Projection theorem, linear transformation matrix with different basis- Gram-Schmidt orthogonalization procedure, QR factorization, Eigen values, Eigenvectors, Singular values, Singular vectors, Computation of Eigen values and Eigenvectors, Eigen vectors of a symmetric positive definite matrix and its meaning. Diagonalization of a matrix and applications, Singular Value Decomposition, Derivatives of scalars w.r.t a vector, Jacobian.

**Module-2**

Probability spaces, Random variables and random vectors, Distributions and densities-Conditional distributions and densities, Independent random variables, Transformation of random variables Expectations, Moment generating function, Characteristic function, Multiple random variable, Gaussian random vector. Co-variance matrix, Complex random variables, Sequence of random variable, Central limit theorem.

**Module-3**

Strictly stationary random process. Wide sense stationary random process. Complex random process. Jointly strictly and wide sense stationary of two random processes. Correlation matrix obtained from random process, Ergodic process, Independent random process, Uncorrelated random process, Random process as the input and output of the system, Power spectral density, White random process, Gaussian random process, Cyclo-stationary random process, Wide sense cyclo-stationary random process.

**Module-4**

Sampling and reconstruction of random process, BandPass random process, Applications of Linear algebra and stochastic process for telecommunication.

**TEXTS/ REFERENCES:**

1. G.Strang, Linear Algebra, Thomson Brooks/Cole Cengage Hill

2. Peter J. Olver, Applied Linear Algebra, Pearson Education

3. A.Papoulis, S.U.Pillai, Probability, Random variables and Stochastic Processes, TataMcGraw Hill

4. GeoffreyGrimmett, Probability and Random Processes, Oxford University Press

**COURSE OUTCOME:**

**CO1:** Apply probability and matrix theory to solve stochastic models.

**CO2:** Solve stochastic process problems mathematically and using software.

**CO3:** Identify and apply the most appropriate stochastic process technique for a given applied problem.

**CO4:** Interpret and understand the solution for a stochastic process application.

**CO5:** Be familiar with the usage of random process in telecommunication engineering and to solve the corresponding problems.

| Advanced Digital Signal Processing | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To provide rigorous foundations in multirate signal processing,
- To provide the knowledge of design & analysis of Adaptive Filters and their applications.
- To provide knowledge on different methods of Spectrum Estimation.

**COURSE CONTENT:**

**Module-1**

Review of sampling theory, sampling rate conversion by integer and rational factors, efficient realization and applications of sampling rate conversion

**Module-2**

Wiener filtering. Optimum linear prediction. Levinson- Durbin algorithm, Prediction error filters, Adaptive filters, FIR adaptive LMS algorithm, Convergence of adaptive algorithms, Fast algorithms, Applications: Noise canceller, echo canceller and equalizer.

**Module-3**

Recursive least squares algorithms, Matrix inversion lemma, Convergence analysis of the RLS algorithm, Adaptive beam forming, Kalman filtering.

**Module-4**

Spectrum estimation, Estimation of autocorrelation, Periodogram method, Nonparametric methods. Parametric methods

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**TEXTS/ REFERENCES:**

1. S.Haykin, Adaptive Filter Theory, Prentice- Hall

2. M.H. Hayes, Statistical Digital Signal Processing and Modeling, John Wiley

3. J.G.Proakis, D.M. Manolakis, Digital Signal Processing, Prentice Hall

**COURSE OUTCOME:**

**CO1:** Apply multirate DSP for applications and design efficient digital filters & construct multichannel filter banks.

**CO2:** Apply linear filtering techniques to engineering problems.

**CO3:** Solve adaptive filter problems.

**CO4:** Analyze the various adaptive filter algorithms.

**CO5:** Understand and analyze the statistical properties of the conventional spectral estimators.

| Advanced Digital Communication | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To review and enhance the knowledge of different digital communication schemes.
- To study the different types of digital Amplitude, Frequency, Phase Keying, different M-array and hybrid Amplitude-Phase, Phase-Frequency keying techniques for high performance modern communication systems.
- To aware of noise performance of different carrier modulation schemes passing through additive white Gaussian noise (AWGN) channels and accordingly to design optimum receiver.
- To make students aware of interference (Inter Symbol Interference (ISI)) due to non-ideal / non linear channel andto minimize the effects of ISI, and thereby deliver the digital data to its destination with the smallest possible error rate.
- To convert the channel into an equivalent AWGN at each time ‘k’ by using adaptive receivers and equalizers.
- To familiar with carrier and clock synchronization or recovery circuits to avoid the effects of phase shifting and timing jitter.
- To enhance the knowledge of different channel coding techniques and their performance evaluation.
- To understand the coded modulation schemes to increase the minimum distance between the signals that are the most likely to be confused, without increasing the average signal power and to study the digital transmission over fading channels.

**COURSE CONTENT:**

**Module 1:**

Review of digital modulation schemes and receivers in additive white Gaussian noise channels, CPM, MSK, CPFSK.

**Module 2:**

Inter symbol interference, Adaptive receivers and channel equalization: MMSE, ZFE, FSE, Carrier and clock synchronization, Effects of phase and timing jitter.

**Module 3:**

Channel Coding techniques: Linear Block codes, Cyclic codes, Convolution codes and their performance evaluation.

**Module 4:**

Coded modulation schemes: TCM, Turbo codes, Digital transmission over fading channels.

**TEXTS/ REFERENCES:**

1. S. Benedetto and E.Biglieri, Principles of Digital Transmission with Wireless Applications, Kluwer Academic.

2. B. P. Lathi, Z. Ding, Modern Digital and Analog Communication Systems, Oxford University Press

3. J. G.Proakis, Digital Communications, McGraw Hill

4. S.Haykin, Digital Communication Systems, John Wiley

5. H. Taub and D. L.Schilling, Principles of Communication Systems, McGraw Hill.

6. U. Madhow, “Fundamentals of Digital Communication”, Cambridge University Press.

**COURSE OUTCOME:**

After successful completion of this course, students

**CO1:** Will have enhanced knowledge of different digital communication schemes for high speed modern communication.

**CO2:** Will learn to design optimum receivers to obtain correct decision in presence of channel noise.

**CO3:** Will earn sufficient knowledge regarding signal dispersion and fading, and their impact (ISI) due to channel characteristics and accordingly will learn how to take correct decision in presence of ISI.

**CO4:** Will capable to measure ISI and to convert the channel into an equivalent AWGN by designing adaptive receivers and equalizers.

**CO5:** Will familiar with carrier and clock synchronization or recovery circuits to avoid the effects of phase shifting and timing jitter.

**CO6:** Will have knowledge of Channel Coding techniques and Coded modulation schemes desired for advanced digital communication.

## Semester-II

| Estimation and Detection Theory | L-3 T-1 P-0 | 4 credits |
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**COURSE OBJECTIVE:**

- To have some idea about the hypothesis testing in an ensemble of random data.
- To have knowledge about signal detection under various noise environments.
- To learn about various theories of estimation in random data assembly.
- To learn about non stationary filters for signal detection.

**COURSE CONTENT:**

**Module-1**

Binary hypothesis testing, Bayes, mini- max and Neyman-Pearson tests, Composite hypothesis testing.

**Module-2**

Signal detection in discrete time: Models and detector structures. Coherent detection in independent noise. Detection in Gaussian noise. Detection of signals with random parameters. Detection of stochastic signals. Performance evaluation of signal detection procedures.

**Module-3**

Bayesian parameter estimation, MMSE, MMAE and MAP estimates. Nonrandom parameter estimation. Exponential families. Completeness theorem. ML estimation. Information inequality. Asymptotic properties of MLEs.

