| IV Year | | | I Semester | | | | |
|---|---|---|---|---|---|---|---|
| S. No. | Course Type | Course Code | Course Title | Periods Per Week | | | Credits |
| | | | | L | T | P | |
| 1 | PCC | EC701PC | Microwave and Optical Communications | 3 | 0 | 0 | 3 |
| 2 | PEC | | Professional Elective - III | 3 | 0 | 0 | 3 |
| 3 | PEC | | Professional Elective - IV | 3 | 0 | 0 | 3 |
| 4 | OEC | | Open Elective - II | 3 | 0 | 0 | 3 |
| 5 | HSMC | SM701MS | Professional Practice, Law& Ethics | 2 | 0 | 0 | 2 |
| 6 | PROJ | EC703PC | Project Phase-1 | 0 | 0 | 6 | 3 |
| 7 | PCC | EC704PC | Microwave and Optical Communications Lab | 0 | 0 | 2 | 1 |
| 8 | PROJ | EC705PC | Industry Oriented Mini Project | 0 | 0 | 0 | 2 |
| 9 | PROJ | EC706PC | Seminar | 0 | 0 | 2 | 1 |
| **Total** | | | | **14** | **0** | **10** | **21** |

**NOTE: Industrial Oriented Mini Project/ Summer Internship is to be carried out during the summer vacation between 6th and 7th semesters. Students should submit report of Industrial Oriented Mini Project/ Summer Internship for evaluation.**

| IV Year | | | | II Semester | | | |
|---|---|---|---|---|---|---|---|
| S. No | Course Type | Course Code | Course Title | Periods Per We | | | Credits |
| | | | | L | T | P | |
| 1 | OEC | | Open Elective - III | 3 | 0 | 0 | 3 |
| 2 | PEC | | Professional Elective - V | 3 | 0 | 0 | 3 |
| 3 | PEC | | Professional Elective - VI | 3 | 0 | 0 | 3 |
| 4 | PROJ | EC801PC | Project Phase -2 | 0 | 0 | 14 | 7 |
| **Total** | | | | **9** | **0** | **14** | **16** |

## Professional Elective –I

| | |
|---|---|
| EC511PE | Error Correcting Codes |
| EC512PE | Mobile Communications and Networks |
| EC513PE | Electronic Measurements and Instrumentation |

### Professional Elective–II

| | |
|---|---|
| EC611PE | Speech Processing |
| EC612PE | EMI & EMC |
| EC613PE | Embedded System Design |

## Professional Elective –III

| | |
|---|---|
| EC711PE | Digital Image Processing |
| EC712PE | Radar Systems |
| EC713PE | Artificial Neural Networks |

### Professional Elective–IV

| | |
|---|---|
| EC721PE | Adaptive Signal Processing |
| EC722PE | Satellite Communications |
| EC723PE | Internet of Things |

## Professional Elective–V

| | |
|---|---|
| EC811PE | Global Navigation Satellite Systems |
| EC812PE | Wireless Sensor Networks |
| EC813PE | Test and Testability |

**Professional Elective–VI**

| | |
|---|---|
| EC821PE | System on Chip Architecture |
| EC822PE | Television Engineering |
| EC823PE | Low Power VLSI Design |

***Open Elective –** Students should take Open Electives from List of Open Electives Offered by Other Departments/Branches Only.