**Module-4**

Discrete time Kalman-Bucy filter. Linear estimation. Orthogonality principle. Wiener-Kolmogorov filtering – causal and non -causal filters.

**Module-5**

Signal detection in continuous time: Detection of deterministic signals in Gaussian noise. Coherent detection in white Gaussian noise.

**TEXTS/ REFERENCES:**

1. H.V.Poor, Introduction to Signal Detection and Estimation, Springer.

2. B.C.Levy, Priciples of Signal Detection and Parameter Estimation, Springer

3. H.L.Vantrees, Detection, Estimation and Modulation theory, Part I, Wiley.

4. M.D.Srinath&P.K.Rajasekaran, Statistical Signal Processing with Applications, Wiley

5. J.C.Hancock& P.A. Wintz, Signal Detection Theory, Mc-Graw Hill, 1966.

**COURSE OUTCOME:**

CO1: To be able to gain the basic concept of hypothesis testing in random data assembly.

CO2: To have the idea of detection of original signal under different noises.

CO3: To be able to understand about different signals under different time and sample domain.

CO4: To learn the concept of stationary and non-stationary filters.

| Mobile Communication | L-3 T-1 P-0 | 4 credits |
|---|---|---|

## COURSE OBJECTIVE:

- To make students familiar with fundamentals of wireless and mobile communication systems and to impart an introduction to radio wave propagation techniques for mobile wireless radio.
- To discuss various multiple access techniques for wireless communication and choose system (TDMA/FDMA/CDMA) according to the complexity, installation cost, speed of transmission, channel properties etc.
- To identify the requirements of mobile communication as compared to static communication.
- To identify the limitations of 2G and 2.5G wireless mobile communication and use design of 3G /4G and beyond mobile communication systems.

## COURSE CONTENT:

Evolution of mobile radio Communication From 1G to2G systems, 2.5G Mobile Radio networks, 3G/4G Wireless networks, WLAN

**Module-1**

**Introduction and Basic system Design:** Cellular concept Cellular system, Frequency re-use , Co-channel interference and its reduction GOS, Frequency Spectrum, utilization, Traffic and channel assignments, various handoff strategies, Analog and digital cellular systems. Loss Models for Mobile Radio Propagation: Point to point Propagation. Model, Foliage loss, Free space propagation model, Reflection, Diffraction analysis using Fresnel zone geometry and knife Edge diffraction model, Outdoor Propagation models, Indoor propagation models, signal penetration into buildings . scale Fading and Multipath: Causes of fading ,Reciprocity theorem Amplitude and Selective fading Doppler shift ,Impulse response model of multipath Channel, Doppler spread and Rican distributions, Statistical analysis of Multipath fading channels, fading behavior analysis using channel models, Bit error rate and word error rate in fading Environment.

**Module-2**

**Design Parameter for Mobile Radio Network:** Antenna location, Antenna Spacing and heights for base station and mobile units, Antenna configurations for Base Environment, Frequency dependence of mobile unit Diversity schemes of mobile Unit, Antenna connection's locations on mobile unit. Modulation techniques –MSK-GMSK spread spectrum modulation multicarrier modulation (OFDM,MC-CDMA techniques).

**Module-3**

**Multiple Access Techniques:** Frequency division multiple access, Time division multiple access, Spread spectrum multiple access, space division multiple access, Pure and slotted ALOHA, CSMA protocols, Reservation protocols.

**Module-4**

**Cellular systems:** ARQ Techniques, Digital mobile telephony system, GSM architecture, services and features, GSM channels, CDMA digital cellular standard, Forward and reverse CDMA channel.

**TEXTS/ REFERENCES:**


1. T. Rappaport, Wireless Communication, Pearson Education

2. A. Goldsmith, Wireless Communications, Cambridge University Press

3. D. Tse, P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press

4. V.K. Garg, Wireless Communications & Networking, Elsevier


**COURSE OUTCOME:**

**CO1**: To make students familiar with various generations of mobile communications and basics of wireless communication.

**CO2:** Knowledge of GSM mobile communication standard, its architecture, logical channels, advantages and limitations.

**CO3:** To understand the concept of tele-traffic engineering

**CO4:** To understand various Wireless LANs and multicarrier communication systems.

| Switching and Communication Networks | L-3 T-1 P-0 | 4 credits |
|---|---|---|

## COURSE OBJECTIVE:

- To understand the principles of switching systems from manual and electromechanical to electronic systems.
- To provide the understanding of traffic engineering in telecommunication system along with the network architecture of modern day communication systems.
- To familiarize with the theory of Data communication components, networks and systems.
- To provide the understanding of principle of ISDN.

## COURSE CONTENT:

**Module-1**

**Introduction to Telecommunication Switching:** Evolution of Telecommunications, Simplex-duplex telephone communication, Elements of switching systems, Structure of rotary dial telephone, Step by step switching, Touch tone dial telephone, Principles of crossbar switching & crossbar exchange organizations. Electronic Space Division Switching: Centralized SPC with dual processor architecture, Levels of processing in Distributed SPC, Enhanced services, Design and determination of blocking probability of two stage and N stage networks. Time division multiplexing. Time Division Switching: Time division space switching with input-controlled and output–controlled configuration, Time multiplexed space switch.

**Module-2**

**Telecommunication Traffic Modeling and Analysis:** Various parameters of network traffic, GOS and blocking probability, Types of stochastic processes, Markov and Birth-Death processes, Poisson process, Blocking models and loss estimates, Erlang B formula, Delay systems with queuing configuration, Erlang C formula.

**Module-3**

**Introduction to Communication Networks and Services**: Data communication components, Data representation, Categories of networks (LAN, MAN, WAN), Unified view of OSI reference model, TCP/IP architecture and protocols, Physical structure connection and topology. Circuit and Packet Switching Systems: Circuit switched network routing tables; hierarchical routing, the Bellman-ford algorithm, Dijkstra's algorithm.

**Module-4**

**ISDN and Other Modern Networks:** ISDN services, Network and protocol architecture, Transmission channels & multiplexing schemes, ISDN message format and address structure, Internetworking of ISDN with other networks, Broadband ISDN, Brief architecture and operation of cable modem, DSL Technology, WLAN: IEEE 802.11, Introduction to Bluetooth.

**TEXTS/ REFERENCES:**

1. Wireless Communication: Rappaport, Second Edition, Pearson

2. William C.Y.Lee, Mobile Cellular Telecommunications-Analog & Digital Systems, Mc.Graw Hill

3. Computer organization and design: the hardware/software interface/David A. Patterson, John L. Hennessy

4. Telecommunication Switching Systems and Networks 2nd Edition by Thiagarajan Viswanathan.

**COURSE OUTCOME:**

**CO1:** Describe and apply fundamentals of switching in telecommunication systems and its associated technologies.

**CO2:** Apply the principles of queuing theory in evaluating the performance of congested telecommunication networks and explain the reasons for switching, and the relative merits of the possible switching modes, e.g. packet and circuit switching.

**CO3:** Understand the principles of the internal design and operation of telecommunication traffic modelling.

**CO4:** Understand the principles of Data communication and Networks components, procedure and types.

# ELECTIVES

| Antenna Theory and Design | L-3 T-1 P-0 | 4 credits |
|---|---|---|

## COURSE OBJECTIVE:

- To provide an in-depth understanding of modern antenna concepts, and practical antenna design for various applications.
- To familiarize with the essential parameters of antenna theory.
- To understand the basics of radiation pattern of different types of antennas.
- To study the different types of antenna and their application.

## COURSE CONTENT:

**Module-I**

**Fundamental Concepts**: Radiation pattern, near- and far-field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency, Friis transmission equation, radiation integrals and auxiliary potential functions.

**Module-2**

**Radiation from Wires and Loops:** Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop.

**Module-3**

**Aperture Antennas:** Huygens' Principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, and Fourier transform method in aperture antenna theory.

**Module-4**

**Horn and Reflector Antennas:** Radiation from sectoral and pyramidal horns, design concepts, prime-focus parabolic reflector and casse-grain antennas.

**Module-5**

**Microstrip Antennas:** Basic characteristics, feeding methods, methods of analysis, design of rectangular and circular patch antennas.

**Module-6**

**Antenna Arrays:** Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, beam forming, extension to planar arrays, synthesis of antenna arrays using Schelkunoff polynomial method, Fourier transform.

**TEXTS/ REFERENCES:**

1. C.A. Balanis, "Antenna Theory: Analysis and Design', Wiley

2. J.D Kraus, R. J. Marhefka and A. Khan, Antennas and Wave Propagation, MGH

3. R. S. Elliot, "Antenna Theory and Design", Wiley

4. R. Garg, P.Bhartia, I. Bhal and A. Ittipiboon, "Microstrip Antenna Design Handbook", Artech House 6. G. Kumar and K.P. Ray, Broad Band Microstrip Antennas, Artech House.

**COURSE OUTCOME:**

**CO1:** Understand the basics and theory behind antenna radiation mechanisms, point sources, small-wave dipoles, and half-wave dipoles.

**CO2:** Understand and apply the various figures of merit for antennas such as radiation pattern, gain, polarization, efficiency, bandwidth, and others.

**CO3:** Learn about, and design various types of wire antennas, such as dipoles, loops, arrays, Yagi-Uda and logarithmic.

**CO4:** Learn about patch antennas, microstrips, MIMOs, mobile antennas and smart antennas.

| Smart Antenna | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To gain understanding and achieve familiarity with smart antenna environments.
- To understand algorithms and their implementation.
- To apply the concepts in Smart Antenna system design

**COURSE CONTENT:**

### Module-1

Introduction, Need of Smart Antenna Systems, Overview of smart antenna systems, The Vector Channel Impulse Response and the Spatial Signature, Spatial Processing Receivers, Fixed Beam forming Networks, Switched Beam Systems, Hybrid Beamformer, Overview of distributed beam forming, interference rejection using adaptive antennas.

### Module-2

Adaptive Antenna Systems, Wideband Smart Antennas, Diversity Techniques, Multiple Input - Multiple Output (MIMO) Communications Systems, MIMO for frequency selective scenarios. SDMA using smart antennas

### Module-3

Sample matrix inversion algorithm, unconstrained LMS algorithm, normalized LMS algorithm, Constrained LMS algorithm, Perturbation algorithms, neural network approach, Adaptive beam space processing, Implementation issues.

### Module-4

Direction of Arrival (DOA) Estimation for smart antennas: Spectral estimation methods, linear prediction method, Maximum entropy method, Maximum likelihood method, Eigen structure methods, MUSIC algorithm – root music and cyclic music algorithm, the ESPRIT algorithm.

**TEXTS/ REFERENCES:**


1. R.A. Monzingo, R.A. Haupt, W.H. Miller, Introduction to Adaptive Arrays, SciTech Publishing Inc

2. Frank Gross, Smart Antennas for Wireless Communications, McGraw Hill

3. Ahmed El-Zooghby, Smart Antenna Engineering, Artech House Publishers

4. Constantine Balanis, Introduction to Smart Antennas, Morgan and Claypool Publishers

5. J. Liberti, T.S. Rappaport, Smart Antennas for Wireless Communications-IS-95 and Third Generation CDMA Applications, Prentice Hall

**COURSE OUTCOME:**

**CO1:** Compare the performances of digital radio receivers and software radios.

**CO2:** Study the CDMA spatial processors to analyze the multi-cell systems.

**CO3:** Analyze the channel models for smart antenna systems.

**CO4:** Study the environmental parameters for signal processing of smart antenna systems.

**CO5:** Evaluate the requirements for the design and implementation of smart antenna systems.

| Microwave & Millimeter Wave Devices | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To understand the basics of microwave device physics.
- To familiarize with operation and characteristics of various microwave devices and circuits such as klystron, TWT, magnetrons.
- To Study the application of RF and Microwave devices.
- To study three terminal Microwave devices.

**COURSE CONTENT:**

**Module-1**

**RF and Microwave tubes:** Vacuum tube microwave device physics: Beam field interaction; power frequency limitation, device size limitations; special features of microwave tubes. Non relativistic electron tubes, Parallel field type – Klystron, Reflex Klystron, Helix TWT, coupled cavity TWT, Twystrons; Crossed field type – magnetrons, FWCFA, carcinotron. Relativistic electron tubes: gyrotrons; free electron LASER.

**Module-2**

**RF and Microwave Devices:** Diodes; high-frequency equivalent circuit; Schottky barrier diode; varactor diode; PIN diode; Applications, Tunnel diodes, Quantum tunneling mechanism, Impact ionization; IMPATT and other related diodes; small-signal analysis and model of IMPATT diode; TRAPATT; BARRITT, Transferred electron devices; differential negative resistance and two-valley model of Gunn Effect devices; modes of operation; waveguide cavity Gunn oscillator.

**Module-3**

**Three terminal devices:** BJT, MESFET, MOSFET, HFET, HEMT – device physics, characteristics, model, Three terminal devices; BJT, MESFET, MOSFET, HFET, HEMT – device physics, characteristics, model.

**TEXTS/ REFERENCES:**

1. A. S. Gilmour, “Microwave Tubes”, Artech House

2. K. C. Gupta, Microwaves, New Age International

3. S. Y. Liao, Microwave Devices and Circuits, Pearson Education

4. R. E. Collin, Foundations for Microwave Engineering, Wiley

5. S. Das, Microwave Engineering, Oxford University Press

6. M. L. Sisodia, “Microwave Active Devices: Vacuum and Solid State, New Age Publishers

**COURSE OUTCOME:**

The student after undergoing this course will be able to:

**CO1:** Explain different types of RF and Microwave tubes and their features.

**CO2:** Differentiate the working of various tubes and their applications.

**CO3:** Explain working of microwave active devices such as ATT, TED and tunnel diode etc

**CO4:** Describe and explain working of microwave tubes and solid-state devices.

| Radar Signal Processing | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- ❖ To achieve understanding of the principles of Signal Processing techniques used in Radar Systems.
- ❖ To apply the concepts in real time processing of RADAR signals

**COURSE CONTENT:**

**Module-1**

**Introduction:** Radar Block Diagram, Radar Equation, Information Available from Radar Echo. Review of Radar Range Performance– General Radar Range Equation, Radar Detection with Noise Jamming, Beacon and Repeater Equations, Bistatic Radar, Matched Filter Receiver – Impulse Response, Frequency Response Characteristic and its Derivation, Matched Filter and Correlation Function, Correlation Detection and Cross-Correlation Receiver, Efficiency of Non Matched Filters, Matched Filter for Non-White Noise.

**Module-2**

**Detection of Radar Signals in Noise:** Detection Criteria – Neyman-Pearson Observer, Likelihood-Ratio Receiver, Inverse Probability Receiver, Sequential Observer, Detectors – Envelope Detector, Logarithmic Detector, I/Q Detector. Automatic Detection - CFAR Receiver, Cell Averaging CFAR Receiver, CFAR Loss, CFAR Uses in Radar, Radar Signal Management – Schematics, Component Parts, Resources and Constraints, RADAR System Losses.