These are the list of open electives offered by our branch to other branches

| **Open Elective - 1** |
|---|
| Fundamentals of Internet of Things |

| **Open Elective - 2** |
|---|
| Electronic Sensors |

| **Open Elective - 3** |
|---|
| Measuring Instruments |

# EC701PC: MICROWAVEANDOPTICALCOMMUNICATIONS

| B. Tech. IV Year I Semester | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Category** | **Hours/Week** | | | **Credits** | **Maximum Marks** | | |
| **EC701EC** | **PCC** | **L** | **T** | **P** | **C** | **CIA** | **SEE** | **Total** |
| | | 2 | - | - | 2 | 30 | 70 | 100 |

**Prerequisite:** Antennas and Propagation

**Course Objectives:**

- To get familiarized with microwave frequency b ands, their applications and to understand the limitations and losses of conventional tubes at these frequencies.
- To distinguish between different types of microwave tubes, their structures and principles of microwave power generation.
- To impart the knowledge of Scattering Matrix , itsformulationandutility,andestablishtheS-Matrixforvarioustypesofmicrowavejunctions.
- Understand the utility of Optical Fibres in Communications.

**Course Outcomes:** Upon completing this course, the student will be able to

- Knownpowergenerationatmicrowavefrequenciesandderivetheperformancecharacteristics.
- realize the need for solid state microwave sources and understand the principles of solid state devices.
- distinguishbetweenthedifferenttypesofwaveguideandferritecomponents,andselectpropercomponentsforengineering applications
- underst and theutilityofS-parametersinmicrowavecomponentdesignandlearnthemeasurementprocedure of various microwave parameters.
- Understand theme chanism of light propagation through Optical Fibres.

## Unit: I — Microwave Tubes, Helix TWTs

**Microwave Tubes:** Limitations and Losses of conventional Tubes at Microwave Frequencies, Microwave Tubes – O Type and M Type Classifications, O-type Tubes: 2 Cavity Klystrons – Structure, Reentrant Cavities, Velocity Modulation Process and Applegate Diagram, Bunching Process and Small Signal Theory – Expressions for O/P Power and Efficiency. Reflex Klystrons – Structure, Velocity Modulation and Applegate Diagram, Mathematical Theory of Bunching, Power Output, Efficiency, Oscillating Modes and O/P Characteristics.
**Helix TWTs:** Types and Characteristics of Slow Wave Structures; Structure of TWT and Amplification Process (qualitativetreatment),SuppressionofOscillations,GainConsiderations.

## Unit: II — M-Type Tubes, Micro wave Solid State Devices

**M-Type Tubes:**

Introduction, Cross-field Effects, Magnetrons–Different Types, Cylindrical Traveling Wave Magnetron -
– Hull Cut-off and Hartree Conditions, Modes of Resonance and PI-Mode Operation, Separation of PI-Mode,o/p characteristics,
**Microwave Solid State Devices:** Introduction, Classification, Applications. TEDs–Introduction, Gunn Diodes – Principle, RWH Theory, Characteristics, Modes of Operation - Gunn Oscillation Modes, Principle of operation of IMPATT and TRAPATT Devices.

## Unit: III — Wave guide Components

**WaveguideComponents:**CouplingMechanisms–Probe,Loop,Aperturetypes.WaveguideDiscontinuities–WaveguideWindows,TuningScrewsandPosts,MatchedLoads.WaveguideAttenuators–DifferentTypes,ResistiveCardandRotaryVaneAttenuators;WaveguidePhaseShifters
– Types, Dielectric and Rotary Vane Phase Shifters, Waveguide Multiport Junctions - E plane and Hplane Tees. Ferrites– Composition and Characteristics, Faraday Rotation, Ferrite Components –Gyrator, Isolator,

## Unit: IV — Scattering matrix, Microwave Measurements

**Scattering matrix**: Scattering Matrix Properties, Directional Couplers – 2 Hole, Bethe Hole, [s] matrix of Magic Tee and Circulator.

**Microwave Measurements:** Description of Microwave Bench – Different Blocks and their Features, Errors and Precautions, Measurement of Attenuation, Frequency. Standing Wave Measurements, measurement of Low and High VSWR, Cavity Q, Impedance Measurements.

| Unit: V | Optical Fiber Transmission Media |
|---|---|

**Optical Fiber Transmission Media:** Optical Fiber types, Light Propagation, Optical fiber Configurations, Optical fiber classifications, Losses in Optical Fiber cables, Light Sources, Optical Sources, Light Detectors, LASERS,WDM Concepts, Optical Fiber System link budget.