**Module-3**

**Waveform Selection:** Radar Ambiguity Function and Ambiguity Diagram – Principles and Properties; Specific Cases – Ideal Case, Single Pulse of Sine Wave, Periodic Pulse Train, Single Linear FM Pulse, Noise Like Waveforms, Waveform Design Requirements, Optimum Waveforms for Detection in Clutter, Family of Radar Waveforms, Radar and its composite environment, Review of Radar range performance computations, Detection Processes, Sequential and adaptive processes, Atmospheric effects, Sea and land Back scatter, Signal Processing concepts and waveform designs MTI &CW radars, phase coding techniques, FM pulse compression waveforms, Meteoroidal Radar and system performance analysis, Monopulse radars, Amplitude Comparison Monopulse & Phase Comparison Monopulse, error signal of amplitude comparison Monopulse, Phased Array RADAR.

**Module-4**

**Pulse Compression in Radar Signals:** Introduction, Significance, Types, Linear FM Pulse Compression – Block Diagram, Characteristics, Reduction of Time Sidelobes, Stretch Techniques, Generation and Decoding of FM Waveforms – Block Schematic and Characteristics of Passive System, Digital Compression, SAW Pulse Compression.

**TEXTS/ REFERENCES:**

1. R.J Sullivan, Radar Foundations for imaging and Advanced Concepts, PHI.

2. F.E Nathanson, Radar Design Principles, Signal Processing and the Environment, PHI.

3. J.C. Toomay, Principles of Radar, PHI.

4. M. Skolnik, Introduction to Radar Systems, McGraw Hill

**COURSE OUTCOME:**

**CO1**: Understand the principles of Radar Systems and Signal Processing techniques.

**CO2**: Detect radar signals in noise using different receivers.

**CO3**: Analyze the properties of Ambiguity function and waveform design requirements.

**CO4**: Describe the concepts of pulse compression Radar.

| Microwave Circuits, Systems and Application | L-3 T-1 P-0 | 4 credits |
| --- | --- | --- |

**COURSE OBJECTIVE:**

- ❖ To have the basic idea of microwave passive circuits and their methods of representation.
- ❖ To learn about the concept of periodic structures in microwave circuits
- ❖ To have some knowledge about the design principles of microwave oscillators and amplifiers
- ❖ To collect the basic knowledge of mobile communication
- ❖ To have some knowledge about the fundamentals of radar systems.

**COURSE CONTENT:**

**Module-1**

Microwave Circuits: Lumped and distributed circuit elements at RF and microwave frequencies, transmission lines for RF & microwave circuits, Discontinuity Model, Impedance Matching Using Smith Chart. Network Parameters, ABCD, Z, Y, S, S -parameter description of passive and active networks, network concept. Periodic structures and Design of filters. Attenuators: Fixed Digital & Programmable Attenuators

**Module-2**

Network concept. Periodic structures and Design of filters. Attenuators: Fixed Digital & Programmable Attenuators.

**Module-3**.

Performance and design principles of amplifiers and oscillators using Klystron, Magnetrons: Co-axial magnetron, inverted co-axial magnetron, voltage tunable magnetron, TWTs: Design of TWT amplifiers, carcinotrons, Amplitrons

**Module-4**

Microwave Systems and Application: Mobile Communication: Frequencies, regulations, Signals, Antennas, Signal propagation, Multiplexing, Modulation Techniques, Satellite networks, Wireless Application Protocol.

**Module-5**

Radar: Radar equations for tracking, volume search, jamming and cluttering. Non coherent MTI, MTI from moving platform, Pulse compression radar, Phased array, synthetic aperture radars, Radar antenna systems, ECCM techniques

## TEXTS/ REFERENCES:

1. S. L. Liao, Microwave Devices and Circuits, Pearson

2. D.M. Pozar, Microwave Engineering, John Wiley

3. R.E. Collin, Foundations for Microwave Engineering, John Wiley

4. M. Skolnik, Introduction to Radar Systems, McGraw Hill

## COURSE OUTCOME:

**CO1:** To be able to learn the basic difference between the concept of lower frequency circuits and microwave circuits.

**CO2:** To collect the knowledge about the mathematical methods of representing the periodic microwave passive structures.

**CO3:** To understand the concept of design of microwave oscillators and amplifiers.

**CO4:** To learn the basic idea about mobile communication techniques.

**CO5:** To understand the principles of various radar systems.

| Cryptography & Network Security | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To have an understanding of the fundamentals of Cryptography.
- To know the goals of cryptography e.g. data secrecy, message integrity, non-repudiation and authentication.
- To have a knowledge of the prominent techniques for private key encryption, hashing and message authentication e.g, DES, AES, SHA-1, HMAC.
- To understand the difference between private key cryptography and public key cryptography.
- To have knowledge of the prominent techniques for public-key cryptosystems and digital signature schemes e.g. RSA, ElGamal, EC.

**COURSE CONTENT:**

**Module-1**

**INTRODUCTION:** Security Policies, Model of network security, Security attacks, services and mechanisms, OSI security architecture, Classical encryption techniques

**Module-2**

**SYMMETRIC KEY CRYPTOGRAPHY**: Mathematics of symmetric key cryptography: Modular arithmetic, Euclid's algorithm, Linear Congruence, Matrices, Block ciphers and Stream ciphers, Symmetric key ciphers: DES, Differential and linear cryptanalysis, AES, RC4.

**Module-3**

**PUBLIC KEY CRYPTOGRAPHY:** Mathematics of asymmetric key cryptography: Primes, Primality Testing, Factorization, Euler‘s totient function, Fermat‘s and Euler‘s Theorem, Chinese Remainder Theorem, Exponentiation and logarithm, Asymmetric Key Ciphers, RSA cryptosystem, Key distribution, Key management, Diffie- Hellman key exchange , ElGamal cryptosystem, Elliptic curve arithmetic, Elliptic curve cryptography.

**Module-4**

**MESSAGE AUTHENTICATION AND INTEGRITY:** Authentication function, MAC, Hash function, Security of hash function and MAC, SHA, Digital signature and authentication protocols, DSS, Entity Authentication: Biometrics, Passwords, Challenge Response protocols- Authentication applications – Kerberos.

**Module-5**

**SECURITY PRACTICE AND SYSTEM SECURITY:** PGP, S/MIME, IP security, Web Security, System Security: Intruders – Malicious software – viruses –Firewalls, SSL and TSL**.**

**TEXTS/ REFERENCES:**

1. William Stallings, Cryptography and Network Security: Principles and Practice, PHI

2. Forouzan and Mukhopadhyay, Cryptography and Network Security, McGraw Hill.

**COURSE OUTCOME:**

After the completion of the course, students will:

**CO1:** Have an idea about the basics of cryptography.

**CO2:** Will understand the difference between private key and public key cryptography.

**CO3:** Will have knowledge of different enciphering techniques.

**CO4:** Will have knowledge of digital signature, hash function, key exchange, digital certificate, security etc.

**CO5:** Will get an insight in to message authentication and integrity.

| Light Wave Technology | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- The objective of this course is to provide an in-depth understanding of optical fiber communication. To study various types of light sources, photo detectors, amplifiers in optical communication. To understand the basics of Transmission characteristics of an optical fiber and to design and analyze optical networks and optical fiber links.
- To provide an in-depth understanding of optical fiber communication
- To study various types of light sources, photo detectors, amplifiers in optical communication
- To understand the basics of Transmission characteristics of an optical fiber.
- To design and analyze opticalnetworks and optical fiber links.

**COURSE CONTENT:**

**Module-1**

Introduction and fiber optics components: optical fiber; optical cables; splices and connectors; couplers and dividers

**Module-2**

Optical sources, detectors and displays for communication: LED; semiconductor LASER; PIN, APD; CCD; LCD.

**Module-3**

Transmission and detection systems: intensity modulation; direct and coherent detection; S/N ratio; BER; WDM.

**Module-4**

LIDAR and its applications. Optical space communication.

**Module-5**

Application of fiber optics systems.

**Module-6**

Broadband technology: fiber optics links – design and systems; application of light wave technology to microwaves

**TEXTS/ REFERENCES:**

1. J. M. Senior, "Optical Fiber Communications: Principles and Practice", Pearson Education India

2. G. Keiser, "Optical Fiber Communication", McGraw Hill India.

3. T. L. Singal, "Optical Fiber Communications: Principles and Applications", Cambridge University Press

4. M. Alhaider, “Optical Fiber Communications”, Notion Press

5. C. K. Sarkar and D. C. Sarkar, “Optoelectronics and Fiber Optic Communication”, New Age International

6. J. Franz and V. K. Jain, “Optical Communication System”, Narosa Pub. House

7. M. Young, “Optics and Lasers including Fibres and Optical Waveguides”, Springer

**COURSE OUTCOME:**

The student after undergoing this course will be able to:

**CO1:** Working and design of Optical fiber cables, fiber alignment and splicing Techniques

**CO2:** Understand the basics of Transmission characteristics and the concept of absorption losses and Dispersion.

**CO3:** Understand the construction and working of Optical sources- LEDs and LASERs

**CO4:** Design and analysis of Optical networks and Optical fiber link design

| MIMO Communication Systems | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To provide a comprehensive coverage of MIMO communication systems.
- To introduce the coding techniques used in MIMO systems and their performance analysis.
- To apply the concepts in analysis and design of MIMO Communication Systems.

**Module-1**

Overview of MIMO communications: Introduction to MIMO, Introduction to Spatial Diversity and Spatial Multiplexing, MIMO capacity formula, MIMO System Model. Application of MIMO Capacity.

**Module-2**

Phenomenology of multipath channels, Power law propagation, Impulse response of a multipath channel, intrinsic multipath channel parameters, Classes of multipath channels, Statistics of small-scale fading.

**Module-3**

MIMO channels in LOS geometry, Antenna spacing and scattering angle, Alamouti Coding and Space-time Coding: Maximal ratio receive combining(MRRC), Maximum likelihood decoding in MRRC and Alamouti receivers, Performance results, Space-time coding.

**Module-4**

Spatial Multiplexing: Overview of spatial multiplexing, BLAST architecture, Broadband MIMO, Narrowband and Broadband MIMO channel estimation

**TEXTS/ REFERENCES:**


1. Jerry R. Hampton, Introduction to MIMO Communications, Cambridge University Press.
2. Bliss and S. Govindasamy, Adaptive Wireless Communications: MIMO Channels and Networks,

Cambridge University Press

3. Simon Haykin, Michael Moher, Modern Wireless Communications, Pearson.

4. Andrea Goldsmith, Wireless Communication, Cambridge University Press.

5. Jafarkhani, Space-Time Coding: Theory and Practice, Cambridge University Press


**COURSE OUTCOME:**

**CO1:** Design precoders for MIMO communication systems.

**CO2:** Design MIMO communication transceivers with and without channel state information.

**CO3:** Design space time codes for MIMO systems.

**CO4:** Analyze and design optimum MIMO Communication systems for given channel conditions.

| Optical Communication Systems | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To provide an in-depth understanding of optical fiber communication.
- To study various types of light sources, photo detectors, amplifiers in optical communication.
- To understand the basics of Transmission characteristics of an optical fiber and to design and analyze optical networks and optical fiber links.

**COURSE CONTENT:**

**Module-1**

Fundamentals of coherent systems: Basic concepts. Modulation and demodulation schemes. System performance.

**Module-2**

Semiconductor optical amplifiers. EDFA and Raman amplifiers – modeling and analysis, Analysis and digital transmission with high power fiber amplifiers.

**Module-3**

Multichannel systems: WDM light wave systems, TDM and code division multiplexing, Advances in wavelength division multiplexing / demultiplexing technologies.

**Module-4**

SONET/SDH, ATM, IP, storage area networks. Wavelength routed networks. Next generation optical Internets.

**Module-5**

Soliton systems: Nonlinear effects, Soliton – based communication. High speed and WDM soliton systems, Fiber based grating, Broadband.

**TEXTS/ REFERENCES:**

1. G.P.Agrawal, "Fiber Optic Communication Systems (4/e)", Wiley, 2010

2. B.P.Pal , "Guided Wave Optical Components and Devices", Elsevier , 2006

3. C.S.Murthy&M.Gurusamy, "WDM Optical Networks", PHI, 2002

4. R.Ramaswami, K.N. Sivarajan, "Optical Networks", (2/e), Elsevier, 2002.

5. J.M. Senior, Optical Fiber Communications: Principles and Practice, Pearson

6. A Selvarajan, S. Kar, T. Srinivas, "Opticl fiber communication principles and systems", Tata McGraw Hill, 2005.

**COURSE OUTCOME:**

At the end of the course student will be able

**CO1:** Understand the modulation and demodulation schemes in the coherent optical systems.

**CO2:** Understand the various types of the optical amplifiers

**CO3:** Analyze various multiplexing techniques used and evaluate the recent advances in this field

**CO4:** Compare the merits and demerits, potential applications of microwave semiconductor devices.

**CO5:** Analyze the operating principle of WDM solutions systems.

| Electromagnetic Metamaterials | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To understand the principles of Metamaterials
- To apply the concepts in design of Metamaterial components

**COURSE CONTENT:**

**Module-1**

Definition of Metamaterials & Left handed materials, Theoretical Speculation by Viktor Veselago, Conventional backward waves & Novelty of LH MTMs, Terminology, Transmission Line Approach Composite right & Left handed(CRLH) MTMs, MTMS & Photonic Band Gap Structures(PBG), Historical Germs of MTMs.

**Module-2**

Fundamentals of LH MTMs: Left handedness from Maxwell's Equations, Entropy condition in dispersive media, boundary Conditions, Reversals of Doppler Effect, Radiation, Snell's Law, Convergence & Divergence in Convex & Conclave Lenses. Sub wavelength Diffraction.

**Module-3**

TL Theory of MTMLs: Ideal Homogeneous CRLH TLs, LC Network Implementation, Real Distributed1D CRLH Structures, Transmission Characteristics, Conversion to Constitutive Parameters.

Two Dimensional MTMs : Eigen Value Problem, Driven Problem by the Transmission Matrix Method(TMM), Transmission Line Matrix Modelling(TLM), Negative Refractive Index(NRI) Effects, Distributed 2D Structures, Guided Wave applications, Radiated wave applications.

**Module-4**

Guided-Wave Applications - Dual-Band Components: Dual-Band Property of CRLH TLs - Quarter wavelength TL and Stubs - Passive Component Examples: Quadrature Hybrid and Wilkinson Power Divider - Enhanced-Bandwidth Components: Principle of Bandwidth Enhancement - Rat-Race Coupler Example .Tight Edge-Coupled Coupled-Line Couplers (CLCs): Generalities on Coupled-Line Couplers - TEM and Quasi-TEM Symmetric Coupled-Line Structures with Small Interspacing: Impedance Coupling (IC) - Non- TEM Symmetric Coupled-Line Structures with Relatively Large Spacing: Phase Coupling (PC) - Summary on Symmetric Coupled-Line Structures - Asymmetric Coupled-Line Structures -Advantages of MTM Couplers - Symmetric Impedance Coupler - Radiated-Wave Applications and examples - Uniform and Periodic Leaky-Wave Structures - "Real-Artificial" Materials: the Challenge of Homogenization – Special Topics of Interest.