## Text Books:

1. MicrowaveDevicesandCircuits–SamuelY.Liao,Pearson,3rdEdition,2003.
2. ElectronicCommunicationsSystems-WayneTomasi,Pearson,5$^{th}$Edition

## Reference Books:

1. OpticalFiberCommunication–GerdKeiser,TMH,4$^{th}$Ed.,2008.
2. *MicrowaveEngineering-DavidM.Pozar,JohnWiley&Sons(Asia)PvtLtd.,1989,3red.,2011Reprint.*
3. MicrowaveEngineering-G.S.Raghuvanshi,CengageLearningIndiaPvt.Ltd.,2012.
4. ElectronicCommunicationSystem–GeorgeKennedy,6$^{th}$Ed.,McGrawHill.

# EC711PE: DIGITALIMAGE PROCESSING

| B. Tech. IV Year I Semester | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Category** | **Hours/Week** | | | **Credits** | **Maximum Marks** | | |
| **EC711PE** | **PEC** | **L** | **T** | **P** | **C** | **CIA** | **SEE** | **Total** |
| | | 3 | - | - | 3 | 30 | 70 | 100 |

**Prerequisite:** Digital Signal Processing

**Course Objectives:**

- To provide a approach twards image processing and introductionabout2Dtransforms
- To expertise about enhancement methods in time and frequency domain
- To expertise about segmentation and compression techniques
- To understand the Morphological operations on an image

**Course Outcomes:** Upon completing this course, the student will be able to

- Explorethefundamentalrelationsbetweenpixelsandutilityof2-Dtransforms in image processer.
- Understand theen hancement, segmentation and restoration processes on an image.
- Implement the various Morphological operations on an image
- Understandtheneedofcompressionandevaluationofbasiccompressionalgorithms.

| Unit: I | Digital Image Fundamentals & Image Transforms |
|---|---|

.

**Digital Image Fundamentals & Image Transforms:** Digital Image Fundamentals, Sampling and Quantization, Relationship between Pixels.

**Image Transforms:** 2-D FFT, Properties, Walsh Transform, Hadamard Transform, Discrete Cosine Transform, Haar Transform, Slant Transform, Hotelling Transform.

| Unit: II | Image Enhancement |
|---|---|

**ImageEnhancement(SpatialDomain):**Introduction,ImageEnhancementinSpatialDomain,Enhancement through Point Processing, Types of Point Processing, Histogram Manipulation, Linear and Non – Linear Gray Level Transformation, Local or Neighborhood criterion, Median Filter, Spatial Domain High-Pass Filtering.
**Image Enhancement (Frequency Domain):** Filtering in Frequency Domain, Low Pass (Smoothing)and High Pass(Sharpening) Filters in Frequency Domain.

| Unit: III | Image Restoration |
|---|---|

**Image Restoration:** Degradation Model, Algebraic Approach to Restoration, Inverse Filtering, Least Mean Square Filters, Constrained Least Squares Restoration, Interactive Restoration.

| Unit: IV | Image Segmentation, Morphological Image Processing |
|---|---|

**Image Segmentation:** Detection of Discontinuities, Edge Linking And Boundary Detection, thresholding, Region Oriented Segmentation.
**MorphologicalImageProcessing:**DilationandErosion:Dilation,StructuringElementDecomposition,Erosion,CombiningDilationandErosion,OpeningandClosing,HitorMissTransformation

| Unit: V | Image Compression |
|---|---|

**ImageCompression:**RedundanciesandtheirRemovalMethods,FidelityCriteria,ImageCompressionModels, Huffman and Arithmetic Coding, Error Free Compression, Lossy Compression, Lossy andLosslessPredictiveCoding,TransformBasedCompression,JPEG2000Standards.