**TEXTS/ REFERENCES:**

1. N. Engheta , R. W. Ziolkowski, Metamaterials: Physics and Engineering Explorations, John Wiley

2. F. Capolino, Theory and Phenomena of Metamaterials, CRC Press

3. C. Caloz, T. Itoh, Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications, Wiley IEEE Press

**COURSE OUTCOME:**

**CO1:** Learn and understand the principles of Metamaterials

**CO2:** Understand the theory of Transmission line theory of Metamaterials.

**CO3:** Learn the applications of and Principles of two dimensional MTMs.

**CO4:** Learn the principles of Guided Wave Applications of MTMs.

**CO5:** Learn the principles coupling theory and its applications in MTMs.

| | | |
|---|---|---|
| **Advanced Control System** | **L-3 T-1 P-0** | **4 credits** |

**COURSE OBJECTIVE:**

- To study state variable approach for the analysis of control system
- To learn testing techniques for controllability and observability of a given system
- To acquire knowledge to design pole placement and state observer using state feedback
- To understand describing function and phase plane analysis of non-linear system.
- To study the analysis of non-linear system using Lyapunov function.
- To learn the concept of various linearization techniques.

**COURSE CONTENT:**

**Module- 1: State Space Analysis:**

Introduction, State variable modelling, decomposition, solutions of state equations, state transition matrix, Linear Transformations, Controllability & Observability, Pole-placement and Observer design.

**Module- 2: Non-Linear System:**

Classification of non-linearity, types of non-linearity in physical system, jump resonance, methods of analysis of non-linear systems, linearization.

**Module- 3 : Phase Plane Analysis:**

Concept of phase plane, phase trajectory, phase portraits, methods of plotting phase plane trajectories, Vander Pol's equation, limit cycle.

stability from phase portrait, time response from trajectories, isoclines method, Pell's method of phase trajectory, Delta method of phase trajectory construction.

singular points, Classification of singular points.

**Module- 4: Describing function analysis:**

Fundamentals, computation of Describing function, describing functions of common non-linearities, Describing function method for stability analysis.

**Module- 5: Lyapunov Stability Analysis:**

Asymptotic stability, global stability, Concepts of definiteness, Lyapunov Stability theorem, stability analysis by Lyapunov direct method, Lyapunov function, generation of Lyapunov function.

**Module-6: Nonlinear Control Design:**

Feedback linearization, Input Output linearization, sliding mode control

**TEXTS/ REFERENCES:**

1. Gopal - Modern Control System Theory, New Age International

2. John Doyle, Bruce Francis & Allen Tannenbaum - Feedback Control Theory, Macmillan Publishing Co.

3. Tan, J - Modern Control Theory, Mc. Grawhill.

4. Ogata K - Modern Control Engg. PHI

5. Kuo B.C - Automatic Control System, PHI

6. Dorf R C & Bishop R.H - Modern Control System, Addison – Wisley.

7. Nagrath I J &Gopal M - Control Systems Engineering, New Age International Pub.

8. Hassan K. Khalil - Nonlinear systems, 3rd edition, Prentice Hall, 2002.

9. Stanislaw H. Zak - Systems and Control.

**COURSE OUTCOME:**

**CO1:** Acquire knowledge to develop state models of a system and find solution of state equations for the system.

**CO2:** Ability to test a system for controllability and observability.

**CO3:** Ability to design pole placement and state observer with the help of state feedback.

**CO4:** Acquire knowledge to analyse non-linear system behaviour by describing function and phase plane techniques.

**CO5:** Acquire knowledge to perform stability analysis of non-linear system using Lyapunov function.

**CO6:** Ability to apply linearization techniques in the analysis of non-linear systems

| Digital Control System | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To introduce control theory in the analysis and design of computer-controlled system.
- To acquire knowledge on pulse transfer function and their analysis.
- To study stability concepts in discrete domain.
- To introduce state variable approach in discrete domain.
- To acquire knowledge about the design techniques of Digital controller.
- To study PID controller in discrete domain.

**COURSE CONTENT:**

**Module- 1: Introduction to Discrete time control**

**Features of Discrete time control** system, Structure of a computer-controlled system, Signal processing in discrete time control.

**Module- 2 : Modeling of discrete-time systems**

Review of Z-transform, Mapping of S-plane to Z transform, Pulse transfer function, Pulse transfer function of closed loop system

**Module- 3: Stability analysis of discrete time systems**

Jury stability test, Stability analysis by use of the Bi-linear transformation and Routh stability criterion, Root locus

**Module- 4: Design of Discrete time control system**

Transient and steady state response analysis, design based on the frequency response method, Bi-linear transformation and design procedure in the W-plane.

**Module- 5: State Space representation of discrete-time system**

Discrete state space model, Pulse transfer function matrix solving discrete time state space equations, state transition matrix, Discretization of continuous time state space equations, Controllability, observability.

**Module- 6: State feedback design**

Pole placement by State feedback, State estimator

**Module- 7 : Design of Controller in discrete domain**

Digital controllers, Digital PID controller, Dead beat control design

**TEXTS/ REFERENCES:**

1. B. C. Kuo, "Digital Control Systems", 2nd Edition, Oxford University Press, 2003.

2. K. Ogata, "Discrete-Time Control systems", 2nd Edition. PHI, 2002.

3. M. Gopal, "Digital Control and State Variable Methods", 3rd Edition, TMH, Sep-2008.

4. M. Gopal, "Modern Control Systems Theory", Wiley Eastern, 1984

5. M. Gopal, "Digital control engineering", New Age International Publications, 2003

6. Kannan M.Moddgalya, Digital Control, Wiley India, 2007.

**COURSE OUTCOME:**

**CO1:** Acquire knowledge to understand the concepts of digital control system.

**CO2:** Ability to analyse the stability of discrete time system.

**CO3:** Acquire knowledge to analyse digital control system using transform techniques.

**CO4:** Ability to analyse and design discrete time system using state space method

**CO5:** Ability to design digital controller.

| Advanced Microwave Circuits | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To understand the basics of transmission lines & Waveguides.
- To familiarize with principle of various microwave circuits.
- To study Impedance transformers.
- To familiarize with Power Dividers, Couplers and filters.
- To understand the basics of Resonator circuits.

**COURSE CONTENT:**

**Module-1**

**Transmission Lines and Waveguides**: Review of TEM, TE, and TM mode solutions of Maxwell's equations; TEM mode transmission lines: lossless line, line with small losses, power flow in a terminated line; Quasi- TEM mode lines: Fields in microstrip lines and strip lines, losses in microstrips, microstrip discontinuities, coupled lines, slot lines and coplanar waveguides; Surface waveguides: Surface waves along an impedance plane, dielectric-coated conducting plane, slab waveguide, corrugated plane; Wave velocities.

**Module-2**

**Microwave Circuit Theory Principles**: Equivalent voltages and currents; Z, Y, S, and ABCD parameters; Equivalent circuit representation of microwave junctions; Scattering parameter analysis of microwave junctions; Coupling of waveguides through probes, loops, and apertures.

**Module-3**

**Impedance Transformers:** Review of single-, double- and triple-stub tuners, waveguide reactive elements, quarter-wave transformers, design of maximally flat and Chebyshev transformers; Introduction to tapered transmission lines.

**Module-4**

**Power Dividers and Couplers:** Scattering matrix of 3- and 4-port junctions; Design of T-junction

**Filters:** Analysis of periodic structures, Floquet's theorem, filter design by insertion loss method, maximally flat and Chebyshev designs.