**Text Books:**

1. Digital Image Processing- RafaelC.Gonzalez,RichardE.Woods,3rdEdition,Pearson,2008
2. Digital Image Processing- SJayaraman, SEsakkirajan, TVeerakumar-TMH,2010.

**Reference Books:**

1. DigitalImageProcessingandAnalysis-HumanandComputerVisionApplicationwithusingCVIPTools-ScotteUmbaugh,2ndEd,CRC Press,2011
2. Digital Image Processing using MATLAB– RafaelC.Gonzalez,RichardEWoodsand Steven L. Eddings, 2ndEdition,TMH,2010.
3. DigitalImageProcessingandComputerVision–Somka,Hlavac,Boyle-CengageLearning(Indianedition)2008.
4. IntroductoryComputer VisionImagingTechniquesandSolutions-Adrianlow,2ndEdition,BSPublication,2008.

# EC712PE: RADARSYSTEMS

| B. Tech. IV Year I Semester | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Category** | **Hours/Week** | | | **Credits** | **Maximum Marks** | | |
| **EC712PE** | **PEC** | **L** | **T** | **P** | **C** | **CIA** | **SEE** | **Total** |
| | | 3 | - | - | 3 | 30 | 70 | 100 |

**Prerequisite:** Analog and Digital Communications

**Course Objectives:**

- To explore the concepts of radar and its frequency bands.
- To understand Doppler effect and get acquainted with the working principles of CW radar, FM-CW radar.
- To impart the knowledge of functioning of MTI and Tracking Radars.
- To explain the deigning of a Matched Filter in radar receivers.
-

**Course Outcomes:** Up on completing this course, the student will be ableto

- Derive the completer ad arrange quation.
- Understand then eedand functioning of CW,FM-CW and MTIradars
- Known various Tracking methods.
- Derive the matched filter response characteristics for radar receivers.

## Unit: I Basics of Radar, Radar Equation

**Basics of Radar**: Maximum Unambiguous Range, Simple form of Radar Equation, Radar Block Diagram and Operation, Radar Frequencies and Applications. Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise, Modified Radar Range Equation.

**Radar Equation:** SNR, Envelope Detector – False Alarm Time and Probability, Integration of Radar Pulses, Radar Cross Section of Targets, Transmitter Power, PRF and Range Ambiguities, System Losses(qualitative treatment).

## Unit: II CW and Frequency Modulated Radar, FM-CW Radar

**CW and Frequency Modulated Radar:** Doppler Effect, CW Radar–Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar.

**FM-CW Radar:** Range and Doppler Measurement, Block Diagram and Characteristics, FM-CW altimeter.

## Unit: III MTI and Pulse Doppler Radar

**MTI and Pulse Doppler Radar:** Principle, MTI Radar - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers–Filter Characteristics, Blind Speeds, Double Cancellation, Staggered PRFs. Range Gated Doppler Filters. MTI Radar Parameters, Limitations to MTI Performance, MTI versus Pulse Doppler Radar.

## Unit: IV Tracking Radar

**TrackingRadar:**TrackingwithRadar,SequentialLobing,ConicalScan,MonopulseTrackingRadar – Amplitude Comparison Mono pulse (one- and two- coordinates), Phase Comparison Mono pulse, Tracking in Range, Acquisition and Scanning Patterns, Comparison of Trackers.

## Unit: V Detection of Radar Signals in Noise, Radar Receivers

**Detection of Radar Signals in Noise** Matched Filter Receiver – Response Characteristics and Derivation, Correlation Function and Cross-correlation Receiver, Efficiency of Non-matched Filters, Matched Filter with Non-white Noise.

**Radar Receivers** – Noise Figure and Noise Temperature, Displays – types. Duplexers – Branch typeandBalancedtype,CirculatorsasDuplexers.IntroductiontoPhasedArrayAntennas–BasicConcepts,RadiationPattern,BeamSteeringandBeamWidthchanges,Applications,AdvantagesandLimitations

**Text Books:**

Introduction to Radar Systems–MerrillI. Skolnik,TMH Special IndianEdition,2$^{nd}$Ed.,2007.

**Reference Books:**

1. Radar: Principles, Technology, Applications–Byron Edde, Pearson Education, 2004.
2. Radar Principles– Peebles,Jr.,P.Z.,Wiley,NewYork,1998.
3. PrinciplesofModernRadar:BasicPrinciples–MarkA.Richards,JamesA.Scheer,William A.Holm,Yesdee,2013
4. Radar Handbook- MerrillI.Skolnik,3rdEd.,McGrawHillEducation,2008.

# EC713PE: ARTIFICIAL NEURALNETWORKS

| B. Tech. IV Year I Semester | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Category** | **Hours/Week** | | | **Credits** | **Maximum Marks** | | |
| **EC713PE** | **PEC** | **L** | **T** | **P** | **C** | **CIA** | **SEE** | **Total** |
| | | 3 | - | - | 3 | 30 | 70 | 100 |

**Prerequisite:** Nil

**Course Objectives:**

- To understand the biological neural network and to model equivalent neuron models.
- To understand the architecture, learning algorithms
- To know the issues of various feed forward and feedback neural networks.
- To explore the Neuro dynamic models for various problems.

**Course Outcomes:** Upon completing this course, the student will be ableto

- Understand the similarity of Biological networks and Neural networks
- Perform the training of neural networks using various learning rules.
- Understanding the concepts of forward and backward propagations.
- Understand and Construct the Hopfield models.

## Unit: I Introduction, Learning Process

.

**Introduction**: A Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks

**Learning Process**: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem, Memory, Adaption, Statistical Nature of the Learning Process

## Unit: II Single Layer Perceptrons, Multilayer Perceptron

**Single Layer Perceptrons**: Adaptive Filtering Problem, Unconstrained Organization Techniques,LinearLeastSquareFilters,LeastMeanSquareAlgorithm,LearningCurves,LearningRateAnnealingTechniques, Perceptron –Convergence Theorem, Relation Between Perceptron and Bayes Classifier for a Gaussian Environment

**MultilayerPerceptron**:BackPropagationAlgorithmXORProblem,Heuristics,OutputRepresentationandDecision Rule, Computer Experiment, Feature Detection

## Unit: III Back Propagation

**Back Propagation:** Back Propagation and Differentiation, Hessian Matrix, Generalization, CrossValidation,NetworkPruningTechniques,VirtuesandLimitationsofBackPropagationLearning,AcceleratedConvergence, Supervised Learning

## Unit: IV Self-Organization Maps (SOM)

**Self-Organization Maps (SOM):** Two Basic Feature Mapping Models, Self-Organization Map, SOM Algorithm, Properties of Feature Map, Computer Simulations, Learning Vector Quantization, Adaptive Patter Classification

## Unit: V Neuro Dynamics, Hopfield Models

**NeuroDynamics:**DynamicalSystems,StabilityofEquilibriumStates,Attractors,NeuroDynamicalModels,Manipulation of Attractorsasa Recurrent Network Paradigm

**Hopfield Models**–Hopfield Models, restricted boltzmen machine.

## Text Books:


1. Neural Networks a Comprehensive Foundations, Simon SHaykin,PHIEd.,.
2. Introduction to Artificial Neural SystemsJacekM.Zurada,JAICO PublishingHouseEd.2006.