**Module-5**

**Resonators:** Principles of microwave resonators, loaded, unloaded and external Q, open and shorted TEM lines as resonators, microstrip resonators, dielectric resonators.

**TEXTS/ REFERENCES:**

1. S. L. Liao, Microwave Devices and Circuits, Pearson

2. D.M. Pozar, Microwave Engineering, John Wiley

3. R.E. Collin, Foundations for Microwave Engineering, John Wiley

4. S. Das, Microwave Engineering, Oxford University Press

**COURSE OUTCOME:**

**CO1:** Explain different types of waveguides and their respective modes of propagation.

**CO2:** Analyze typical microwave networks using impedance, admittance, transmission and scattering matrix representations.

**CO3:** Design microwave matching networks using L section, single and double stub and quarter wave transformer.

**CO4:** Explain working of microwave passive circuits such as isolator, circulator, Directional couplers, attenuators etc.

| Fundamentals of Antenna and Design | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- The objective of this course is to provide a detailed idea of antenna parameters and numerical methods to analyze and differentiate the antennas. The student will learn and understand radio wave propagation concepts and radiation mechanism of various antennas and practical antenna design for various applications.
- To understand the basics of antenna parameter.
- To familiarize with different types of antennas.
- To study antenna array and beam pattern.
- To familiarize with the theory of radio wave propagation.
- To understand the basics of link budget in communication system.

**COURSE CONTENT:**

**Module-1**

Antenna parameters; radiation from wires and loops; infinitesimal dipole; finite-length dipole; linear elements near conductors; small circular loop.

**Module-2**

Aperture antenna: Huygens' Principle; radiation from rectangular and circular apertures; design considerations; Fourier transform method in aperture antenna theory.

**Module-3**

Horn and reflector antennas: radiation from sectoral and pyramidal horns; design techniques; parabolic reflector.

**Module-4**

Printed antenna: basic characteristics; feeding methods; methods of analysis; design of rectangular and circular patch antennas; bandwidth enhancement techniques.

**Module-5**

Antenna arrays and beam forming, beam pattern: analysis and synthesis; dielectric resonator antennas; ultra wideband antennas; active antennas; antenna measurements.

**Module-6**

Radio wave propagation: Antenna located over flat and spherical earth; coverage diagram, it's application and interference formulas. Modes of propagation: LOS and radio horizon; non-LOS propagation – indirect, tropospheric and ionospheric propagation; propagation effects as a function of frequency. Need for modeling propagation; model selection and application.

**Module-7**

Communication systems and link budget. Atmospheric effects; fading and multipath characterization; indoor and outdoor propagation model; microwave and mm wave propagation and rain drop attenuation.

**<u>TEXTS/ REFERENCES:</u>**

1. C.A. Balanis, "Antenna Theory: Analysis and Design', Wiley

2. J.D Kraus, R. J. Marhefka and A. Khan, Antennas and Wave Propagation, MGH

3. R. S. Elliot, "Antenna Theory and Design", Wiley

4. S. R. Saunders and A. R. Zavala, "Antennas and Propagation for Wireless Communication Systems", Wiley

5. W. A. Stutzman and G. A Thiele, "Antenna Theory and Design"' Wiley

6. R. Garg, P.Bhartia, I. Bhal, A. Ittipiboon, Microstrip Antenna Design Handbook, Artech

House

7. R. E. Collin, "Antenna and Radio Wave Propagation", McGraw Hill

**<u>COURSE OUTCOME:</u>**

**CO1:** Define various antenna parameters.

**CO2:** Analyze radiation patterns of antennas.

**CO3:** Analyze radiation patterns of antennas

**CO4:** Illustrate techniques for antenna parameter measurement.

| Remote Sensing and Navigational Systems | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To familiarize with the principle of Radar system.
- To study the basics of remote sensing.
- To understand the basics of satellite communications and different satellite communication orbits
- Provide an in-depth understanding of satellite communication system operation, launching techniques, satellite link design and earth station technology.
- To understand the basics of satellite based navigational systems.

## COURSE CONTENT:

**Module-1**

**Radar:** Introduction; basic radar range equation and modification; CW, FM and pulsed radar; MTI and pulsed Doppler radars; scanning and tracking radars; receiver; duplexer; display systems; ambiguity diagram; pulse compression; radar antennas; ECM and ECCM .

**Module-2**

**Remote sensing:** Overview, earth's atmosphere; land surface; oceans; land and sea ice; radiation budget; climate; radar altimeters; synthetic aperture radars (SAR); wind scatterometers; multispectral imaging; IR and microwave radiometers; concept of GIS.

**Module-3**

**Satellite System:** Kepler's Laws, Newton's law, orbital parameters, orbital perturbations, station keeping, geo stationary and non-Geo-stationary orbits –Limits of visibility – Structure, Primary power, Attitude and Orbit control, Thermal control and Propulsion, communication Payload and supporting subsystems.

**Module-4**

**Satellite communication: Telemetry**, Tracking and command-Transponders-Basic link analysis, Interference analysis, Ionospheric characteristics, Link Design with and without frequency reuse, INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. GPS Position Location Principles, Differential GPS, Direct Broadcast satellites (DBS/DTH).

**Module-5**

**Satellite based navigational systems:** Electronic navigation systems – global and regional; concepts of satellite based navigation systems – GPS, GLONASS, Galileo, Beidou, QZSS, NaVIC; code and carrier phase based measurement techniques; augmentation; relative positioning – DGPS, RTK; Precise Point Positioning (PPP); Satnav applications.

**TEXTS/ REFERENCES:**

1. MerillSkolnik; Introduction to Radar Systems, 3rd Edition; Tata McGraw Hill
2. Satellite Communication- T. Pratt & W. Boston
3. Satellite Communication- Roddy
4. Fundamental of Remote Sensing, Noam Levin
5. James B. Campbell & Randolph H. Wynne., Introduction to Remote Sensing, The Guilford Press

**COURSE OUTCOME:**

**CO1:** Understand the working principle of various RADAR techniques

**CO2:** Explain the concepts, methodologies and applications of Remote Sensing.

**CO3:** Understand satellite system

**CO4:** Illustrate techniques and concepts of satellite-based navigation systems.

| Optoelectronic Devices & Circuits | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To familiarize with the principle of optical systems.
- To study basics of semiconductor Optoelectronics.
- To study the basics of Photo detector, Optical Wave Guide and Optical Amplifier.
- To understand the basics of optical passive and active device, Filters etc.

**COURSE CONTENT:**

**Module 1:**
Introduction: Generic Optical Systems and Fundamental Building Blocks.

**Module 2:**
Basics of Semi-conductor Optoelectronics: Elemental and Compound Semiconductors.

**Module 3:**
Electronic Properties and Optical Processes in Semiconductors, P-N Junction Theory, LEDs and Photo detectors.

**Module 4:**
Heterostructures, Confinement of Electron Waves, Optical Waveguides and Guided Modes.

**Module 5:**
Semiconductor Optical Amplifiers and Fabry-Perot Lasers, Coupled Mode Theory, DBR and DFB Lasers.

**Module 6:**
Silicon Photonics: Integrated Optical Passive and Active Components. Tunable Filters, Delay-Lines and Switching Circuits in SOI Platform. CMOS Technology: Electrical vs. Optical Interconnects.