**Reference Books:**

1. NeuralNetworksinComputerInteligance,LiMinFuTMH2003
2. NeuralNetworks-JamesAFreemanDavidMSKapuraPearsonEd.,2004.
3. Artificial Neural Networks-B.Vegnanarayana Prentice Hall of India P Ltd2005

# EC721PE: ADAPTIVE SIGNAL PROCESSING

| B. Tech. IV Year I Semester | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Category** | **Hours/Week** | | | **Credits** | **Maximum Marks** | | |
| **EC713PE** | **PEC** | **L** | **T** | **P** | **C** | **CIA** | **SEE** | **Total** |
| | | 3 | - | - | 3 | 30 | 70 | 100 |

**Prerequisite: 1.** Probability Theory and Stochastic Process, 2. Digital Signal Processing

**Course Objectives:**

1. To introduce some practical aspects of signal processing, and in particular adaptive systems.
2. Differentiate random variables and random processes, covariance matrices; Z transforms of stationary random processes.
3. Describe error surfaces and minimum mean square error, principle of orthogonality.
4. Formulate discrete time Wiener filter as constrained optimization problem. 5. Analyze steepest descent - convergence issues; Stochastic gradient descent LMS and RLS, its convergence case study. 6. Formulate the Kalman filter.

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

1. Apply the basic probability theory to model random signals in terms of second order statics of Random Processes.
2. Evaluate the covariance matrices to describe the Wiener filter for signals with known second order statistics.
3. Design and implement discrete time Wiener filter.
4. Determine suitable LMS step size to trade off convergence time and misadjustment.
5. Derive and apply the RLS algorithm for iteratively estimating the Wiener filter weights.
6. Design and implement the Kalman filter.

## Unit: I — Introduction to Adaptive Systems

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**Introduction to Adaptive Systems:**
Definitions, Characteristics, Applications, Example of an Adaptive System. The Adaptive Linear Combiner-Description, Weight Vectors, Desired Response Performance function -Gradient & Mean Square Error.

## Unit: II — Development of Adaptive Filter Theory

**Development of Adaptive Filter Theory**:
Introduction to Filtering – Smoothing and Prediction-Linear Optimum Filtering, Problem statement, Principle of Orthogonality-Minimum Mean Square Error, Wiener-Hopf equations, Wiener filter, Error Performance-Cost function, Minimum Mean Square Error. Applications in estimation theory.

## Unit: III — Steepest Descent Algorithms

**Steepest Descent Algorithms:** Searching the performance surface – Methods & Ideas of Gradient Search methods – Gradient Searching Algorithm & its Solution – Stability & Rate of convergence – Learning Curves Gradient Search by Newton's Method, Method of Steepest Descent, Comparison of Learning Curves.

## Unit: IV — LMS Algorithm & Applications

**LMS Algorithm & Applications**:
Overview -LMS Adaptation algorithms, Stability & Performance analysis of LMS Algorithms -LMS Gradient & Stochastic algorithms-Convergence of LMS algorithm. LMS Applications.

## Unit: V — Design and Implementation of Kalman Filter

**Design and Implementation of Kalman Filter:**
Introduction to RLS Algorithm, Statement of Kalman filtering problem, The Innovation Process, Estimation of State using the Innovation Process- Expression of Kalman Gain, Filtering Example-Estimation of State from observations

of Noisy observed Narrow Band Signals.

**Text Books:**

1. Bernard Widrow, Samuel D.Strearns, Adaptive Signal Processing, 1st Edition, PE, 2005.
2. Simon Haykin, Adaptive Filter Theory, 4th Edition, PE Asia, 2002.

**Reference Books:**

1. S.Thomas Alexander, Adaptive signal processing-Theory and Applications, Springer-Verlag, 1986.
2. James V.Candy, Signal Processing: A Modern Approach, McGraw-Hill, International Edition, 1988.
3. L.Sibul, Adaptive Signal Processing, IEEE Press, 1987. 4. Ali H. Sayed, Fundamentals of Adaptive Filtering, John Wiley, 2003.

**Web References:**

1.Lectures on Adaptive Signal Processing by Prof. Mrityunjoy Chakraborty, IIT KGP https://nptel.ac.in/courses/117105075/

2 http://www.ee.iitm.ac.in/~skrishna/ee5040/