**TEXTS/REFERENCES:**

1. Pallab Bhattacharya, Semiconductor Opto-Electronic Devices, Prentice Hall of India.

2. Yariv and P. Yeh, Photonics - Optical Electronics in Modern Communications, Oxford University Press.

M. Jamal Deen and P.K. Basu, Silicon Photonics - Fundamentals and Devices, John Wiley & Sons Ltd.

**COURSE OUTCOME:**

At the end of this course the students should be able to

**CO1:** Develop a basic understanding on the key concepts in quantum and statistical mechanics relevant to physical, electrical and optoelectronic properties of materials and their applications to optoelectronic devices and photonic integrated circuits that emit, modulate, switch, and detect photons.

**CO2:** Become proficient with the fundamental and applied optoelectronic device physics and its applications.

**CO3:** Learn to analyze optoelectronic device characteristics in detail and brainstorm ways towards improving them or adapting them to new applications.

**CO4:** Illustrate applications of quantum and statistical mechanics in opto electronic devices and photonic integrated circuits that emit, modulate, switch, and detect photons.

| LASER Science & Technology | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- To prepare the students understand fundamental physics behind laser light radiation
- To enable students familiar with Solid state, gas and semiconductor lasers
- How to generate ultra short laser pulses

**COURSE CONTENT:**

**Module-1**

Laser fundamentals: Spontaneous and stimulated emission, absorption, Einstein's coefficients, active medium, population inversion, laser-pumping, laser gain, metastable state, condition for light amplification, Optical resonator, Solid state laser: Ruby laser, Nd:YAG laser,

**Module-2**

Liquid lasers: Principle and main components of laser, levels of laser action, continuous wave lasers, construction and working of dye laser.
Gas Laser: Principle, working and usefulness of gas laser, He-Ne laser, lasing action in Ion lasers.

**Module-3**

Semiconductor laser: Characteristics of semiconductor lasers, semiconductor diode lasers construction and operation of ion lasers.

Laser fabrication, Laser in optical communication: Optical source for fiber optical communication, essential characteristics of laser in fibre optic communication.

**Module-4**

Fundamentals of Nonlinear Optics: Nonlinear Wave Propagation, Second Harmonic Generation, Phase Matching, Q-switching, mode locking.

**TEXTS/REFERENCES:**

1. Laser Fundamentals, 2nd Edition, William T. Silfvast

2. Lasers- Fundamentals & Applications, 2nd Edition, K. Thyagarayan and Ajay Ghatak

3. G.P.Agarwal, Nonlinear Fiber Optics, 4th edition, Academic

**COURSE OUTCOME:**

**CO1:** Understand the special characteristics of laser light and optical resonator function

**CO2:** Understand constructional features of different types of Lasers

**CO3:** Compare different ultra-short laser pulse generation

**CO4:** Explore laser fabrication and its various applications

| Metaheuristic Algorithms& their applications | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- Understanding computational intelligence techniques and methods, particularly metaheuristic algorithms for optimization problem
- Learning the use of software tools which are specific for computational intelligence.
- Ability to conduct research activity and to prepare reports on a given topic.

**COURSE CONTENT:**

**Module-1**

**Introduction:**

Classes of difficult problems (planning, assignment, selection, adaptation, prediction) and corresponding search spaces, classes of metaheuristics, overall structure of a metaheuristic algorithm.

**Module-2**

**Overview of Heuristic and Meta-Heuristic Search:**

Deterministic local search (Pattern Search, Nelder Mead), Random local search (Matyas and Solis-Wets algorithms), Global search (restarted local search, iterated local search, simulated annealing, tabu search, variable neighborhood search etc).

**Module-3**

**Population-based metaheuristics:**

Overall structure, Main components (exploration and exploitation operators), Operators for evolutionary algorithms: mutation, crossover, selection, Encoding types, Genetic algorithms, evolution strategies, evolutionary programming, genetic programming.
Swarm Intelligence: Ant colony optimization, Particle swarm optimization, Artificial bee colony.
Difference-based and Probabilistic Algorithms: Differential Evolution, Population Based Incremental Learning, Estimation of Distribution Algorithms, Bayesian Optimization Algorithms.

**Module-4**

**Scalability of Metaheuristic Algorithms**: Cooperative coevolution, Parallel models for population-based metaheuristics

**Multi-objective/ multi-modal/ dynamic optimization:**
Particularities of multi-objective optimization (non-domination, Pareto front etc), Apriori and aposteriori techniques, Quality metrics, Multi-modal optimization and specific approaches (niching, sharing etc), Techniques for dynamic optimization (hyper-mutation, random immigrants, ageing mechanisms). Applications of metaheuristic algorithms in engineering.

**TEXTS/ REFERENCES:**

1. Mohammad Solgi, Hugo A. Loáiciga, OmidBozorg-Haddad, Meta-heuristic and Evolutionary Algorithms for Engineering Optimization, Wiley

2. Ke-Lin Du, M. N. S. Swamy, Search and Optimization by Metaheuristics: Techniques and Algorithms Inspired by Nature, Birkhauser

3. Xin-She Yang, Nature-Inspired Optimization Algorithms, Elsevier

**COURSE OUTCOME:**

**CO1:** Present basic principles of metaheuristic techniques.

**CO2:** Identify& apply the appropriate technique to a given problem.

**CO3:** Implement and validate a computational model based on metaheuristic algorithms

**CO4:** Present examples of metaheuristics for global, multi-modal, multi-criteria and dynamic optimization.

**CO5:** Solve a real-world problem using computational intelligence tools.

| Electromagnetic Interference & Compatibility | L-3 T-1 P-0 | 4 credits |
|---|---|---|

**COURSE OBJECTIVE:**

- 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.
- Acquire broad knowledge of various EM radiation measurement techniques.
- Model a given electromagnetic environment/system so as to comply with the standards.

**COURSE CONTENT:**

**Module-1**

Introduction, Natural and Nuclear Sources of EMI / EMC: Electromagnetic environment, History, Concepts, Practical experiences and concerns, frequency spectrum conservations, An overview of EMI / EMC, Natural and Nuclear sources of EMI.

**Module-2**

EMI from Apparatus, Circuits and Open Area Test Sites: Electromagnetic emissions, Noise from relays and switches, Non-linearity in circuits, passive inter modulation, Cross talk in transmission lines, Transients in power supply lines, Electromagnetic interference (EMI), Open area test sites and measurements.

**Module-3**

Radiated and Conducted Interference Measurements and ESD: Anechoic chamber, TEM cell, GH TEM Cell, Characterization of conduction currents / voltages, Conducted EM noise on power lines, Conducted EMI from equipment, Immunity to conducted EMI detectors and measurements, ESD, Electrical fast transients / bursts, Electrical surges.

**Module-4**

Grounding, Shielding, Bonding, and EMI filters: Principles and types of grounding, Shielding, and bonding, Characterization of filters, Power lines filter designs.

**Module-5**

Cables, Connectors, Components and EMC Standards: EMI suppression cables, EMC connectors, EMC gaskets, Isolation transformers, optoisolators, National / International EMC standards.

**TEXTS/ REFERENCES:**

1. Dr. V.P. Kodali, IEEE Publication, Engineering Electromagnetic Compatibility,S. Chand & Co. Ltd.

2. Clayton R. Paul, Introduction to Electromagnetic Compatibility, Wiley

3. Henry W. Ott , Electromagnetic Compatibility Engineering, Wiley

**COURSE OUTCOME:**

**CO1:** Designing electronic systems that function without errors or problems related to electromagnetic compatibility.

**CO2:** Diagnose and solve basic electromagnetic compatibility problems.

**CO3:** Real-world EMC design constraints and make appropriate tradeoffs to achieve the most cost-effective design that meets all requirements.

**CO4:** Understand the effect of EM noise in system environment and its sources.

**CO5:** Identifying of EMI hotspot and various techniques like Grounding, Filtering, Soldering, etc